APPLICATION OF REMOTE SENSING
TO COASTAL ZONE MANAGEMENT
DOCUMENT 10

Hawaii Coastal Zone Management Program

[Doc]ument 10

[Appl]ication of Remote/Sensing to Coastal Zone Management

HAWAII COASTAL ZONE MANAGEMENT PROGRAM

Document 10

The Application of Remote Sensing to Coastal Zone Management

This document was prepared for the

State of Hawaii Department of Planning and Economic Development

by the

Electromagnetic Systems Laboratories, Inc.
Sunnyvale, California

The preparation of this report was financed in part through a Coastal Zone Management Program Development Grant from the United States Department of Commerce

December, 1976

THE COASTAL ZONE MANAGEMENT PROGRAM DOCUMENTS

Document	
1	Technical Considerations in Developing a Coastal Zone Management Program for Hawaii
2	Inventory of Federally Controlled Land in Hawaii
3	Documentation for Illustrative Mapping of Alternative Coastal Zone Boundary Designations for Selected Sites in Hawaii
4	Bibliography of Sources Relating to Coastal Zone Land and Water Uses
5	The Application of Remote Sensing and Computer Systems to Coastal Zone Management
6	Legal Aspects of Hawaii's Coastal Zone Management Program
7	Organizational Structure, Management, and Implementation of Hawaii's Coastal Zone Management Program
8	Coastal Resources and Hazards: Identification, Analysis and Recommendations Regarding Management Problems
9	Revised Inventory of Federally Controlled Land in Hawaii
10	The Application of Remote Sensing to Coastal Zone Management
11	Organizational Aspects of Managing Hawaii's Coastal Zone

Library of Congress Cataloging-in-Publication Information:

Electromagnetic Systems Laboratories, Inc.
The application of remote sensing to coastal zone management. Prepared for the State of Hawaii Department of Planning and Economic Development. [Honolulu]: Hawaii Coastal Zone Management Program, Dec. 1976.

(Document - Hawaii Coastal Zone Management Program; 10)
1. Coastal zone management - Data processing. 2. Remote sensing systems. I. Hawaii. Department of Planning and Economic Development. II. Title. III. Series.

HT392.H321 no.10 (x Hawaii Coastal Zone Management Program)

PREFACE

ESL's output products for the fiscal 1976 year consist of this final report plus the resources inventories and classification legends. The inventory consists of various mylar overlays keyed to different map bases and depicts the location and extent of pertinent resources. These maps and classification keys are referenced in this report; but, because of scale and volume limitations, cannot be included in their entirety. The actual resource inventories can be reviewed at the Department of Planning and Economic Development, 250 S. King Street. ESL encourages review and comments on the content and format of these prototype CZM map products.

Similarly, ESL work encompasses the extensive use of color and color infrared data, both in the analysis phase and the presentation phase.

Due to reproduction costs, only a limited number of reports contain color photographs. This is unfortunate because the analysis of color infrared imagery is based on the differences in hue and saturation of various objects and backgrounds. Black and white renditions of color infrared imagery do not exhibit these important differences. Furthermore, although black and white reproduction of color infrared photographs appear similar to black and white panchromatic and black and white infrared photographs, they cannot be interpreted as such. The gray scale values of various objects in black and white renditions of color infrared images are not the same as those for the same objects as recorded in standard panchromatic or standard black and white infrared photographs.

The reader wishing to verify personally any discussions concerning the analysis of the imagery presented herein should contact the CZM Data Facility to make arrangements to view positive transparencies.

ACKNOWLEDGMENTS

This document constitutes the final report for ESL's contribution to Hawaii's fiscal 1976 Coastal Zone Management (CZM) program. This report and accompanying resource inventory overlays were prepared by ESL Incorporated for the Department of Planning and Economic Development, State of Hawaii, under contract. The work was performed under the direction of Mr. Richard Poirier, CZM Project Manager for the State of Hawaii.

The work described in this report was accomplished by the Earth Resource Applications Technology Department headed by Mr. James Nichols. Mr. Gary E. Gnauck is project manager for ESL's Coastal Zone Management program. Mr. Larry Chime and Mr. Leonard Zuras have made extensive and important contributions to this program. Dr. Deral Herbst, formerly with the Harold L. Lyon Arboretum, was a consultant to ESL and provided assistance in Hawaiian vegetation taxonomy.

Many groups and individuals have provided valuable assistance to ESL. We would like to express our appreciation to the Department of Planning and Economic Development headed by Hideto Kono. Additional individuals within DPED providing guidance on the CZM program were Frank Skrivanek, Deputy Director; Shoji Kato, Head, Planning Division; Richard Poirier, Branch Chief, Long-range Plans Branch and Planners; Virginia Brooks MacDonald; Carol Takahashi; Steven Shinn; Robert Lew; Joan Yim; and C. J. Christoffels. We have also received valuable assistance from the Policy Coordinating Committee, chaired by Jackie Parnell; the Statewide Citizens Forum, chaired by Mr. Aaron Levine; and the Kauai County Citizens Group; headed by Mr. John Arzadon.

Our specific thanks are extended to Brian F. Nishimoto, Planning Director, Kauai County, and Bert Matsumoto and Tom Ishikawa, also of the Kauai County Planning Department, for assistance provided us in understanding the specific needs and requirements for Kauai County. Tom Tagawa, Ed Petteys and Ralph Dhaeler of the Department of Natural Resources, Division of Forestry provided direct assistance in understanding Hawaii's forestry problems and aided us in our Kauai County field activities. Additional individuals providing helpful suggestions and input were Dwayne Kanuha, Hawaii County Planning; Dr. James Maragos of the U.S. Army Corps of Engineers; Ray Tobata of the University of Hawaii Sea Grant Program; and Mr. Kenji Nishioka of the National Aeronautics and Space Administration, Ames Research Center.

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1. INTRODUCTION.

The 1972 Coastal Zone Management (CZM) Act, Public Law 92-583, provides financial support to encourage individual states in effective management of their coastal environment. Two major sections of the CZM Act are Section 305, which provides for the development of a management plan, and Section 306, which supports implementation of the management plan.

The State of Hawaii legislature elected to participate in the CZM program and designated the Department of Planning and Economic Development (DPED) as the lead agency for CZM plan preparation. DPED is presently completing its second year work program under Section 305 of the Act. Part of this program responds to incorporation of advanced technology to aid in plan preparation and ultimately in management of the coastal resources and environment.

ESL Incorporated, under contract to DPED in the Coastal Zone Management Program, is investigating the application of remote sensing technology to the Hawaiian CZM program. This report presents the results of ESL's work efforts during the second year planning program.

1.1 ESL Objectives.

ESL's participation in Hawaii's CZM program investigates the utility of remote sensing technology to provide resource and environmental information required by the planner and managers. The long-term objective is to provide an efficient system capable of responding to the informational needs of the CZM program from plan development through the management of the coastal resources.

The specific objectives of the second year's work effort are:

1. to refine and expand the analysis methodology begun during the first year's program
2. to test the effectiveness of this methodology by performing actual resource inventories on critical resources and selected areas
3. to increase communication and develop an educational training program on practical application of remote sensing.

The first objectives are concerned with defining user requirements, establishing resource classification systems, developing efficient analysis techniques that incorporate existing data sources and remote sensing, and, finally, establishing a suitable presentation format. Section 2 of this report presents detailed discussions of analysis methodology.

The second objective is to employ these techniques and classification systems to collect actual resource and environmental information. An evaluation of the resulting products and information can then be used to determine the most appropriate analysis system for the Hawaii CZM program. Ideally, this evolves into an on-going system that provides input for management and planning decisions, a long-term monitoring capability, and a source of scientific documentation which will support controversial decisions. Section 3 and supporting appendices present the results of this year's inventory efforts.

Less conspicuous, but equally important, is the problem of integrating and synthesizing a broad range of technologies and scientific disciplines in such a manner that their combined output product can and will be accepted by planners as a valuable information source. This task begins by increasing communication between the information gatherer and the planner/manager. The coastal zone planning and management program is interdisciplinary and each group must become more informed about the other's problems, capabilities and limitations. A common language must be established which translates planning activities into quantitative informational requirements which can then be addressed by the remote sensing specialists and resource scientists. To facilitate this, ESL hopes to familiarize CZM staff, citizens groups, other concerned state and local agencies, and legislative representatives with the state-of-the-art regarding remote sensing. A better understanding of "new techniques" fosters cooperation and effects a greater utilization of this new technology. Section 4 presents this year's activities in communication, public awareness and training.

1.2 First and Second Year Work.

During ESL's first year's effort, an experimental classification system was developed and several informational parameters were mapped. The output product, available for inspection at the Department of Planning and Economic Development (DPED), was a set of multiple overlay maps registered to 7 1/2 minute U.S. Geological Survey (USGS) quadrangle maps. ESL accomplished this inventory in a very short time (April and May 1975), primarily through an interpretation of high altitude aerial photographs and supporting field investigations. The first year's remote sensing applications study demonstrated, among other things, a quick response capability for gathering information. However, time was also spent assessing existing information sources, the extent of local remote sensing capabilities and user requirements relative to an information system.

The second year's work analyzes the first year's product in terms of format and user utilization capabilities. This analysis, together with input from citizen's groups, CZM staff, consultants and other State CZM programs, scrutinizes the original classification schemes and informational parameters; then tests for relevance, usability and accessibility by plan designers. The second year's output, with the proper use, will produce an inventory process* capable of a) providing information crucial to the establishment of a management plan, and b) furnishing input over

*The importance of a process as opposed to a routine lies in the fact that a process, while aware of history and trends, keeps an open mind to the advances of the present and adapts to the most up-to-date ideas and technology. A routine "sustains past achievements" by endlessly repeating them, losing touch with the present and its implications for the future. See Section 2.1 for further details.

1.2 -- Continued.

time as required under Section 306 Implementation. Once that process is defined, the emphasis can shift from methodology development to providing statewide inventory updates of key parameters in a relatively short time frame.

1.3 Summary and Recommendations.

The previous sections outlined and briefly discussed the objectives of ESL's first and second year's work with regard to the Hawaiian coastal zone management planning. This section summarizes the approach employed to achieve these objectives and the results obtained, and recommends future direction on both general and specific levels.

ESL's expertise lies within the technical realm and is aimed at solving problems, gathering information and processing that information into a usable format. Much of the information required by CZM planners and managers is already available with current data. It needs only to be defined, extracted and properly formatted. The goals and informational parameters required, however, must be identified and defined by the planners, the citizens and the political representatives. Herein lies the greatest difficulty -- the communication of those needs from the planner to the technical scientist; and, in reverse, communication of technological capabilities and limitations by the scientist to the planner. This problem is not unique to Hawaii. It is found whenever an interdisciplinary team addresses a common problem. As representatives of the various disciplines become more aware of the contributions of all toward the common end, a more thorough analysis can be accomplished; thus attaining a more realistic plan.

1.3 -- Continued.

Major technical sections of this report deal with Methodology (Section 2), Inventory (Section 3), and Information Dissemination and Education (Section 4). Methodology explores various possible alternatives for completing the tasks and describes that technology which could provide cost-effective information. Inventory utilizes the developed methodology on an operational level to obtain needed cultural and resource information. Information Dissemination and Education is extremely important as it concerns the training and education of the Hawaii CZM planners and managers to aid them in incorporating the developed methodology in their CZM program and in understanding the advantages and limitations of the resulting inventory information.

Various classifications, descriptions, map reproductions and expanded scenarios have been placed in an appendix format. The reader must realize that these are not working maps and have been included in this report only to make the reader aware of their existence. Full sized maps and overlays are available for examination at DPED/CZM offices in Honolulu. Readers are encouraged to comment on ESL's second year's methodology work based upon an understanding of the multiple overlay system, working scale maps and data processing involved.

1.3.1 METHODOLOGY DEVELOPMENT.

Analysis methodology attempts to define the informational requirements of the CZM program and then determines,

1.3.1 -- Continued.

or develops, the most efficient means to collect, process, analyze and disseminate the information. To determine the cultural and resource informational needs, one must understand the coastal zone system including the administrative and management aspects. ESL undertook a fairly rigorous analysis of requirements during our first year's program. This work focused primarily on the Federal requirements as presented in the National Oceanic and Atmospheric Administration (NOAA) Rules and Regulations for Plan Development (ESL Inc., 1975). This year's efforts relate to the specific needs of the State of Hawaii.

1.3.1.1 Systems Approach to Coastal Zone Planning and Management.

The "systems approach" to understanding and managing Hawaii's coastal zone is a relatively simple concept, yet an often misunderstood one. As used here, it is the process by which the existing state of the cultural and physical resources is compared to the desired or preferred state of those resources. Should the former not be in the long-term of interest of the people of Hawaii, procedures and controls are instituted to reverse any deteriorating condition. High technology, such as computers and remote sensing, is not implicit in this definition. Their use can improve, however, the efficiency with which the state of the resources is measured and evaluated, thereby aiding in developing procedures and controls to rectify the existing conditions.

There are two major components of a coastal zone management system: the biophysical subsystem and the resource

1.3.1.1 -- Continued.

management/control subsystem. The biophysical subsystem consists of the natural geological-ecological processes of the Hawaiian Islands modified by the influence of man in terms of both utilization and production of resources. All usable resources are constantly present within the coastal zone, and their presence is measured by the most suitable means available.* The management/controls subsystem compares the existing state of the resources against the ideal or desired state, the latter being the long-term objectives and policies of the Hawaiian people with regard to the coastal environment. It is possible, though unlikely, that the desired state of the biophysical resources is identical to the existing resource state. More likely, some management controls (legal, administrative, biophysical) will be necessary to alter the existing condition in the direction of the preferred state.

Remote sensing technology is concerned with the data acquisition, data processing, data analysis and dissemination functions of the overall coastal zone management system. The resulting information serves as input to the planning and decision-making functions and, in turn, influences the management controls exerted on the resources.

1.3.1.2 Remote Sensing and the Planning Process.

Typically, remote sensing addresses the scientific aspects of a resource problem. This involves understanding the

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*No measurement technique is 100% accurate. The measured state of the resource is an estimate and any measurement technique(s) which improve(s) accuracy, timeliness or completeness increase(s) the effectiveness of the entire system.

1.3.1.2 -- Continued.

biological and ecological processes of a region or resources by measuring the state of the resources, i.e., mapping location, extent, quality and quantity of the resources and changes over time.

An equally important question is the place of remote sensing in the public planning process. By public planning process is meant the development of public policies and objectives with regard to some issue or problem and the implementation of method(s) to achieve the objective(s). The central issue concerns the mechanism (organization, processes and procedures) required to utilize remote sensing technology, systematically, in the public planning process.

The results of our investigation in this area have identified the primary problem - communication between the public, the planner and the technologist; and the solution - education and training.

The scientist and the technologist must understand the planning process including the political realities common to major projects such as the CZM program. The planner must have some understanding of technology, how it works and its limitations. The technologist who is unable to grasp important qualitative elements of the planning process may develop a scientifically rigorous methodology having little practicable application. The planner unable to cope with the quantitative approach of the technologist-scientist will continue to employ inaccurate and inefficient methods of data collection, processing and analysis; and the resulting policies and controls will suffer accordingly.

1.3.1.2 -- Continued.

The solution is to foster understanding and communication between the two groups and the public, not on a one-time basis, but on a continuing day-to-day basis.

1.3.1.3 Analysis Techniques.

To support DPED's inventory and information gathering needs, ESL has investigated several classification systems and analysis techniques to optimize the environmental data collection and processing and analysis functions of the CZM system.* The goal is to integrate various data sources and analysis techniques into a cost-effective information gathering process. Considerable effort was directed at developing the resource classification system most suitable to Hawaiian coastal zone management. Toward this end, field observations, low altitude panchromatic photographs, high altitude color, and color infrared photographs, and LANDSAT satellite data were investigated as possible input mechanisms. Analysis of this combination of data sources resulted in a multilevel data collection approach which has historically shown to be useful in other projects.

*NOAA's Coastal Zone Management Program, Development Grants, 305 Guidelines, Subpart C, Section 920.20(a) states: "(a) It is clear that the process of developing (and operating) a management program for the coastal zone will necessarily involve frequent access to informational and research sources. In many cases, adequate understanding of questions such as dune stabilization, barrier beach dynamics, salt marsh productivity and estuarine circulation and flushing, to mention only a few, will be needed in order to develop successful management programs. Also, the process of inventorying and mapping the nature of a State's zone and designating areas of particular concern almost certainly will benefit from the application of technologies employing remote sensing."

1.3.1.3 -- Continued.

Traditional photo interpretation techniques were applied to low altitude black and white and high altitude color and color infrared photographs. The interpreter-scientist relates the size, shape, tone, texture, shadow pattern and location of the various objects and backgrounds as portrayed in the imagery to the necessary resource or cultural information; (e.g., land use, vegetation, sedimentation source, soil erosion, marine habitat). Inference, convergence of evidence, is also a powerful technique in deriving information from photographs. These techniques taken in aggregate were found to be useful in providing much of the required resource information. The reader desiring detailed methodology of the interpretation process should consult any one of several standard references; e.g., American Society of Photogrammetry, 1960, 1975.

Moreover, additive color analysis was employed for greater water penetration capabilities; and digital processing of LANDSAT imagery was investigated to determine its usefulness to the CZM program. A separate study on computer processed LANDSAT Data was accomplished and is discussed in detail in the report. This technique holds promise depending upon the definition of CZM requirements.

The results of investigating various analysis techniques have shown that no one data source or analysis technique is optimum for the CZM program. Because of the complex and divergent informational requirements of the CZM program, it will be necessary to identify and define the informational needs for each problem or resource attribute, and then apply the most appropriate data sources and analysis methods for each one. To try to force

1.3.1.3 -- Continued.

one data source or analysis method to fit all problems will result in inaccurate or inefficient procedures.

1.3.2 INVENTORY.

The second year focused additional effort on inventory products as a platform for implementing and evaluating methodology. Many interpretive and analytic techniques were brought to bear in establishing an optimal multiple data collection system.

An important aspect of ESL's CZM inventory task is that of converting raw data into relevant information and then presenting that information as an easily understood, useful tool, for non-scientifically oriented planners. This task includes:

1. Definition of categories of required information

2. Formulation of a meaningful classification system

3. Providing adequate accuracy and detail within that classification system without exceeding funding limitations

4. Furnishing a presentation system which will allow easy access, be graphically sufficient, and facilitate and support user decisions with scientific documentation.

1.3.2 -- Continued.

ESL's inventory work includes: 1) the statewide wetlands study undertaken in conjunction with the U.S. Army Corps of Engineers, 2) the Kauai County inventory, and 3) geographically specific problem analysis areas.

ESL's inventory task produced maps, classifications, formats, etc. The output products are described and discussed in the final report; however, the nature of these products precludes complete inclusion within this document. It is imperative that the output products themselves be carefully examined and critiqued by planners, public committees and others in order to be truly valuable.

1.3.2.1 Wetlands Inventory.

The Hawaii Coastal Zone Management Program, realizing the importance of wetland areas and the impact those areas have on planning and management decisions in the coastal zone, began discussing a wetland survey early in 1976. Following negotiations with the U.S. Army Corps of Engineers, a cooperative statewide wetlands inventory effort between the Hawaii CZM Program and the Corps was undertaken. This two-phase program, begun in late February 1976, was to combine the capabilities and outputs of each participant into a single, informative document as cost-effectively as possible.

Phase one, supported by the CZM program, consists of identifying and locating all significant wetlands, or probable wetlands in the state. The output product is an overlay registered

1.3.2.1 -- Continued.

to the 7.5 USGS quadrangle maps indicating the general type and location of the wetland.

Phase two, to be conducted by the U.S. Army Corps of Engineers, will consist of visits to each indicated site to determine if the wetland should be included in the inventory; and, if so, to obtain detailed vegetation and ecological information.

The Coastal Zone Management (ESL Incorporated) portion of the wetland study is based primarily upon aerial photographic interpretation of high altitude color infrared photographs of October 1974 and July 1975 and U.S. Army Corps of Engineers' low altitude, black and white shoreline photographs of 1975 and 1976. General wetland type (e.g., lowland meadow, estuarine, salt marsh, etc.) is provided with more precise vegetation species descriptions included where ESL field teams have gathered ground truth support data. Wetland delineation over the entire State of Hawaii has been accomplished for those wetlands approximately five acres or greater in size. Gaps in the statewide aerial coverage, due mainly to cloud cover, necessitated ancillary information sources be utilized (USGS quadrangle maps) in some areas.

For this study, a wetland is defined as "areas having wet, marshy soil conditions, frequently inundated by or covered with fresh, brackish or salt water, subject to tidal, riparian or drainage ponding influence, and including 'high bogs'; those areas distinguished by particular and unique vegetative species that require saturated soil conditions for their growth and reproduction."

1.3.2.1 -- Continued.

The phase One product is a systematic display of delineated wetland areas accomplished through an overlay system keyed to USGS quadrangle maps (1:24,000 scale and 1:250,000 scale). Only the overlays are provided, to be utilized in conjunction with in-house copies of the various quadrangle maps. These maps will provide over-view wetlands locational information to the CZM planners and will facilitate detailed ground investigation by the U.S. Army Corps of Engineers. The combined output product is an excellent example of interagency cooperation and the application of multilevel data gathering and analysis to obtain the desired information.

1.3.2.2 Kauai County Resource Inventory.

Webster defines resource as "an available means; a natural source of wealth or revenue". Hawaii is rich in natural resources and not very many years ago was substantially richer in some of its resources. Recent public awareness has forced governmental representatives to address the problem of diminishing natural resources. ESL's resource inventory is aimed at providing information to managers thereby enabling them to serve this task better.

The purpose of this inventory study is based upon the planning/management informational needs of the State and County governments, and is in accord with NOAA threshold papers (Federal recommendations).

1.3.2.2 -- Continued.

The perennial problems encountered with constructing a resource attribute classification system are correct identification of user perspectives and anticipation of long-term value fluctuations. The user perspective is as varied as the individuals using the system and is complicated further through resource weighting, projected program goals, and funding limitations. As time passes, land value patterns change placing new planning and management requirements on a system designed for old demands. The definition and compatibility of "land use" and "land cover" classes is also difficult.

ESL has reviewed many classification scheme designs in formulating a system for the Hawaii Coastal Zone Management Program methodology study. Each design presented several very positive elements; but, in each the value of the positive element was partially offset by irreconcilable conflicts when operationally tested. The problem was not solely with the classification schemes reviewed, but with the complexity of uses to which coastal zone management would subject them. The goal was to design a classification system which would: 1) deal with a wide range of resources, 2) be flexible enough to access information relevant to specific combinations of resources, and 3) be easily corrected, updated or modified.

Through our inventory methodology studies, a multiple overlay system was formulated and implemented. Eight categories of information were defined and mapped:

1.3.2.2 -- Continued.

1. Land Use Districts

2. Transportation

3. Land Use

4. Vegetation

5. Shoreline Habitat

6. Sand and Reef

7. Rivers and Streams

8. Wetlands

These categories were determined by the technical consultants (ESL, PUSPP and H. Mogi) and approved by CZMP staff. Discussion with the Kauai County Planning Department also provided input; particularly, the level of detail relevant to local government planning.

Each category has its own map and a specifically tailored classification system which furnishes the maximum amount of information through a minimum number of detail levels. On any map or classification scheme as more delineations are drawn out, the number of detail levels increases. As these increase, the design of the system becomes more and more complicated and the illustrative graphics and class breakouts become progressively more difficult to utilize. By separating major resource categories

1.3.2.2 -- Continued.

and supplying each with a simplistically tailored class breakdown, the data become more accessible, easier to use and deal smoothly with redundancies. An excellent example is, "is it grassland or pasture; bare ground or recreational beach, waste field or open space?" Each resource category map supports the resource inventory function, but by being individually autonomous, provides stand-alone information as well.

Network system overlays (e.g., rivers and streams) are completely compatible with areal delineation overlays (e.g., vegetation); and, though designed for initial manual use, both can be quickly converted to a computerized process.

Several use benefits become readily apparent with the multiple overlay system. First, new categories can easily be added. Soil conservation maps, already completed by USDA can be added to this system with little if any modification. Orthophoto quad maps could easily create a new base map. Secondly, individual resource maps or overlays can be selected and combined to focus on particular problems. For example, vegetation maps and rivers/streams maps can be combined to study water demand problems. Thirdly, the problem of separating land use and land cover is solved. On a vegetation overlay, the classification may be "grassland" while on a land use overlay it would be "pasture". Bare ground on a vegetation overlay might be a boulder beach on the shoreline habitat overlay indicating a micro-environment to be conserved. Levels of detail need not become excessively complex

1.3.2.2 -- Continued.

on any one overlay since other overlays are addressing other resource informational requirements. By analyzing a relatively small number of problem areas, planners and managers can begin to set up predictive models which, in turn, can assist in prioritizing permissible uses.

ESL's task is to present relevant resource and environmental information to these decision makers. The final decisions, however, must include a consideration of economic, social, and political factors. Subsections in the final report discuss geographically specific problems and attempt to draw the reader, through a process which involves the use of remote sensing, into detecting, identifying and recommending solutions.

1.3.2.3 Problem Analysis.

Much effort has been directed towards the identification of problems in the Hawaiian Coastal Zone. As could be expected, one man's pleasure is another man's problem. PUSPP undertook to determine what Hawaii's citizens considered to be problems and then formulated a list prioritizing these for further attention. Problem analysis, however, goes far beyond simple listing. Both PUSPP and ESL have delved into the question, "what are the significant causes behind the problem" and "how can managers best deal with the causes to ameliorate the problem."

ESL's approach to problem analysis is:

1.3.2.3 -- Continued.

1. Identify the problem (e.g., coral kill).

2. Locate the physical effect creating the problem, e.g., sedimentation).

3. Through remote sensing technology, trace the effect of the problem to its physical cause (e.g., soil erosion).

4. Determine the land use activities or conditions which initiated the cause, (e.g., overgrazing).

5. Outline the physical boundary of the problem to include cause, pathway(s) and effect(s); establish geographic area of particular concern.

6. Recommend key points at which to monitor cause and effect of the problem.

1.3.3 INFORMATION DISSEMINATION AND EDUCATION.

"AWARENESS" on the part of both planners and scientists has been discussed previously and in a plethora of publications relating to the interdisciplinary importance of successful planning and management. Germane to this theme, ESL approached the task of making the technology of remote sensing less mysterious and hence more accessible to everyone participating or interested in the Hawaii Coastal Zone Management Program.

1.3.3 -- Continued.

Over and above the numerous scheduled presentations and workshops in which ESL took part, two major educational tasks were accomplished. A data facility or centralized information clearing house feasibility study was begun and partially implemented; and a REMOTE SENSING Seminar was held.

1.3.3.1 Data Facility Alternatives.

Now in its second year, DPED has been working closely with ESL and the National Aeronautics and Space Administration, Ames Research Center, in the area of remote sensing technology. During 1974 and 1975, Ames Research Center obtained over 2600 high-altitude U-2 photographs of large portions of the Hawaiian Islands. This imagery, sent to DPED, represents extremely valuable source information on land use and cultural and natural resources of the state. Furthermore, collected over time, these data provide information on the changing nature of key resources as discussed in the previous sections. The CZM program (as well as other long-range planning programs within DPED) is not a one time effort; and the established data base can be effectively used for years to come.

The mere physical existence of remote sensing data, however, is no assurance that it will be effectively utilized. Some means must be developed to catalog the data, and suitable equipment must be obtained to carry out the necessary planning, processing, and analysis functions discussed previously. The existing U-2 imagery must be used in concert with (not as a

1.3.3.1 -- Continued.

replacement for) other types of remote sensing data (satellite, low-altitude aircraft) and ancillary information such as maps, charts, reports, and interpreted results from earlier investigations and field notes in order to derive maximum benefit. This suggests some sort of data facility or information clearinghouse is needed to ensure effective use of the imagery for the CZM and related programs.

A data facility, clearly, would be beneficial in providing: 1) an efficient informational storage and interpretation center, 2) uniformity of information format presentation, 3) a capability to update information quickly and effectively, 4) an historical data base to be used for trend analysis, and 5) to establish a mechanism for interdisciplinary communication essential to the success of the CZM program.

ESL has undertaken exploration of various alternate data facilities and plans for their implementation. Specifically, this study addresses:

- The type of facility best suited to the needs of the State of Hawaii
- A recommendation for a phased long-range implementation plan
- Specific procedures and data cataloging criteria for the existing in-house U-2 imagery.

1.3.3.1 -- Continued.

Thus far a data facility has been discussed, advertised, approved and looked for by interested potential users. It has not, however been implemented.

1.3.3.2 Remote Sensing Seminar.

Held in April of this year the seminar was, based upon feedback from the participants, a worthwhile and reasonably successful undertaking. Topics, speakers and agenda are discussed in the final report in Section 4.2.

1.3.4 Recommendations.

ESL Incorporated recommends an extension of the basic inventories begun over the Island of Kauai this year to encompass the entire State. These statewide inventories will be updated every five years and serve as an overall planning aid. Specific recommendations are:

1. Examine the multiple overlay resource attribute system; and expand and extend the attributes and classification system for the entire State.

2. Incorporate the final analysis methodology into the statewide planning process on a systematic basis.

3. Continue and strengthen liaison with U.S. Army Corps of Engineers to facilitate Phase II of statewide wetlands study and incorporate the end product into CZM data base.

1.3.4 -- Continued.

4. Use the results of 1. through 3. above, in conjunction with input from other CZM consultants, the various advisory groups and citizens, to identify geographic areas of particular concern and to define specific informational needs for detailed quantitative inventories required for CZM management activities.

To aid in accomplishing the above objectives and to synthesize and coordinate all aspects of the CZM program, ESL recommends the establishment of a CZM Information Clearinghouse or Data Facility. This facility can: 1) serve as a means of communication between all interested CZM participants; 2) consolidate state data acquisition and analysis requirements thus avoiding costly duplication of effort; and 3) serve as a mechanism to establish information requirements and aid in the implementation of CZM policies and guidelines under Section 306 Funding.

ESL has recommended a phased approach to the establishment and expansion of a CZM data facility (details are provided in Section 4.1). Specific recommendations are:

1. Review alternative data facility scenarios, and decide upon long-term goals.

2. Acquire necessary space, equipment and personnel; then implement plan.

1.3.4 -- Continued.

ESL further recommends that the State of Hawaii maintain liaison with NASA and other research and technology agencies; and using the above recommended data facility as an efficient mechanism, incorporate new advances in computer information systems and remote sensing into the state planning process. Two areas, color additive analysis and digital image processing using LANDSAT data, were investigated by ESL during the past year and both hold considerable promise. Details can be found in Section 3. With regard to LANDSAT, the following are recommended:

1. Determine future availability/probability of cloud free LANDSAT over the Hawaiian Islands or key areas of the Islands.

2. Based upon clearly defined informational requirements, incorporate LANDSAT digital processing, along with photo interpretation of existing U-2 and new low altitude photographs and field surveys, for detailed quantitative inventories.

2. METHODOLOGY DEVELOPMENT.

Analysis methodology attempts to define the informational requirement of the CZM program and then determines, or develops, the most efficient means to collect, process, analyze and disseminate the information. To determine the cultural and resource informational needs one must understand the coastal zone system including the administrative and management aspects. ESL undertook a fairly rigorous analysis of requirements during our first year program. This work focused primarily on the Federal requirements as presented in the National Oceanic and Atmospheric Administration (NOAA) Rules and Regulations for Plan Development (ESL Inc., 1975). This year's efforts relate to the specific needs of the State of Hawaii.

Section 2.1 provides a discussion of the systems approach to managing Hawaii's Coastal Zone. Section 2.2 looks at the place of remote sensing in the public planning process. The emphasis here is on the public planning decision-making process rather than on the biological or resource aspects of the CZM program. Finally, a discussion of various analysis techniques and resource classification systems is reviewed in Section 2.3.

2.1 Systems Approach to Coastal Zone Planning and Management.

The "systems approach" to understanding and managing Hawaii's coastal zone is a relatively simple concept, yet an often misunderstood one. As used here, it is "the process by which the existing state of the cultural and physical resources

2.1 -- Continued.

is compared to the desired state of those resources and, should the former not be in the long-term of interest of the people of Hawaii, procedures and controls are instituted to reverse any deteriorating condition." High technology, such as computers and remote sensing, is not implicit in this definition; however, their use can improve the efficiency with which the state of the resources is measured and evaluated and thereby aiding in developing procedures and controls to rectify the existing conditions.

There are two major components of a coastal zone management system: the biophysical subsystem and the resource management/control subsystem. The biophysical subsystem consists of the natural geological-ecological processes of the Hawaiian Islands modified by the influence of man in terms of both utilization and production of resources. All usable resources are constantly present within the coastal zone, and their presence is measured by the most suitable means available.* The management/controls subsystem compares the existing state of the resources against the ideal or desired state, the latter being the long-term objectives and policies of the Hawaiian people with regard to the coastal environment. It is possible, though unlikely, that the desired state of the biophysical resources is identical to the existing resource state. More likely, some management controls (legal, administrative, biophysical) will be necessary to alter the existing condition in the direction of the preferred state.

*No measurement technique is 100% accurate. The measured state of the resource is an estimate and any measurement technique(s) which improve(s) accuracy, timeliness or completeness increase(s) the effectiveness of the entire system.

2.1 -- Continued.

A clearer understanding of the entire process is provided in the following material which provides a detailed discussion of each subsystem and a final integration into a single system.

The biophysical subsystem is shown in Figure 2-1. The center block represents the known usable land and natural resource base of Hawaii's coastal zone. Additions to this base are continually being discovered; for example, manganese nodules, new offshore sand deposits or geothermal power. Reduction of the resource base occurs through use, via natural depletion, e.g., soil erosion, and the human consumption e.g., use of sand for concrete. The output of both of these processes is waste and by-products which serve as input to human production, reuse of scrap metal, production of benzene as a by-product of gasoline, and natural replenishment functions. Both the natural replenishment and human production functions have a loss component as well as accretions to the resource base. The oyster industry in Hawaii is an example of an increase in a reusable resource due to human production (Sparks, 1963).

The resource management and controls subsystem is concerned with the administrative mechanisms whereby decisions are made and managerial practices established. Figure 2-2 is a block diagram of the resource management/controls subsystem.

The planning and synthesis (decision-making) function receives input from the public in the form of policies and suggested directives which help to determine the "preferred state of the resource system." Input from the resource system model, including

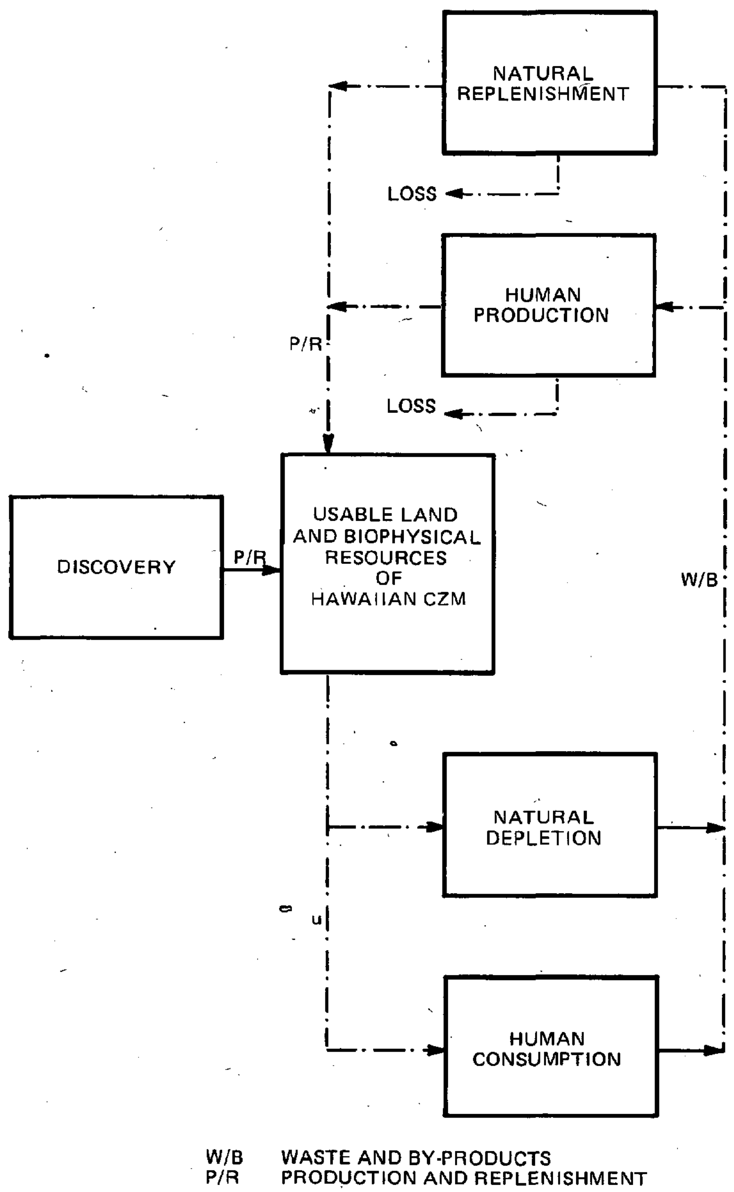

Figure 2-1. Block Diagram of Hawaii's Coastal Zone Biophysical Subsystem

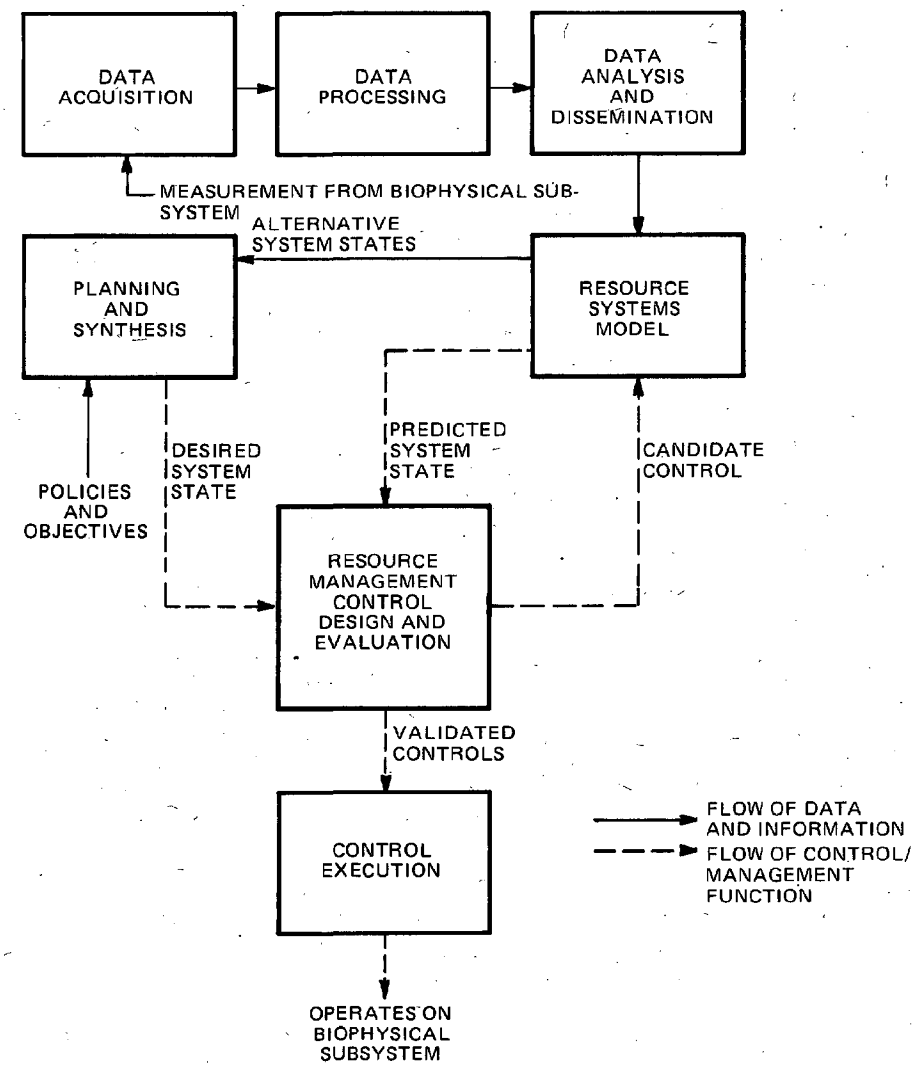

Figure 2-2. Block Diagram of Hawaii's Resource Management/Controls Subsystem

the existing state, also assists in ascertaining the desired system state. Accurate output of alternative system states from the resource system model requires accurate and current information. The planning and synthesis function determines informational needs which serve as inputs to the data acquisition function. The data is acquired, processed and analyzed resulting in information regarding the biophysical subsystem which serves as input to the resources system model.

The resulting "desired system state" is input to the resource management control design and eveluation function. Here various possible controls are designed to achieve the "desired system state". These alternative or candidate measures serve as input to the resources system model for simulation analysis; and the "predicted state" of the resource is input to the resource management control design and evaluation function, which selects the controls most closely approaching the desired system states. These controls serve as the input to the control execution function which carries out the required actions.

These two subsystems are part of a larger coastal zone management system and interface as shown in Figure 2-3. The planning and synthesis (decision making) function dictates the informational requirements driving the data acquisition function which measures the state of the biophysical resources. The control execution function acts on the biophysical resources to bring them closer to the desired state or condition. Also information from the resources systems model provides direct input to the human production and consumption functions essential for economic simulation and development.

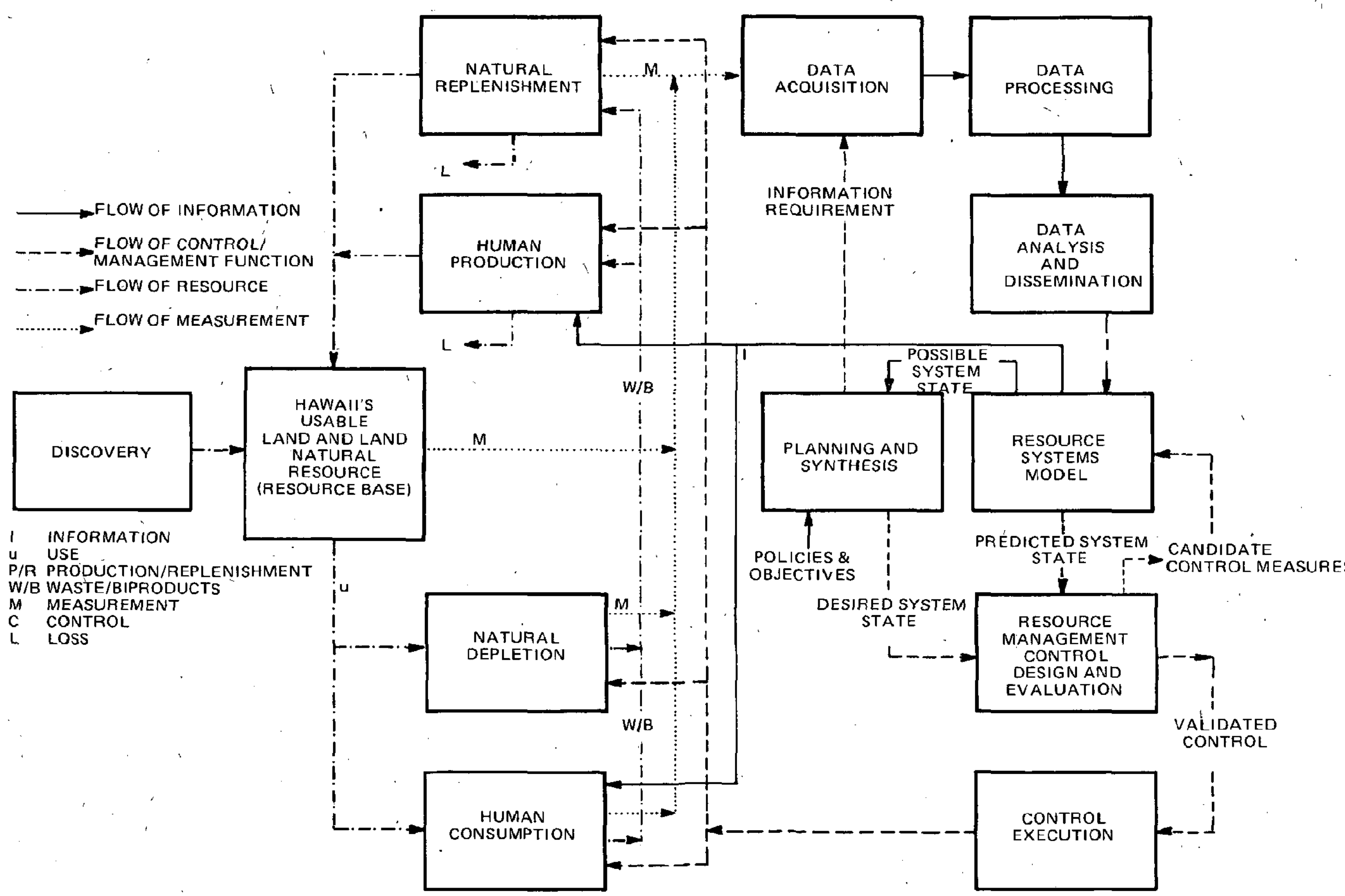

Figure 2-3. Block Diagram Hawaii Coastal Zone Management System

2.1 -- Continued.

There is no implicit requirement to apply advanced technology in the process outlined above. Data acquistion, for example, could consist exclusively of literature survey and on-site inspection. Data processing could be nothing more sophisticated than typing of hand written notes. Similarly, the resource systems model may be one person's intuitive knowledge and understanding of the Hawaiian resources and political environment.

There is an opportunity to apply advanced technology to this system and increase significantly the efficiency and responsiveness of the system. Data acquisition through data analysis and dissemination functions can be accomplished in part with remote sensing, increasing the completeness, accuracy and timeliness of the measurement cycle. The Resources Inventory System (automatic mapping) presently under development by the University of Hawaii Pacific Urban Studies Planning Program (PUSPP) for CZM can serve as the basis for a sophisticated resource information system, which could significantly assist the planners in choosing between alternative means to achieve CZM policies and goals.

2.2 Remote Sensing and the Planning Process.

2.2.1 General.

Remote sensing is a relatively simple concept that has evolved into a highly complex and sophisticated technology. The more conventional elements of this technology, e.g., low

2.2.1 -- Continued.

altitude aerial photography, have received wide acceptance as an efficient method of providing biophysical information. However, the more advanced techniques, e.g., multispectral analysis and digital processing, are rapidly gaining acceptance on an international basis. In the context of the Hawaii CZM program the question is: What can remote sensing tell us about the coastal environment of Hawaii? To address this question puts the emphasis on the environmental or resource aspect of the Hawaii CZM program. This approach is not unique, Jondrow (1975) indicates the remote sensing technology usually addresses the scientific aspect of a problem--understanding the biophysical attributes and relationships involved. This important question was initially addressed by ESL in our first year's report on the Hawaii's CZM program and is discussed later in this report. However, an equally important question, concerns the role of remote sensing in the planning process. By planning process is meant the development of public policy and public objectives with regard to some issue or problem and the implementation of a method(s) to achieve the objective(s).

The first problem encountered in addressing the role of remote sensing to the planning process concerns the completely different training and perspective of the policy planner and the remote sensing technologists. On numerous occasions during the past year ESL personnel have been asked the questions:

2.2.1 -- Continued.

- What can you do with remote sensing?
- What kind of information can you collect?"[1]

We have almost always replied: "Define your specific informational requirements;

- What cultural, or resource attributes do you wish to measure,

- How accurate and how frequently do you need the information?

We can then define a cost-effective data-collection and analysis system to respond to these requirements."

To specify precise informational needs requires that the planner understand clearly public goals and objectives with respect to land use policies and their impact on the quality of life. Ideally, the planner would assess alternative means to achieve the specified goals. This, in turn, would dictate the type, accuracy and frequency of information he requires to make his assessment and would provide the technologist with concrete requirements.

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[1] One attempt to answer these questions was provided in last year's Final Report, Appendix B, "Remote Sensing Literature Review". This was not an effective means of communication and a remote sensing seminar was held in March of this year to address this problem partially. (See Section 3.1.)

2.2.1 -- Continued.

Unfortunately, public goals and objectives with regards to land use policies and resource allocations are not easy to define (Perlman and Ramey 1972). In fact "public goals and objectives" is a theoretical concept often illusionary in practice. When the "public" is divided into various special interest groups and unaligned laymen, the goals and objectives either become contradictory or disappear completely. The planner faced with developing public policy under these conditions has a very difficult time defining his informational requirements.

The technologist is often hampered by his lack of experience in perceiving the general context and political realities of the planning process. The technologist typically likes to proceed with the definable elements of the problem. Decisions requiring the concurrence of many organizations and perhaps the public as well and taking months to resolve instead of the one or two days initially scheduled are an anathema to the technologist.

The social scientists, on the other hand, are often unable to understand the quantitative methods of the technologist. In the case of remote sensing, it may be difficult for the planner to believe that useful information can be obtained from examining data (recorded electromagnetic radiation) from 12 miles (U-2) or 500 miles (satellite) from the problem. Further, the interpretation process (the method by which the abstract EM radiations are transformed into useful information) is not always understood; and, in some cases, simply not trusted by the social scientist. This problem is not unique to the Hawaii CZM effort. It has

2.2.1 -- Continued.

been found to apply in the transfer of any high technology to the planning process (Perlman and Ramey 1972, Lionberger 1960). Perlman and Ramey (1972) describe the above problem as one of "diversity", essentially representing a continuing situation brought on by the multi-disciplinary makeup of the social scientists, remote sensing engineers, computer specialists, and resource analysts which make up the client-consultant team.

The solution to this problem is communication between the technologists and the planners. This would, of necessity, involve iterative interaction whereby ideas could be exchanged, and viewpoints, concerns and doubts expressed.

Those elements of the coastal zone system (see Figure 2-3) applicable to remote sensing and planning are the decision making functions (planning and synthesis) and the data acquisition through analysis and dissemination functions. Planning derives the required information, accuracy and precision levels. The raw data is acquired, processed and analyzed resulting in information which is then used in decision making. The problem, when dealing with advanced technology is that many individuals with different background and viewpoints perform the various functions. If they each operate independently with minimum communication and interaction, the process breaks down; and the advanced technology is usually not employed by the planning agency.

To circumvent this problem, ESL has recommended a CZM informational clearing house or data facility. This facility will serve to integrate the planning, acquisition, and analysis

2.2.1 -- Continued.

elements of the system; and also incorporate the resource system model (CZM Information System) to support internal as well as external (Public participation) informational needs. Further discussion of the recommended CZM data facility is discussed in Section 4.

2.2.2 Review of Recent Results.

This section provides a brief review of some of the current studies in planning and remote sensing.

The success of a planning agency which employs remote sensing techniques successfully is very much influenced by the nature of the planning agency involved. Goehring and McKnight (1972) have studied two different planning agencies in the greater Los Angeles, California, area with specific emphasis on their use of remote sensing. A brief review of some of their findings is appropriate to the use of remote sensing by DPED for the CZM program.

The Community Analysis Bureau (CAB) is a separate unit of the Los Angeles city government established in 1967 to prepare a city-wide program to correct existing urban blight and deter future blight and obsolescence. The Regional Planning Commission (RPC) was established in 1923 to administer a zoning ordinance and perform needed studies. However, due to the rapid growth of the Los Angeles metropolitan area, coupled with the state-of-the-art of city planning in the 1920s (Perloff, 1957), RPC established and administered zoning codes as a means to develop sound land use patterns (Goehring and McKnight, 1972). Physical planning, emphasizing transportation networks and zoning code administration were the primary functions of RPC. Thus the RPC became the land use regulator while the land developer and the assessor performed the land planning of the county (Goehring and McKnight, (1972). Goehring and McKnight (1972) further state "over the years RPC planners have tried to integrate 'physical' (traditional) with 'social' (master) planning, but few have had major success. Code administration still comprises a large share of planning work, particularly in recently growing areas..."

The differing success of the two agencies emphasize both the need to define clear cut objectives and the need for the planning agency to incorporate new technologies in the planning process.

The CAB has employed a systems approach to planning and is developing a comprehensive information storage and retrieval system using a variety of input data including that derived from an analysis of remote sensing data. The objective is clear; "correct existing blight and deter future blight and obsolescence". Large scale (1:10,000) color infrared imagery was collected and analyzed; and positive results were achieved in identifying and delineating urban blight area (Goehring and McKnight, 1972).

As a result, remote techniques are being fully integrated into the planning function; and sufficient funding has been allocated to obtain the required data, equipment, personnel, and contract support. Goehring and McKnight (1972) state:

2.2.2 -- Continued.

> " The system is considered highly successful. It has satisfied HUD to the extent that the grant is annually renewed and that the Bureau's system of management procedures and approaches is being recommended for adoption. Numerous other varied reports on functions and areas have also been prepared for city departments and other public agencies. Remote sensing reports have been produced at a high level of detail for small areas to help assign FACE (Federally Assisted Code Enforcement) funds. Other reports, for larger areas, have been prepared for city councilmen and for planning studies of the City Planning Department. "

The RPC, on the other hand, used remote sensing data (almost exclusively black and white photographs) on an intermittent and ad hoc basis for many years (Goehring and McKnight 1972). Individual studies concerning land-use analysis of selected areas for special purpose agricultural studies did employ the use of remote sensing data. These were interspersed with similar studies and programs using traditional ground survey techniques. There was no mechanism to systemize the planning, acquisition analysis, and decision-making process; and the use of remote sensing was left to the individual supervisor to determine. Goehring and McKnight (1972) report that the use was often based upon free data. In other words, the aerial photographs were often collected for another purpose. This can sometimes prove beneficial and save money, but can also result in marginal or totally unacceptable data for the purpose at hand.

Hill-Rowley, et.al. (1975) have found remote sensing to benefit the planning and resource decision making process in two ways: (1) first generation direct action and (2) second

2.2.2 -- Continued.

generation or indirect delayed action applications. An example of (1) for Hawaii would be isolation and study of a specific problem such as beach erosion at a given location. The problem can be identified, an analysis method established, and results obtained within a few months. An example of (2) would be systematic and continuing inventory of various resource features which, when studied over time, aid trend analyses by managing agencies.

Hill-Rowley, et. al. (1975) discuss seven case studies to illustrate the many contrasts which can be drawn between first and second generation application studies. These include: (1) multi-agency river basin planning; (2) corridor assessment and route location for highway location together with improvement of county-level planning decisions; (3) improving timber management practices; (4) enforcement of new state statutes; (5) county-wide open space preservation; (6) land value reappraisal relative to property tax equalization; and (7) optimizing agri-business processing plant locations.

Hessling (1975) reports significant cost savings in the preparation of land use maps from satellite imagery in response to water quality planning as required by the Environmental Protection Agencies Federal Water Pollution Control Act of 1972 (PL 92-500). Hessling (1975) reports considerable success but underscores the importance of communication and close working relationships between the planner and researcher as illustrated by the following quote.

2.2.2 -- Continued.

> " The OKI (Ohio-Kentucky-Indiana Regional Council of Governments) project has clearly shown an important practical application of LANDSAT data. Indications are that our success has already encouraged several of the other existing and potential water quality planning agencies to consider the use of LANDSAT generated data. Furthermore, the planning applications need not be limited to water quality analysis. As the interpretative process becomes more sophisticated and as planners become more aware of the potential uses of such data, the scope of its use will undoubtedly expand to include other environmental planning activities. For example, satellite imagery may be the best way to monitor suburbanization or land absorption. The extent to which satellite imagery and related services will be used for regional planning in the future may depend upon improved communications and the establishment of a closer working relationship between the users and the researchers. "

Jondrow (1975) also reports success in transferring remote sensing technology to state agency decision making processes, but underscores the importance of communication between the planning data acquisition, processing and analysis functions. A remote sensing data center is also seen as a vehicle to facilitate the communication requirement.

2.3 Analysis Techniques.

2.3.1 General.

To support DPED's inventory and information gathering needs, ESL has investigated several classification systems and analysis techniques to optimize the environmental data collection

2.3.1 -- Continued.

and processing and analysis functions of the CZM system.* The goal is to integrate various data sources and analysis techniques into a cost-effective information gathering process. Considerable effort was directed at developing a useful resource classification system. The findings of this effort are presented under Section 3, Inventories, to provide continuity and readability of ESL inventory efforts and resulting output products. This section provides a discussion of various image analysis techniques both of proven and potential value to the CZM program.

Field observations, low altitude panchromatic photographs, high altitude color, and color infrared photographs, and LANDSAT satellite data were investigated during the second year. This combination of data sources resulted in a multilevel data collection approach shown to be useful in other projects.

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*NOAA's Coastal Zone Management Program, Development Grants, 305 Guidelines, Subpart C, Section 920.20(a) states: "(a) It is clear that the process of developing (and operating) a management program for the coastal zone will necessarily involve frequent access to informational and research sources. In many cases, adequate understanding of questions such as dune stabilization, barrier beach dynamics, salt marsh productivity and estuarine circulation and flushing, to mention only a few, will be needed in order to develop successful management programs. Also, the process of inventorying and mapping the nature of a State's zone, and designation of areas of particular concern almost certainly will benefit from the application of technologies such as those employing remote sensing."

2.3.1 -- Continued.

Traditional photo interpretation techniques were applied to low altitude black and white and high altitude color and color infrared photographs. The interpreter-scientist relates the size, shape, tone, texture, shadow pattern and location of the various objects and backgrounds as portrayed in the imagery to the necessary resource or cultural information; (e.g., land use, vegetation, sedimentation source, soil erosion, marine habitat). Inference, convergence of evidence, is also a powerful technique in deriving information from photographs. These techniques taken in aggregate were found useful in providing much of the required resource information. The reader desiring detailed methodology of the interpretation process should consult any one of several standard references; e.g., American Society of Photogrammetry, 1960, 1975.

Moreover, additive color analysis was employed for greater water penetration capabilities; and digital processing of LANDSAT imagery was investigated to determine its usefulness to the CZM program.

2.3.2 Water Penetration Analysis.

Much of Hawaii's resource lies below the sea. To locate, inventory and study these resources is a difficult task. Field teams require SCUBA divers, boats and expensive equipment; operation schedules are dependent on the weather. Therefore, work is tedious and progress slow. When applied to subsurface marine resources, remote sensing technology is confronted

2.3.2 -- Continued.

with its own set of problems. Much information can presently be gained through this technology, and ongoing studies are expected to resolve many of the problems and improve the results.

2.3.2.1 Discussion.

Near infrared (IR) energy is quickly absorbed by water resulting in very small amounts of IR light in water below one meter (see Figure 2-4). IR photographs of deep water result in a black, devoid of light, image. Thus IR film, Kodak 2443 and SO-127, furnishes very little data on subsurface phenomena below 3 to 4 meters.* True color films (SO-242 and 397) offer better subsurface observation because they record energy in the blue and green light bands which can, under ideal conditions, penetrate through 200 meters of sea water (Ross, 1974).

Photography of the ocean floor depends on (1) spectral transmission characteristics and the water, (2) spectral characteristics of the substrate, and (3) sensitivity of recording media.

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*Color infrared films (2443, SO-127) are sensitive to the ultraviolet, visible, and near infrared portion of the electromagnetic spectrum. In practice, however, these films are usually flown with a Wratten 12 filter which eliminates all energy having a wavelength shorter than 510 nm. This still leaves the green and red portions of the visible spectrum (510-700 nm) and some water penetration is possible in this spectral region. Beyond 700 μm water penetration is very low.

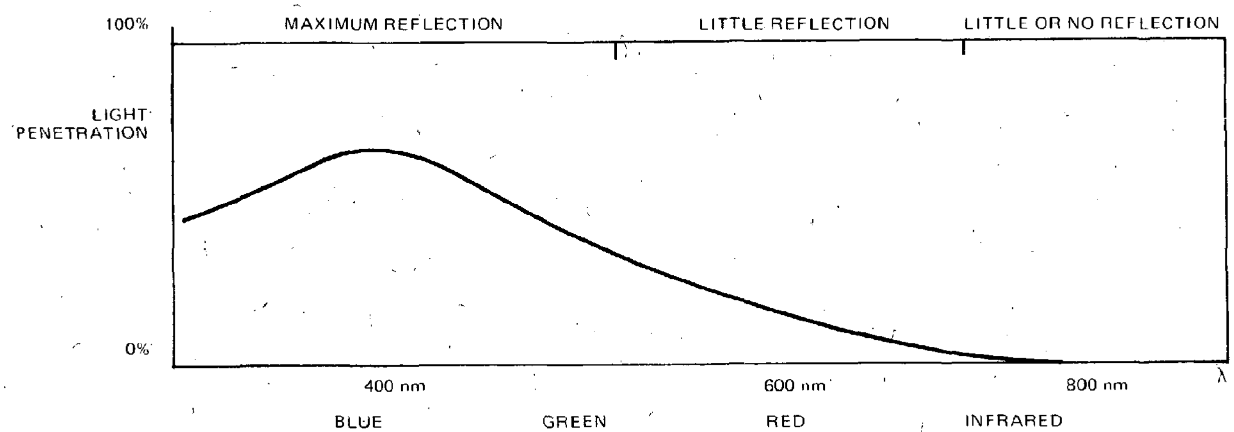


Figure 2-4. Water Penetration as a Function of Wavelength (Water absorbs more IR radiation resulting in little penetration or reflection)

2.3.2.1 -- Continued.

(1) Spectral transmission characteristics of the water: Particles suspended in the water column creating a turbid or cloudy medium will scatter or absorb light. The more light energy lost, the less will penetrate to reflect off the bottom. Light rays must pass through the atmosphere and the water column twice; once, down from the light source, the sun; then, back up to the recording sensor, or camera. In addition, the sea surface, roughed by action of the wind, scatters light. Waves and swell of all periods down to the smallest capillary waves combine to refract and reflect light rays into continually changing directions and even to focus small bundles of rays. Bubbles and spume at the surface scatter the light even further. This entire phenomenon is further complicated by the combination of sun angle and camera angle relative to the water's surface (Jerlov, N.G. and E.S. Nielsen, 1974). The physical properties of the light waves will also react in the water adding another calibration parameter which must be considered.

(2) Spectral characteristics of the substrata: The image obtained by the camera system presents a color contrast image of what was focused upon. Thus the substrate or ocean bottom should have some contrast in order to produce a useful image. For example, dark coral with white sand channels will present excellent contrast and therefore a high-quality image. An all white sand bottom will present a continuous light shaded image.

H_2O penetration tests presently focus on individual substrate parameters, i.e., red coral, black lava, or green vegetation. This enables the investigative sensors to be set up to optimize data collection for that particular parameter.

2.3.2.1 -- Continued.

(3) Sensitivity of the recording media: This refers to the capabilities of the sensor (camera, scanner, etc.), film type, filter combination, platform and recording devices. Remote sensing was originally designed for terrestrial observation. In the past 5-10 years, the use of cameras for subsurface data collection has come under extensive research and development. The primary study area is filter combination in order to take optimal advantage of the individual properties of light bands in the seawater environment.

In the course of our photographic interpretation and analysis of the Hawaii test site areas, ESL has attempted to improve upon conventional methods for enhancement of information output relative to the ocean's substrate.

One technique employed was using an International Imaging Systems additive color enhancement device. An aerial color transparency (SO-242 film type) of Kaneohe Bay was chosen as a test site. A 70mm x 70mm area including a portion of the barrier reef, patch coral, deep channel, dredged coral, and sand streaks was chosen. First, the color positive transparency was rephotographed, breaking down the image into three black and white negatives, each negative representing a different color band of the original photograph. A #25 red filter gave the red band image negative; a #47B blue filter, the blue image negative; and a #58 green filter, the green image negative. Each negative was provided with a 'step wedge' ensuring calibration and equal negative density. The light which passes through or is filtered

2.3.2.1 -- Continued.

from said negatives is due to color differences in the scene, not photographic development processing. Figure 2-5A illustrates two correctly calibrated negatives; allowing a composite image to depict actual color differences, not differences caused by the density of one or the other negatives. Figure 2-5B depicts improperly calibrated negatives which allow, with the same log exposure, (admission of light), a greater amount of red light to pass through the red negative than blue light to pass through the blue negative. The resulting image erroneously displays more red than it should because of photographic processing. This is called color crossover. Thus, step one in this interpretative technique is proper calibration of negatives.

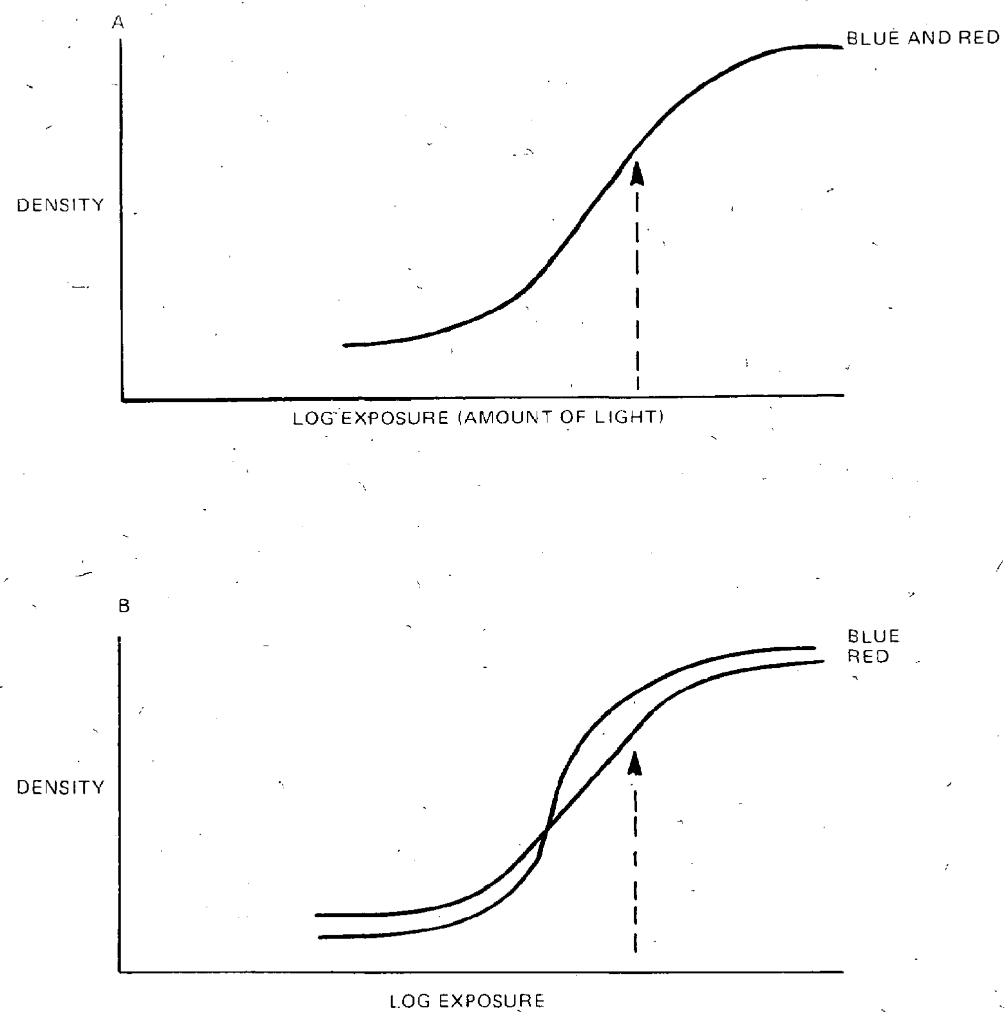


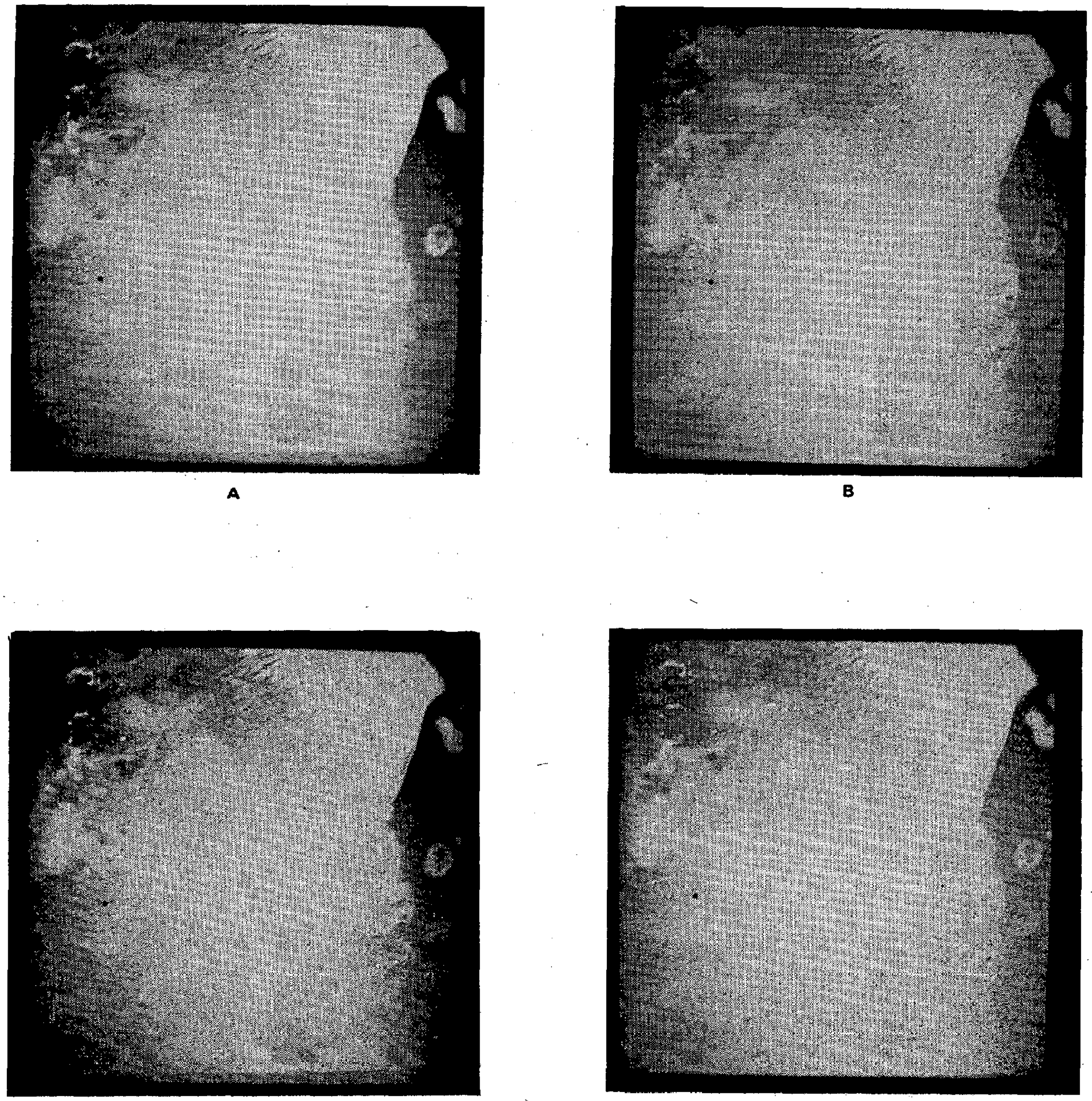
Figure 2-5. Photo Calibration Curves

These curves plot the density of the photo negative against the log exposure or exposure to light. The curves indicate the compatibility of individual (blue, green, red) spectral bands negative density relative to the photographic development process.

2.3.2.1 -- Continued.

The three negatives, representing the three primary colors blue, green, and red, are inserted into the additive color enhancer. A composite image is displayed and can be enhanced to optimize key resource readout. The composite image can be formed with all or any of the negatives and the light intensity on each negative can be varied. Figure 2-6 shows four images from several dozen photographed off the machine's image presentation screen. Figure 2-6A shows an image formed from all three negatives at equal light intensity. The result is a true color picture similar to the original photograph. Figure 2-6B is a composite formed by the green negative/light intensity 9 and the blue negative/light intensity 3.5. This combination eliminates the red light and focuses primarily on the green. In figure 2-6C the green negative light intensity 9-and the red negative-light intensity 9-eliminates the blue light and focuses on contrast enhancement between deep and shallow objects. Figure 2-6D combines the blue negative-light intensity 9-and the green negative-light intensity 9. The blue-green combination should provide maximum depth penetration. Reduced energy attenuation will permit the light energy to reach and illuminate the deeper ocean substrate and allow the reflected image to be transcribed on the recording sensor.

It is difficult to determine the best film/filter combinations without identifying a specific purpose. Each combination will enhance the image for a particular spectral response. Thus, a composite picture should be closely examined relative to a specific task. Recommended reading is D. S. Ross' *Experiments in Oceanographic Aerospace Photography; Some Films and Techniques for Improved Ocean Image Recording,* (1974).



A

B

C

D

Figure 2-6. Photographs Enhanced by Color Additive Process

2.3.2.1 -- Continued.

A second technique examined was photographic analysis via a color densitometer. This device picks up very minor shifts in film density which would represent minor shifts in color contrast, an indication of substrate difference. Again, the machine breaks down the color bands presenting density readings for each band. Table 2-1 shows readings taken from the same photographic transparency of Kaneohe Bay used in the previous study.

Comparison of the densitometer readings from the various substrate types gives an indication of density difference by color band. For example, shallow water sand and shallow water terrestrial sedimentation have similar readings in the green and red bands. The blue band, however, shows a significant separation (1.55 vs. 1.98) indicating that a blue filter/film combination would be optimal for comparison studies of these two substrates. Similar readings in all bands indicate substrate contrast differentiation for the two categories, natural substrate, deep water and dredged coral reef. This kind of data will indicate, in time, the extent to which various categories can be distinguished, the band combination providing this data, and the film/filter combinations which will optimize future data collection efforts in specific areas.

Table 2-1. MacBeth TD-504 Color Densitometer Readings From Positive Color Transparency of Kaneohe Bay

Substrate Description	Filtered Densitometer Readings*		
	Blue	Green	Red
Submerged coral reef	1.57	5.79	6.03
Dredged coral reef	1.22	5.61	5.97
Natural substrate-deep water	1.20	5.60	5.96
Submerged reef; terrestrial sediment	1.81	5.90	6.07
Dredged reef; terrestrial sediment	1.40	5.75	6.06
Shallow coral	1.35	5.77	6.07
Shallow sand	1.55	5.94	6.10
Sand bar	2.59	6.42	6.30
Deep water	0.54	5.39	5.48
Shallow water, terrestrial sediment	1.98	5.96	6.07
Above surface island	2.09	6.00	6.06

*The numerical reading is relative only to other readings.

2.3.2.1 -- Continued.

The use of thermal scanning devices is also being studied for water analysis. This R&D is being done outside the auspices of Hawaii's CZM program; but, since the results may be of value to that program, its progress is being monitored. The Bering Sea Marine Mammal Experiment (BESMEX) is studying the life history and distribution of marine mammals in the Bering Sea by recording temperature differences between the warm blooded walrus hauled out on the ice floe and the cooler background of its environment. Another experiment is a soil moisture study which correlates the presence of water in the soil with soil surface temperature.

The results of these studies, since they relate to no specific task and are still in a research mode, have been examined with future collection and analysis techniques in mind. The primary purpose is to establish an awareness by the ultimate user, the planner and manager, of the possibilities, alternatives and opportunities open to the technical scientist in obtaining data and extracting information.

2.3.3 Analysis of LANDSAT Data.*

The National Aeronautics and Space Administration LANDSAT satellite presently obtains coverage of large portions of the earth on a repetitive 18-day cycle. The data is available at low cost through the U. S. Department of the Interior EROS Data Center in Sioux Falls, South Dakota. Because of the ready availability of this data at low cost and the 18-day repetitive

*See Appendix D for LANDSAT coverage over Hawaii through 22 July 1976.

2.3.3 -- Continued.

cycle,* it has the potential to make a significant contribution to a multi-source (satellite, aircraft, ground) inventory and monitoring program. Mr. Ed Petteys of the Hawaii State Division of Forestry has been studying the use of LANDSAT imagery and digital processing relative to the Hawaiian Ohia forest decline problem. He presented an excellent progress paper on this topic at the D.P.E.D. Remote Sensing seminar held in Hawaii last April (reference 4.2 this report). As part of the methodology development task, ESL undertook a preliminary study to determine the utility of the data source to provide useful information to the Hawaii CZM program.**

2.3.3.1 Analysis Approach.

Because of the small scale (1:1,000,000) of standard hardcopy LANDSAT data and the poor resolution of the human eye (approximately 7 line pairs/mm), traditional photo interpretation of LANDSAT data is not particularly effective. The inherent information content of the LANDSAT data simply cannot be extracted using these techniques. Recent advances in digital software and hardware for earth resource applications, coupled with the fact that LANDSAT data is initially in digital format, strongly suggest a digital processing approach to LANDSAT analysis.

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* With LANDSAT 1 and 2 the repetitive cycle is now 9 days.

**This portion of ESL's report is the most technical of all. It involves a description of data gathered via space vehicle and processed through an advanced computer complex. It is difficult for the layman to understand, but it is even more difficult for the scientist to explain in other than the appropriate technical language. The process holds great promise but requires a real commitment in effort and understanding to deliver as many hope it will deliver.

2.3.3.1 -- Continued.

Digital processing itself has many degrees of sophistication. Image enhancement techniques such as density slicing, contrast stretching and spectral ratioing have shown considerable promise. Essentially, the original image is enhanced or modified to bring out subtle features not easily observed in the original. In all cases the final image is then further interpreted by trained analysts using traditional techniques. The full dynamic range of signal intensities can be displayed and the data magnified so that individual resolution or picture elements (pixels) are readily observed. Thus, the inherent information content of the data can be realized to a greater extent.

Another class of digital processing routines subjects each pixel to a decision rule which classifies the pixel into one of several predetermined classes. The computer automatically classifies every pixel, thus freeing the interpreter from much of the delineation aspects of the interpretation process and allows him to concentrate on establishing the significance of what is presented.

The second type of processing has generally been found to have value for most resource applications and also lends itself to quantitative analysis. ESL's study, therefore, concentrated on digital classification techniques.

2.3.3.2 Test Site Location.

The Kohala-Kamakua Coast on the Island of Hawaii from Kawaihae to immediately south of Kiholo Bay and extending approximately ten (10) miles inland was used as a test site. This

2.3.3.2 -- Continued.

coincides with the Kona test site of the first year. In April and May of 1975, an ESL field reconnaissance team, including remote sensing analysts and resource specialists, accompanied by several local specialists, obtained ground truth information in this area. This field data aided in the interpretation of U-2 color infrared photographs at scales of 1:65,000 and 1:130,000. A detailed interpretation of these photographs for the Hawaiian Coastal Zone Management (CZM) program was accomplished by ESL during the first year's CZM program; and the resulting land use, vegetation, marine and transportation maps (1:24,000 scale) are available from the Department of Planning and Economic Development. The classification system employed in that effort (see Table 2-2) was used in this study to evaluate the utility of LANDSAT data for inventory applications in Hawaii.

The LANDSAT digital image used in this study was obtained on 11 February 1973. The scene identification number is 1203-20182 and covers the entire Island of Hawaii. The areal coverage of this scene is approximately 100 by 100 nautical miles and contains 7,581,600 digital units (pixels). However, the test area chosen was 450 by 512 pixels and comprises approximately 1/33 of the entire scene. Each pixel represents approximately 1.1 acres of coverage on the ground, in this case 253,440 acres.

2.3.3.3 Analysis Procedures.

An ESL HP3000 minicomputer and the Interactive Digital Image Manipulation System (IDIMS) software programs were utilized in this study. A computer-compatible tape (CCT) was obtained

Table 2-2. Classification System - Kona Test Site, Hawaii[1]

CZM Map Symbol	Category
A1	Dense Ohia Forest
A2	Open Ohia Forest
B2	Open Mixed Forest (Ohia)
B3	Open Mixed Forest (Lama)
C	Silk Oak/Jacaranda
D1	Dense Kiawe
D2	Open Kiawe
E1	Fountain Grass/Kiawe
E2	Fountain Grass/Open Mixed Forest
E3	Fountain Grass/Upland Shrub
E4	Fountain Grass
F	Feathery Pennisetum
G1	Upland Shrub/Grass
G2	Mixed Shrub/Grass
H	Improved Pasture
J	Unimproved Pasture
K	Eucalyptus
M	Lava/Sparse Vegetation
N	Bare Lava
O*	Coconut Palm Grove
P*	Residential
R1*	Recreational - Park
R2	Recreational - Golf Course
R3*	Recreational - White Sand Beach
S*	Industrial
T1*	Commercial - Business and Services
T2*	Commercial - Resort/Hotel
U*	Marina/Harbor
V	Dredge Fill/Extractive
W*	Fish Pond/Lagoon
X1*	Mixed Sand Area
X2*	Mixed Shoreline
Y*	Airport

*Not included in LANDSAT Training Site selection due to insufficient sample size within the test area.

[1]For a detailed description of the above categories see *Hawaii Coastal Zone Management Plan Development: The Application of Remote Sensing and Computer Systems*, ESL Incorporated, June 1975.

2.3.3.3 -- Continued.

from the EROS Data Center to allow IDIMS program manipulation of the data and application of various program functions.

Once the data was entered into the computer, the test site was selected and viewed on a high resolution COMTAL color monitor display. A total of 512 by 512 pixels can be viewed at one time in a single display image on this device. The entire test site or any desired portion can be displayed and the scale may be enlarged to facilitate visual interpretation. A total of 127 possible gray levels which contribute to the digital image are expanded to 256 and can be displayed with various color assignments creating a pseudo-color display image. A trackball type cursor is utilized to alter gray scale or color combinations, thereby enhancing categories of particular interest, or changing the representative color of each classified phenomenon displayed.

Using the IDIMS trackball cursor, irregular polygonal "training" areas representing the classes shown in Table 2-2 were input into the system within the displayed test area as shown in Figure 2-7.

Those items in Table 2-2 indicated by an asterisk (*) were not included in the supervised training selection due to insufficient sample size within the test area. Fifty-nine training sets representing 22 class categories were delineated and examined individually, at enlarged scales, in order to determine the positional accuracy of the sample site selection.

Figure 2-7. Selected LANDSAT Training Areas

2.3.3.3 -- Continued.

Each training area was processed by a clustering algorithm which breaks up each input training area into its natural reflectance groups or clusters. The output product of the clustering algorithm and a statistical processing program is a list of the identified clusters, a symbol for use by line printer, the number of pixels in each cluster, the mean response value (0-127) for each band or channel of the LANDSAT scene, the corresponding means standard deviations, distance between clusters, and covariance matrix. An example of this is shown in Table 2-3 for fountain grass/Kiawe.

The size of the training area ranges from approximately 15 acres to several hundred acres. When employing a supervised training exercise, the goal is to input training areas which represent homogeneous classes. In practice, however, some variation exists; and the clustering will bring out these differences. In many cases, different objects will be included in a training area; for example, small patches of vegetation in a lava field, or ranch houses and buildings in an improved pasture. The clusters representing these objects must be deleted from the input training class and reassigned to others or a new class designated. For this particular study, the 22 input classes were initially represented by 68 gray level clusters prior to detailed examination and redesignation of clusters to appropriate classes. The entire test area was then classified by the maximum likelihood decision rule using the statistics for each band generated by the training samples. The result is that each pixel in the scene is assigned to a particular cluster group. These cluster groups are then further combined to form a spectrally distinct class,

Table 2-3. Example of Statistical Analysis for Fountain Grass/Kiawe Category Test Sample

ESL IMAGE PROCESSING LABORATORY
El SIGMA = 2.0

TOTAL NUMBER OF POINTS = 83

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	1	15
2	2	44
3	3	10
4	4	14

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	30.93	24.73	31.93	29.87
2	29.05	24.11	23.70	18.64
3	23.70	16.50	13.60	10.40
4	30.21	25.29	29.00	25.43

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	2.59	2.32	1.98	1.71
2	1.31	1.40	1.90	1.69
3	1.27	1.43	2.50	3.32
4	2.01	1.98	1.46	2.19

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2	3	4
1	.00			
2	7.92	.00		
3	13.08	8.92	.00	
4	2.90	4.85	11.82	.00

2.3.3.3 -- Continued.

which in turn establishes a classification system for the area. Each class should ultimately represent a significantly valuable and distinct category to the intended user; for example, commercial timberland, improved pasture, recreational areas, and so forth. At this point, the level of detail becomes important. A classification system that is too general may be of little value for planning or management purposes, whereas a highly detailed classification scheme may become too cumbersome or mapped with insufficient accuracy, therefore limiting its usefulness.

When the classification process was complete, an algorithm was used to estimate the category conditional probability distribution from which the decision rule is constructed. A line printer map was then created which indicated the probability of correct assignment for each pixel relative to its classification group on the basis of 0 (poor) to 9 (excellent). This map was used to test the reliability of the interpreted categories, but was not examined extensively on this project due to time constraints. This remains an important area for additional, future study.

The classification results or output image of the maximum likelihood run were initially obtained on a line printer map geometrically corrected and registered to the 1:24,000 scale USGS quadrangle maps, then compared to the previous completed 1:24,000 scale maps derived through field reconnaissance and U-2 photographs.

2.3.3.3 -- Continued.

To facilitate the comparison of the line printer map and comparison of spectrally similar classes, multiple line printer maps were created, each containing only two or three classes, all other pixel elements reading as blank spaces. Whole classes or individual clusters within a class were then reassigned to improve the accuracy of the output with some loss of precision. As a result, the 22 input classes were reduced to a final figure of 14 interpreted class categories (see Table 2-4).

The classified image is then redisplayed on the COMTAL color video screen and each of the 14 class categories (see Table 2-4) are assigned a distinct color. The image is now an "interpreted" display or map rather than the initial LANDSAT multiband image which represents only raw uninterpreted reflectance data. Finally, the classified image is run through a smoothing routine, which provides an image output depicting more homogeneous blocks of individual category types. Figure 2-8 represents the final image output of the 14 class categories with their respective color assignments as displayed on the COMTAL color monitor.

2.3.3.4 Results and Conclusions.

The use of land use inventory categories generated by the intepretation of U-2 photographs over this test site provided a rigid test of LANDSAT interpreted capabilities. Working under the assumption that the U-2 provides more detailed information about a given area than can be extracted from a LANDSAT image, the classified output categories were examined against U-2 data. Those categories found in Table 2-2 but not found in Table 2-4 were

Table 2-4. Final 14 Category LANDSAT Classification Code

Category	Cluster No.	Color	# Pixels	% Site
1. Shallow Water	1,2	LIGHT BLUE	9948	4.317
2. Deep Water	3	BLUE	24695	10.718
3. Bare Lava	4,5,6,37	BLACK	13265	5.758
4. Shrub Types a. Lowland Mixed Shrub b. Fountain Grass/ Upland Shrub	7,8,43,44	DARK BLUE	11383	4.941
5. Open Kiawe a. Feathery Pennisetum/ Kiawe b. Open Kiawe c. Fountain Grass d. Fountain Grass/Open Mixed Forest (includes Kiawe)	9,13,14,15,16, 21, 22, 23, 24, 51, 52, 53	RED	40531	17.590
6. Dense Kiawe	10,11,12	YELLOW	2850	1.237
7. Improved Pasture/ Golf Course	17,25,26,27,28	GREEN	6878	2.985
8. Mixed Grass/Shrub Open Mixed Grasses/ Unimproved Pasture	18,39,40,41,45, 46,47,62,63,64, 65,66,67,68	DARK GREEN	47397	20.571
9. Dredge/Coral Fill	19,20	SAND	941	.408
10. Silk Oak/Jacaranda	29,30	PURPLE	1917	.832
11. Clouds/Cloud Shadow	21,32,33,34,35, 36,38	WHITE	23950	10.394
12. Ohia Forest Types a. Dense Ohia b. Open Ohio Forest c. Ohio/Koa Forest	42,54,56	BROWN	23046	10.003
13. Lava/Sparse Vegetation	49,50	AQUA	12764	5.540
14. a. Open Mixed Forest b. Eucalyptus	48,55,57,58,59 60,61	PEACH	10835	4.701
			230,400	100.000

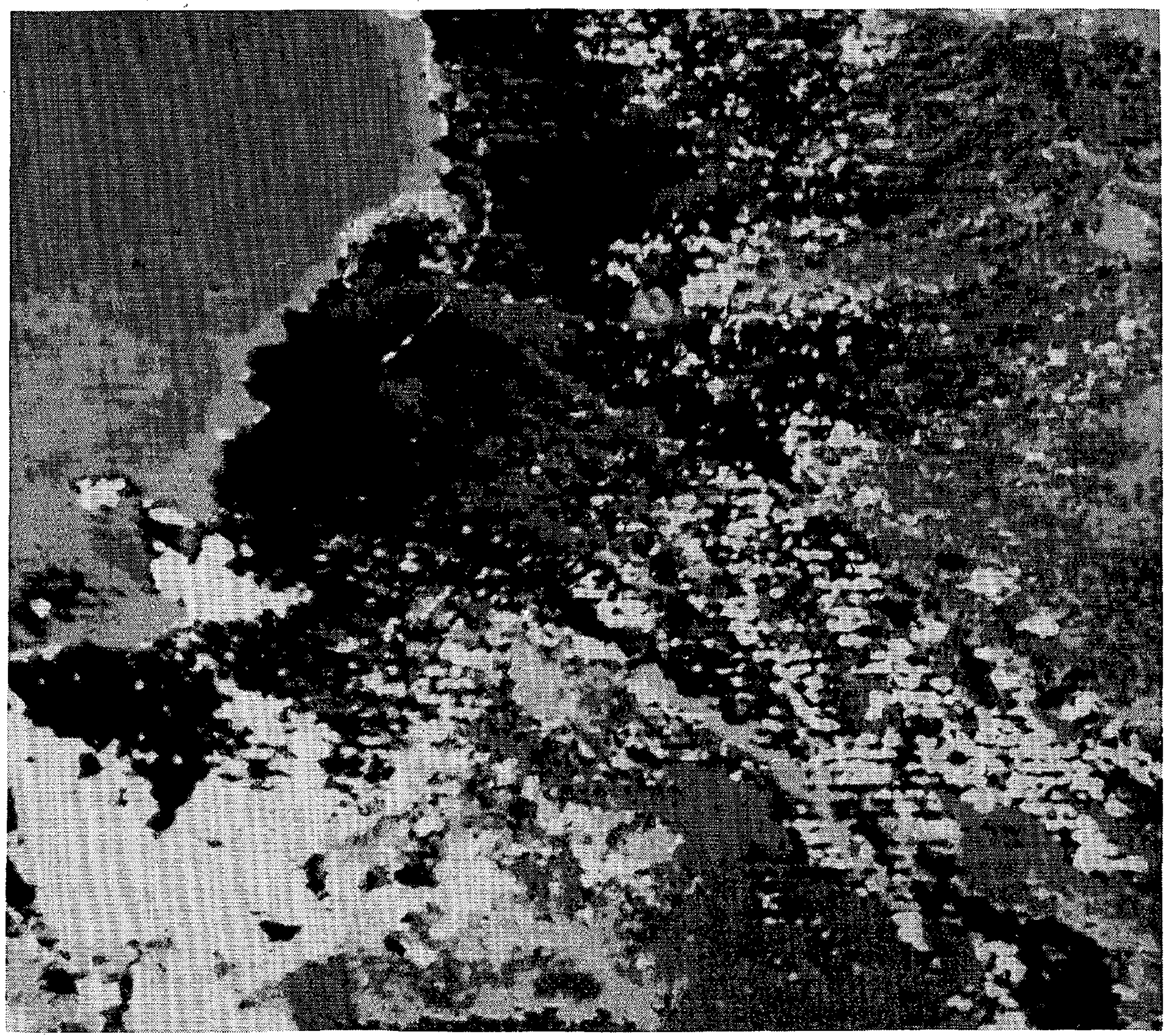


Figure 2-8. Digitally Processed Output Image of LANDSAT Data Showing Destruction of 14 Land Cover Types

2.3.3.4 -- Continued.

either too small in areal extent to be discernible by LANDSAT or too complicated in physical composition to be classified as a distinct interpretive category, based on the analysis techniques employed by this study. The result is that the LANDSAT land use/ inventory capabilities are tested to a rigid extreme by applying a classification scheme which is comprised of significantly more detailed categories than the satellite scanning system can be expected to discern.

In general, the final LANDSAT output was accurate with few exceptions, in terms of those phenomena actually contained within the test site and their spatial distribution. On a broad scale, those phenomena which actually occur in the lowland portion of the test site did categorize properly. This was also true for upland (higher elevation) class phenomena; although to a lesser degree (Table 2-5) rates the accuracy of the various classes selected showing which can stand alone within probable CZM standards and which require further classification processing.

Within this test site, as one proceeds from the coast inland to the higher elevations, the physical characteristics or makeup of the land changes dramatically and becomes more complex. The upland area is characterized by numerous physical categories ranging from unimproved pasture areas to complex forest stands. This portion of the test site was much harder to categorize accurately because of this complexity. For example, forest stands ranged from pure Ohia and Ohia-Koa stands to Open Mixed Forest areas. The general mapping and delineation of the combined forest types were good. The spectral signature of each specific

Table 2-5. Evaluation of LANDSAT Classification Results

Category	Ability to Classify/Remarks
1. Shallow water	Excellent
2. Deep Water	Excellent
3. Bare Lava	Excellent
4. Shrub Types:	
Lowland Mixed Shrub	Good - Some confusion
Fountain Grass/ Upland Shrub	Poor - better sample data needed
5. Kiawe Types:	
Feathery Penni-setum/Kiawe	Excellent
Open Kiawe	Excellent
Fountain Grass	Excellent
Fountain Grass/ Open Mixed Forest (includes Kiawe)	Fair - requires very precise clustering procedure
6. Dense Kiawe	Excellent
7. Improved Pasture/ Residential - Golf Courses	Good - could not separate improved pastures from golf courses based on spectral signatures alone
8. Mixed Grass/Shrub	
Open Mixed Grasses/ Unimproved Pasture	Good - very mixed category
9. Dredge Coral Fill	Good - terms of application must be better defined
10. Silk Oak/Jacaranda	Fair - boundary determination errors
11. Clouds	Good - slight confusion with sun glint
Cloud Shadow	Good - some confusion with dark lava
12. Ohia Forest Types:	
Dense Ohia	Good - slight confusion with Ohia/Koa category
Open Ohia Forest	Fair - some confusion with Dense Ohia category
Ohia/Koa Forest	Fair - some confusion with Dense Ohia category
13. Lava/Sparse Vege-tation	Excellent
14. Open Mixed Forest	Poor - requires more precise clustering within this category
Eucalyptus	Fair - areas too small and scattered to be distinct

type was not always distinct due to gradients of the various forest types. For example, as one distinct tree category blends into another, a "gray" area in terms of cover classification may occur, resulting in a confused output boundary between the two phenomena. This type of problem is also found using traditional photo interpretation techniques and even with field observations.

Within polygons classified as mixed forest areas, some confusion occurred in the classifying process owing to the varying percentages of individual tree types within the mixed forest area. For example, one area may contain as few as 10% kiawe trees while another area may contain as many as 40% kiawe trees, which result in slightly different spectral signatures. (Both areas should be classified as mixed forest, however.) This difference necessitates either the use of ancillary data sources (e.g., U-2 photography, field notes) to resolve data conflicts or a change in the classification scheme to reflect density changes.

One problem area, known as image "banding," was especially apparent in the ocean area near Kiholo Bay. In image banding, a line of horizontally (left to right) erroneous pixels is created during the original generation of the image. There is no precise way to recapture true reflectance values for these pixels, however, several methods for improvement exist. The first is to isolate and analyze the areas of banding and process the pixels through one of several routines to replace the erroneously classified pixels with category assignments based on a spectral averaging of surrounding pixels. Although this procedure is practical, it is not the most accurate. With extensive banding,

2.3.3.4 -- Continued.

a second solution is to replace erroneous data with substitute pixel data over the same area from another LANDSAT image. A third approach consists of deleting the erroneous data pixels and analyzing the voids with other data sources (e.g., low altitude photographs). The optimum method would depend upon the precise purpose of the inventory and the ultimate user requirements.

Classification of two spectrally similar but terrestrially different features of the same phenomenon was a second problem encountered. One example of this occurred in the output products generated by this study effort. Cloud shadow was defined and delineated as a spectrally discrete phenomenon in the classification procedure. Bare exposed lava flows were also classified as a distinct and separate interpretive category. However, individual lava flows are spectrally quite different from one another and thus this category comprised a number of gray levels or clusters, all of which represented bare exposed lava. One lava flow cluster signature exhibited a very dark spectral response which, on the basis of initial classification procedures, was classified as cloud shadow. It is expected that increased samples to a tighter or more precise clustering of cloud shadow and lava will help to separate these items.

2.3.3.5 Recommendations.

LANDSAT has found considerable acceptance in the continental U.S.A. and there is an increasing awareness on the part of resource and planning agencies of its advantages and limitations. ESL is presently involved in extensive use of

2.3.3.5 -- Continued.

LANDSAT imagery for quantitative resource inventory in forestry, range, wildlife habitat, and water demand. In each of these studies, some parameter (e.g., the volume of timber by species per acre) is measured quantitatively. Digital LANDSAT processing is, of necessity, combined with photo interpretation and selected field observation to produce the final result. Sampling techniques for photo interpretation and field plots are designed to adhere to program objectives and cost.

Based upon this and other studies, ESL has four recommendations to make to the Hawaii CZM planning staff. The numerical sequence of the recommendations is important since the later recommendations are based on the success and direction of the earlier ones.

1. Determine the future availability and quality (cloud free images) of LANDSAT data over the state of Hawaii.

2. Based upon the first and second detail levels generated through the resource inventory methodology study (see Section 3), determine whether LANDSAT data is the most cost-effective method of data collection.

3. Based upon the desired accuracy and precision levels, structure the necessary data collection platform combination (LANDSAT, U-2, low altitude, ground teams) to perform the task.

2.3.3.5 -- Continued.

4. Establish the process by which repetitive classifications are accomplished over time.

2.3.4 Future Systems.

Remote sensing is a dynamic technology. Improvements occur rapidly offering more diverse and sophisticated data collection systems. Supplementing the technological improvements are the past and ongoing projects which, during operational use, lead to the development of new application methods and the improvement of old ones. Some of the anticipated future projects, which are primarily under NASA auspices, which will impact remote sensing technology and potential applications, are discussed in the following paragraphs.

The following spacecraft and aircraft programs are either presently operational or are completely new programs still in a research development mode. The progress of these programs is being tracked for possible future input into the Hawaii CZM program. Relevance to resource inventory tasks is derived from the mission of the project.

a. Spacecraft

1. LANDSAT (Environmental Land Satellite) 1, 2 and C.

(This satellite is also known as ERTS-- Earth Resource Technological Satellite)

2.3.4 -- Continued.

Mission:	Earth Resource Survey.
Orbit:	900 km (570 miles) and sun synchronous.
Sensors:	Return beam vidicon (rev)* and 4-channel multispectral scanner. LANDSAT C will have an RBV, improved resolution (better than 1.1 acre) and 5th channel for collecting thermal data.
Launch Data:	LANDSATs 1 and 2 are operational and C has a 1977 launch date. LANDSAT follow-ons are also planned for 1981 and 1982. With both 1 and 2 satellites in orbit, coverage can be obtained every 9 days.

2. Nimbus G Satellite.

Mission:	Atmospheric pollution monitoring and coastal ocean monitoring.
Orbit:	1110 km (690 miles), sun synchronous (high noon).
Sensors:	Multispectral scanners, spectrometers, microwave radiometer, infrared radiometer.
Launch Date:	1979.

*A malfunction occurred and little data has been collected from this sensor.

2.3.4 -- Continued.

3. SeaSat A (Sea Satellite).

Mission: Day and night capability; observation of oceanic, atmospheric, and solid earth geophysics.

Orbit: 800 km (500 miles), 108 degrees inclined.

Sensors: Active radar, passive microwave, and infrared.

Launch Date: 1978.

References: McCandless, Jr., S.W., 1975, *Sea Sat-A--A Product of User Interests*. 10th Intl. Symp. on Rem. Sensing of Env.

4. Synchronous Earth Observation Satellite.

Mission: Earth Resources Survey, Meteorology, and Warning.

Orbit: Synchronous equatorial.

Sensors: Large earth survey telescope, thermal advance atmospheric sounder and imaging radiometer, microwave sounder, and framing camera.

Launch Date: 1985 time frame.

2.3.4 -- Continued.

b. Aircraft

Aircraft	Sensor
1. NP-3A	Photographic, infrared microwave
2. NC-130B	Photographic, multispectral and infrared
3. CY-990	Photographic, microwave, etc.
4. WB-57F	Photographic, multispectral, infrared
5. U-2	Photographic, multispectral infrared

A U-2 aircraft collected over 2,600 color, color infrared, and black and white photographs of the Hawaiian Islands in October 1974 and July 1975. All photographs were furnished to DPED in duplicate at no cost. The plane is scheduled to return to Hawaii in October 1976.

Several typical on-going user projects utilizing remote sensing data are listed in Table 2-6.

ESL's ongoing task is to track these systems as they develop, to examine their potential and relevance to Hawaii's Coastal Zone Program and, where applicable, to begin methodology studies for their implementation.

Table 2-6. Typical Ongoing LANDSAT Demonstration Projects

Project	Mission
LACIE (Large Area Crop Inventory Experiment	Focus: Global Crop Prediction User: USDA and NOAA
Snow Mapping	Focus: Snow Aerial Extent User: Various agencies
PNRC (Pacific Northwest Regional Commission	Focus: Regional Natural Resources Inventory A. Forest inventory B. Noxious weed inventory C. Water demand D. Land resource (land use) E. Coastal zone resource F. Range and wildlife resource User: Washington, Oregon, Idaho
Automated Fire/Weather Data System	Focus: Fire Weather Data Acquisition/Dissemination User: California
Mississippi Natural Resources	Focus: Natural Resource Inventory User: Mississippi

3. INVENTORY.

3.1 Introduction.

The second year focused additional effort on inventory products to evaluate developing methodology. Many of the interpretive and analytic techniques discussed in Section 2 were put to use in establishing an optimal multiple data collection system. As each aspect of ESL's inventory work is discussed in the following subsections, the various combinations of data sources are presented.

An important aspect of ESL's CZM inventory task is that of converting raw data into relevant information and then presenting that information as an understandable, useful tool for non-scientifically oriented planners. This task includes:

1) Definition of categories of required information

2) Formulation of a meaningful classification system

3) Providing adequate accuracy and detail within that classification system without exceeding funding limitations

4) Furnishing a presentation system which will allow easy access, be graphically sufficient and facilitate and support user decisions with scientific documentation.

3.1 -- Continued.

The following subsections discuss specific inventory work accomplished by ESL this year. This includes 1) the statewide wetlands study undertaken in conjunction with the U. S. Army Corps of Engineers, 2) the Kauai County inventory, and 3) geographically specific problem analysis areas.

ESL's inventory task produced maps, classifications, formats, etc. The output products are described and discussed in this report; however, the nature of these products precludes complete inclusion within this document. It is imperative for the output products themselves to be carefully examined and critiqued by planners, public committees and others in order to be truly valuable. A methodology study must be tested by users and modified by feedback until a viable system has been achieved. Prior to embarking on a full-scale statewide inventory, each parameter must be understood, questions resolved and, most importantly, the avenue established to ensure a flow of information from the scientist, to the coastal zone manager, to the public. Information concerning ESL's second year maps, overlays, photo copies, photo enlargements, etc., is available at the Department of Planning and Economic Development, Kamamalu Building, Honolulu.

3.2 Wetlands Inventory.

The Hawaii Coastal Zone Management Program, realizing the importance of wetland areas and the impact those areas have on planning and management decisions in the coastal zone, began discussing a wetland survey early in 1976. Following negotiations with the U.S. Army Corps of Engineers, a cooperative statewide wetlands inventory effort between the Hawaii CZM Program and the Corps was undertaken.* This two-phase program, begun in late February 1976, was to combine the capabilities and outputs of each participant into a single, informative document as cost-effectively as possible.

Phase one, supported by the CZM program, consists of identifying and locating all significant wetlands, or probable wetlands in the state. The output product is an overlay registered to the 7.5 USGS quadrangle maps indicating the general type and location of the wetland.

Phase two, to be conducted by the U.S. Army Corps of Engineers, will visit each indicated site, determine if the wetland should be included in the inventory and if so, obtain detailed vegetation and ecological information.

The purpose of this survey is to supply wetland location information to CZM planners and furnish U.S. Army Corps of Engineers an accurate location map to facilitate their field

*The CZM Act itself urges close cooperation between Federal and state agencies in exercising managerial control over the Coastal Zone. 305 Guidelines, Section 920.21, recommends the U.S. Army Corps of Engineers as a source of information. This cooperative wetland study ensures coordination between Federal and state powers on issues affecting wetlands within the Coastal Zone. (NOAA Threshold Paper No. 5, *State-Federal Interaction - National Interests*.)

3.2 -- Continued.

investigations of individual wetlands.* Eventually their information on species description, distribution and productivity will be combined with CZM's mapping survey to produce a statewide wetland document. This joint effort represents a good example of multi-level data gathering and a cost-effective method of obtaining desired information.

3.2.1 Phase One Study.

The Coastal Zone Management (ESL Incorporated) portion of the wetland study is based primarily upon aerial photographic interpretation of high altitude color infrared photographs of October 1974 and July 1975 and U.S. Army Corps of Engineers' low altitude, black and white shoreline photographs of 1975 and 1976. General wetland type (e.g., lowland meadow, estuarine, salt marsh, etc.) is provided with more precise vegetation species descriptions included where ESL field teams have gathered ground truth support data. Wetland delineation over the entire State of Hawaii has been accomplished for those wetlands approximately five acres or greater in size. Gaps in the statewide aerial coverage, due mainly to cloud cover, necessitated that ancillary information sources be utilized (USGS quadrangle maps) in some areas.

For this study a wetland is defined as "areas having wet, marshy soil conditions, frequently inundated by or covered with fresh, brackish or saline water, subject to tidal, riparian or

*Discussions with Hawaii's U.S. Fish and Wildlife Service indicate their participation at an unspecified future date in a National Wetlands Survey. This more detailed local survey was encouraged, its value primarily seen as an enhancement to a more gross inventory.

3.2.1 -- Continued.

drainage ponding influence, and including 'high bogs'; those areas distinguished by particular and unique vegetative species that require saturated soil conditions for their growth and reproduction."

Reservoirs and riparian habitats were not typically considered wetlands. (These features are considered important and would be mapped on rivers/stream pattern, and vegetation overlays - see Section 3.3.)

3.2.2 Wetland Inventory Methodology.

Photographic interpretation was the primary tool utilized in the Phase One mapping portion of the wetland study. Second generation transparencies were utilized to maintain inherent resolution and, where possible, the imagery was viewed stereoscopically. The stereoscopic analysis of color infrared film greatly facilitates wetland delineation. The infrared film causes viable vegetation to appear red to the human eye. This is a reflectance of the chlorophyll content of the plant which varies either through species differentiation or individual plant vitality and furnishes an identifying 'signature' for each floral type. When viewed in stereo the precise topography of the terrain is evident and individual tree canopies and shrub areas stand out clearly. Because of the diversity of Hawaiian terrain and vegetation, many wetland delineations, when identified solely via photo interpretation techniques retain a "probable" or "possible" prefix. Thus the field verification to be accomplished by the

3.2.2 -- Continued.

U.S. Army Corps of Engineers in Phase Two remains critical. Phase One, however, will greatly facilitate the ground truth operation by directing field teams to areas of high wetland probability.

Each time a wetland or probable wetland was noted on a photographic transparency a direct contact mylar overlay was made delineating that particular wetland's approximate boundary. Scales ranged from 1:65,000 to 1:32,500. These overlays were enlarged to a 1:24,000 scale and transferred onto a second mylar overlay. The second overlay was registered to the particular 7-1/2 minute USGS quadrangle map (1:24,000 scale) which contained the wetland area.

For those wetlands on or near the coastline, the low altitude panchromatic photographs were also examined and a more detailed delineation made on a mylar overlay. The greater resolution of the low altitude imagery assisted in this process; however, spectral differentiation between wetland and non-wetland vegetation types could not be accomplished. Using both data types in tandem when available provided the most confident determinations.

3.2.3 Output Product.

The phase I product is a systematic display of delineated wetland areas accomplished through an overlay system keyed to USGS quadrangle maps (1:24,000 scale and 1:250,000 scale). Only the overlays are provided, to be utilized in conjunction with in-house copies of the various quadrangle maps.

3.2.3 -- Continued.

Five (5) individual sets of data produced in Phase One combine to provide a systematic presentation of the information which lends itself to the Corps' expansion of it and establishes a base format which can be updated, corrected and improved. The five data sets are:

1) Overlays depicting the four counties registered to 1:250,000 scale quads (total of five overlays since Hawaii is divided into North and South Sections). On each overlay respective 7-1/2" quad maps are registered and labeled to give overall and accurate location information.

2) A second set of 1:250,000 scale overlays registered to USGS 1:250,000 scale maps depicts the approximate location of existing wetlands by a reference number.

3) Overlays registered to 1:24,000 scale quad maps delineate the actual wetland area, along with the assigned number correlated with 1:250,000 scale numbers. The actual delineation on this overlay is taken directly from an enlarged overlay of a U-2 infrared photographic transparency.

4) Data sheets for each county with information specific to each individual listed wetland within that county. General wetland type (salt marsh, riparian marsh, estuarian, etc.) is provided and corresponding aerial imagery used in locating the wetland is listed. Detailed photographic

information as it relates to each overlay gives flight numbers, accession number, frame number, film type, data and original scale. The photography is available at DPED's data facility. Light tables, stereoviewers and some ancillary reference material may also be available. Call Mr. Chris Christoffels for assistance.

5) Mylar overlays produced from the 1:6,000 scale low altitude photographs are furnished to provide a "close look" at wetlands located near the shoreline. These are labeled and to be used with the low altitude imagery located at the U.S. Army Corps of Engineers, or at DPED. They are correlated to individual wetlands on the data sheets (#4) and precise locations can be obtained by examining the quad overlays.

It should be remembered that the actual output product of the Phase One wetland survey produced by ESL is not included within this report because of its size, bulk and printing difficulties. It is a separate entity available through the DPED or the U.S. Army Corps of Engineers. Mention of the wetland study is made in this document only to inform readers of its existence and to provide some idea as to its format, anticipated value and inherent limitations. Appendix A provides the data sheets (item 4 above) for the entire state.

3.3 Kauai County Resource Inventory.

Webster defines "resource" as "an available means; a natural source of wealth or revenue". Hawaii is rich in natural resources and not very many years ago was substantially richer in some. Recent public awareness has forced governmental respresentatives to address the problem of diminishing natural resources. ESL's resource inventory is aimed at providing information to managers enabling them to serve this task better.

3.3.1 Extent and Purpose.

The purpose of this inventory study is based upon the planning/management informational needs of the State and in accord with NOAA threshold papers (Federal recommendations).

A. Threshold Paper No. 1 Boundaries

"The following are necessary elements of this (boundary) indentification process:---------- An identification of transitions and intertidal areas, salt marshes, wetlands and beaches." Proper identification of these features must include: A definition of each area based solely upon biological, chemical, and/or physical criteria; developmental, political, or administrative factors would be inapplicable.

3.3.1 -- Continued.

B. Threshold Paper No. 2 Permissible Uses

"These determinations (permissible uses) must be based upon --------------

- "An inventory of natural and man-made coastal resources." (923.12(b)(2))
- Analyses or establishment of methods for analysis."

C. Threshold Paper No. 3. Geographic Areas of Particular Concern

"Establish a process to determine the areas meeting these criteria (GAPC), and thus desirable for designation. Two such processes are:
(a) A state inventory in progress
(b) Public nomination for subsequent review."

The perennial problems encountered with constructing a resource attribute classification system are correct identification of user perspectives and anticipation of long-term value fluctuations. The user perspective is as varied as the individuals using the system and complicated further through resource weighting, projected program goals and funding limitations. As time passes, land value patterns change placing new planning and management requirements on a system designed for old demands. The definition and compatibility of 'land use' and 'land cover' classes is also difficult.

3.3.1 -- Continued.

ESL has reviewed many classification scheme designs in formulating a system for the Hawaii Coastal Zone Management Program methodology study. Each design presented several very positive elements; but, in each, the value of the positive element was partially offset by unreconcilable conflicts when operationally tested. The problem was not with the classification schemes reviewed, but with the complexity of uses to which coastal zone management would subject them. The goal was to design a classification system which would (a) deal with a wide range of resources, (b) be flexible enough to access information relevant to specific combinations of resources, and (c) be easily corrected, updated or modified.

Through our inventory methodology studies a multiple overlay system was formulated and implemented. Eight categories of information were defined and mapped:

1) Land Use Districts
2) Transportation
3) Land Use
4) Vegetation
5) Shoreline Habitat
6) Sand and Reef
7) Rivers and Streams
8) Wetlands*

*Wetlands category has been previously discussed in Section 3.3.

3.3.1 -- Continued.

These categories were determined by the technical consultants (ESL, PUSPP and H. Mogi) and approved by CZMP staff.** Discussion with the Kauai County Planning Department also provided input, particularly the level of detail relevant to local government planning.

Each category has its own map and a specifically tailored classification system which furnishes the maximum amount of information through a minimum number of detail levels (see Figure 3-1). On any map or classification scheme as more delineations are drawn out the number of detail levels increases. As these increase, the design of the system becomes more and more complicated; and the illustrative graphics and class breakouts become progressively more difficult to utilize. By separating major resource categories and supplying each with a simplistically tailored class breakdown, the data becomes more accessible, easier to use and deals smoothly with redundancies such as "is it grassland or pasture; bare ground or recreational beach, waste field or open space?" Each resource category map supports the resource inventory function, but by being individually autonomous, provides stand alone information as well.

Network system overlays (e.g., rivers and streams) are completely compatible with areal delineation overlays (e.g., vegetation) and, though designed for initial manual use, both are quickly convertible to a computerized process.

**Reference letters of 30 October 1975 (technical attachment) and 10 December 1975 PUSPP to ESL. Reference letter of 27 February 1976 ESL to PUSPP.

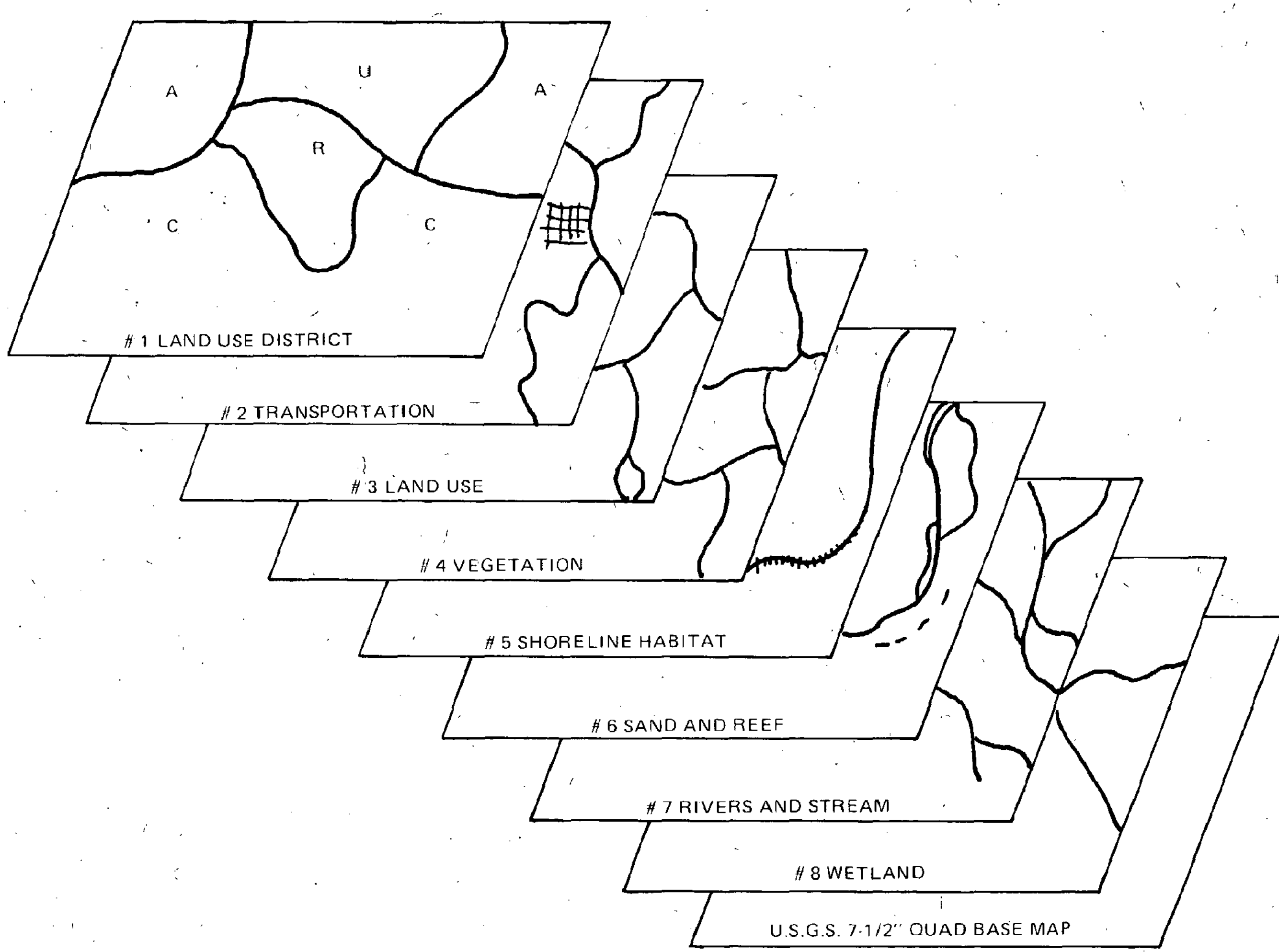


Figure 3-1. Illustration of Multiple Overlay Resource Inventory Classification System

3.3.1 -- Continued.

Several use benefits become readily apparent with the multiple overlay system. First, new categories can easily be added. Soil conservation maps, already completed by USDA can be added to this system with little if any modification. Orthophoto quad maps could easily create a new base map. Secondly, individual resource maps or overlays can be selected and combined to focus on particular problems. For example, vegetation maps and rivers/streams maps can be combined to study water demand problems. Thirdly, the problem of separating land use and land cover is solved. On a vegetation overlay the classification may be "grassland" while on a land use overlay it would be "pasture". Bare ground on a vegetation overlay might be a boulder beach on the shoreline habitat overlay indicating a micro-environment to be conserved. Levels of detail need not become excessibly complex on any one overlay since other overlays are addressing other resource informational requirements.

3.3.2 Inventory Methodology.

The inventory was accomplished utilizing existing sources thereby establishing optimal procedures for new data collection later on. The information sources used were:

- High altitude color, color infrared and black and white photographs

- Low altitude black and white photographs

3.3.2 -- Continued.

- U.S. Department of Agriculture soil conservation maps
- Department of Land and Natural Resources, State Division of Forestry, forest type maps
- Existing studies, reports, papers, etc.
- Interviews with local experts
- Ground truth verification by ESL field teams and local consultants.

Interpretation and analysis techniques have been discussed in previous sections and, to avoid redundancy, will not be elaborated upon again here. Pertinent comments on each resource attribute map are provided in the following sections.

3.3.3 Test Site.

The Lihue/Nawiliwili area in Kauai county is the primary test site for ESL's second year resource inventory methodology study. The entire Island perimeter (as defined by Coastal U.S.G.S Quad maps) is the secondary test area and its inventory extent is limited by time and funding. Most importantly however, is the structure, or format of the mapping and classification system. The inventory encompasses sufficient resource categories and geographical area to permit substantial use as well as documented critique. Bear in mind that this study is methodological, requiring user feedback and modification.

3.3.4 Output Product.

The output product generally is in the form of a transparent mylar multiple overlay system (see Figure 3-1) registered to 1:24,000 scale U.S.G.S. 7-1/2 minute quadrangle maps. This scale is compatible with the University of Hawaii's (PUSPP) computer information system which is registered to the Soils Survey Study, also at 1:24,000 scale. Similar scale will allow for a single format digitizing process and compatible computer output maps. Appendix B contains reduced copies of various mylar overlay maps to familiarize generally readers with the format. As in the case of the wetland mapping this document only refers to the resource inventory, attempting to make the reader aware of its existence and availability. Actual use or critique of the output product must stem from the output products themselves, e.g., the quad maps, overlays and classification schemes. Again, these are available at DPED.

3.3.4.1 Overlay #1. District Land Use Boundary.

This overlay merely transfers existing land use district boundaries onto a clear mylar overlay registered to quad maps at a 1:24,000 scale. The four district classifications are:

"U" Urban
"A" Agriculture
"C" Conservation
"R" Rural

3.3.4.1 -- Continued.

The Hawaii State Land Use Commission has very specifically defined each district type and regulates the various land use activities permitted within the boundaries of each (State Lands Use Commission, 1975). Appendix B quotes these definitions for the convenience of the reader.

In constructing resource overlay maps ESL felt that a visual illustration of land use districts which could be used in tandem with all of the other maps would greatly enhance the value of the multiple overlay system. For example, the land use map (#3) when examined with the districts clearly overlayed can (a) provide indications of the direction of urban sprawl, (b) quickly point out land use violations, (c) clarify options for regulating the direction of urban expansion and (d) determine the percentage of productive agricultural area among other things.

There are procedures for petitioning a change in the land use district boundary and as these occur this overlay category should be updated. Once again new overlays should be made preserving the old ones for trend analysis.

3.3.4.2 Overlay #2. Transportation.

This overlay is a network system illustrating major highways, roads, jeep trails and foot paths. It was compiled with U.S.G.S. quadrangle maps and high altitude aerial photographs, the latter illustrating newly constructed transportation routes. The primary function of this map is to indicate the accessibility of resources delineated on other overlays. It can also provide assistance in estimating use density of particular areas.

3.3.4.3 Overlay #3. Land Use.

The land use delineation map illustrates "man's activities on the land which are directly related to the land" (Clawson and Steward, 1965). This overlay should be used in conjunction with the Land Use district map, Overlay #1, to combine political boundaries with actual land use. In essence this category monitors the usage to which the resource categories are put. Management of resources directly relates to management of land use.

Problems were encountered in the construction of a classification system which would be on the one hand sufficiently broad to deal with the wide range of coastal zone management questions and yet precise and accurate enough to provide users with practical and beneficial information. These design problems and the general solutions applied by ESL are discussed in the introduction to this section. Suffice it to say here that the land use overlay will, in and of itself, provide much information (Appendix B-3 contains the land use classification).

However the dynamic concept of multiple overlays will enhance that information by allowing tandem usage with other resource inventories.

U. S. Geological Survey Circular 964 contains that agency's latest Land Use and Land Cover Classification System by Anderson (1976) (see Table 3-1). It is an attempt to create a viable classification system which will serve as a common format for the nation. Only two detail levels are provided allowing each

Table 3-1. U.S. Geological Survey Land Use and Land Cover Classification System for Use with Remote Sensor Data

LEVEL I	LEVEL II
1 Urban or Built-up Land	11 Residential
	12 Commercial and Services
	13 Industrial
	14 Transportation, Communications and Utilities
	15 Industrial and Commercial Complexes
	16 Mixed
	17 Other
2 Agricultural Land	21 Cropland and Pasture
	22 Orchards, Groves, Vineyards, Nurseries; and Ornamental Horticultural Areas
	23 Confined Feeding Operations
	24 Other
3 Rangeland	31 Herbaceous Range
	32 Shrub-Brushland Range
	33 Mixed
4 Forest Land	41 Deciduous
	42 Evergreen
	43 Mixed
5 Water	51 Streams and Canals
	52 Lakes
	53 Reservoirs
	54 Bays and Estuaries
6 Wetland	61 Forest
	62 Nonforested
7 Barren Land	71 Dry Salt Flats
	72 Beaches
	73 Sandy Areas Other than Beaches
	74 Bare Exposed Rock
	75 Strip Mines, Quarries, and Gravel Pits
	76 Transitional Areas
	77 Mixed

Table 3-1. -- Continued.

LEVEL I	LEVEL II
8 Tundra	81 Shrub and Brush Tundra 82 Herbaceous Tundra 83 Bare Ground Tundra 84 Wet Tundra 85 Mixed
9 Perennial Snow or Ice	91 Perennial Snowfields 92 Glaciers

3.3.4.3 -- Continued.

user to add additional levels in accord with his own unique use requirements or environment. Table 3-2 compares this system with ESL's multiple overlay concept to give the reader a better feel for the depth of the latter system.

The land use classification system accompanying the overlay map extends to the fourth level of detail. Additional levels of detail can easily be added but should be done only after the planning element reviews and, if necessary, modifies the initial design.

The mylar overlay map, as with all the overlays, is registered to 7 1/2 minute U.S.G.S. Quad maps at a 1:24,000 scale. In addition to this presentation format a second, slightly different format structure was designed. The urban district in the Lihue Quad was photomapped at a scale of 1 inch equal to 1000 feet (1" = 1000'). This involves a delineation, similar to the mylar overlay map procedure; only an enlarged photographic photocopy is used as a base. The photobase was obtained through an RC-10,12" metric mapping camera specially designed to minimize the distortion inherent in all photographs. The result is a large scale, photobase map which would be beneficial for local county planners. These maps have not been rectified and should be limited to planning. Feedback relative to this format should emanate from the Kauai County planning staff.

Table 3-2. Corresponding Categories of U.S.G.S. Circular 964 and Multiple Overlay System*

USGS Land Use and Land Cover System	Multiple Overlay System
1 Urban or Built-up Land	Land District Land Use Shoreline Habitat Transportation
2 Agricultural Land	Land District Land Use Vegetation
3 Rangeland	Vegetation Rivers and Streams
4 Forest Land	Vegetation
5 Water	Rivers and Streams
6 Wetland	Wetland
7 Barren Land	Shoreline Habitat Sand and Reef
8 Tundra	Vegetation
9 Perennial Snow or Ice	

*(See Appendix B for a detailed breakdown and description for multiple overlay attributes.)

3.3.4.4 Overlay #4. Vegetation.

The study and mapping of vegetation types are important to the CZM program. Areas in agriculture determining food supplies, grassland and range are important for cattle grazing, and forested areas are necessary for watershed protection and timber and pulp. All types are used by wildlife for food, cover and as a source of human recreation.

The study and typing of vegetation are time consuming and a complex problem. As one becomes more familiar with the vegetation of a given region, subtle differences are easier to detect and finer divisions become possible. Those factors constituting the definition of a specific type are very much influenced by the purpose of the investigation. Foresters are primarily concerned with timber and watershed, range resources specialists with animal carrying capacity and the ecologist with details of species composition and interrelationships.

The purpose here is to provide general categories of vegetation to obtain a planning overview of CZM related resources. In some cases four levels of detail are provided when this could be reasonably done and still be consistent in the interpretations.

The primary focus was the areas near the coast; examination of upland tree and brush types was limited to very general categories. Primary source material was the 1975 U-2 photographs supplemented by limited field observations. The Department of Natural Resources, Division of Forestry type maps were also extensively used, particularly in upland areas and for forest plantations. The forestry maps, however, include a land use/land potential classification and a stand size and density rating.

3.3.4.4 -- Continued.

In this classification system, land use is treated as a separate attribute (overlay #3); quantitative measure of stand density, size, etc. are considered important, but are suggested for detailed studies in areas of particular concern.

A list of scientific names of the plant species referenced in this report is provided in Appendix B as well as the detail classification scheme. The species list for each area is by no means complete and is intended only to provide a general description of the vegetation stand.

One specific item is noted; there is no attempt in this classification system to delineate wetland as a separate type. These vegetation communities will be studied by the U.S. Army Corps of Engineers and the results of that study can be used to update and expand the classification system established here.

3.3.4.5 Overlay #5. Shoreline Habitat.

This overlay illustrates the physical habitat of that area of the Coastal Zone where the sea and land meet. The purpose of this overlay is to make the planner generally aware of the different types of shoreline, their relative abundance, location and importance. The latter would best be accomplished in conjunction with ancillary information such as species/habitat comparison studies (Maragos, et. al., 1975), other overlays and/or the quad maps themselves. The accompanying shoreline habitat classification scheme (Appendix B) is accurate to Level III. Level IV

3.3.4.5 -- Continued.

is reasonably accurate, but, for illustrative aesthetics, occasionally combines small areas of closely related types, e.g., rocky outcrop and boulder beach. The classification system is open to modification and amenable to the addition more detail levels of information. For this reason, a section listing the aerial photography utilized for a particular quadrangle is included with the classification scheme. This will enable a user requiring more precise and accurate information to go directly to the data source. All aerial photographs used are available at the DPED Data Facility for examination. Private copies are available at cost through the U.S. Department of Interior, EROS Data Center, Sioux Falls, South Dakota.

The description accompanying the classification attempts to explain the various class headings in a way as to be most meaningful to the manager and not the scientist. It includes a description of the physical terrain, a brief explanation of natural interactions brought about by the physical characteristics and finally a simplistic analysis of what impact, relative to man, that interaction has had in the past.

3.3.4.6 Overlay #6. Sand and Reef.

The depletion and erosion of sand resources have been almost universally posed as a Hawaiian CZM problem. One can assume that virtually all beaches in Hawaii possess the potential for recreational use. However, recreational and industrial uses compete for the sand resource; private interests compete with

3.3.4.6 -- Continued.

public rights for access to beaches; developers alter the shoreline with seawalls, breakwaters and dredging which, in turn, changes the dynamics of a sandy beach. This overlay maps the location of beach and dune areas on shore and roughly points out some offshore sand channels and deposits. The photography used is listed in Appendix B and should be examined for more detailed delineations in geographically specific areas.

Here is an excellent example of the problems encountered in establishing cost-effective levels of information for coastal zone management. The amount of informational detail inherent in the data source (here high and low altitude photographs) far exceeds that required for planning. ESL has determined that general subsurface sand resource mapping, with reference to easily accessible data sources, provides the optimum detail level tradeoff. Critique from users will establish that level of detail necessary for the CZM program.

In many cases the water penetration of the photography is limited because it was not specifically obtained for this purpose, and additional effort will have to be used to complete and/or update the map.* This overlay can be used in conjunction with overlay #5, Shoreline Habitat, to obtain information on beach composition. As more detailed studies are completed, sand quantity and quality parameters can be added to the classification scheme as additional levels of detail.

*See Section 2.3 for problems relating to subsurface resources and water penetration capabilities of aerial photography.

3.3.4.6 -- Continued.

Many studies have been conducted and papers written on Hawaii's sand resources. The intention of this map is to draw together some of these studies and present them in a clear and understandable manner through an "information system" designed to communicate timely scientific data to the planners and managers. (Gerritsen, F. 1973; Moberly, R., J.F. Campbell and W.T. Coulbourn, 1975; Roach, J. 1975; Levin, J., 1970; Moberly, R., 1968.)

Also illustrated on Overlay #6 is reef information. Reef locations, in addition to their natural beauty and ecological niche, are important for navigation, recreation and shoreline protection from high energy wave action. Present aerial photo interpretation techniques give little information on coral type or condition delineating only their extent in shallow water (20-50 feet). Again, water penetration techniques are being studied and improved upon.

J. Maragos, et. al., (1975) breaks reef into several descriptive components which give the reader a better understanding of the extent and interaction of the reef habitat. Excerpts from the above referenced work are included in the appendix.

As with subsurface sand, reefs are difficult to map. The question "level of detail" is a significant one and the final methodology will depend upon CZM user feedback.

3.3.4.7 Overlay #7. Rivers and Streams.

This overlay separates the river and stream patterns. Much information has been obtained from the U.S.G.S. Quad maps themselves. However, in some instances the spectral response of the vegetation in aerial photographs indicates a water drainage pattern which is not visible on the surface.

Perhaps the most important aspect of this overlay is that it provides a base for CZM planners to build upon, incorporating new study results and additional data into an understandable format.

3.3.4.8 Overlay #8. Wetlands.

Discussions of wetlands overlay was provided in Section 3.1. Detail classification system currently under development by U.S. Army Corps of Engineers.

3.4 -- Continued.

ESL's approach to problem analysis is:

1. Identify the problem (e.g., coral kill).

2. Locate the physical effect creating the problem, (e.g., sedimentation).

3. Through remote sensing technology, trace the effect of the problem back to its physical cause (e.g., soil erosion).

4. Determine the land use activities or conditions which initiated the cause, (e.g., overgrazing).

5. Outline the physical boundary of the problem to include cause, pathway(s) and effect (establish geographic area of particular concern).

6. Recommend key points at which to monitor cause and effect of the problem.

By analyzing a relatively small number of problem areas, planners and managers can begin to set up predictive models which, in turn, can assist in setting up priorities for permissible uses.

ESL's task is to present relevant resource and environmental information to these decision makers. The final decisions, however, must include a consideration of economic, social, and

3.4 -- Continued.

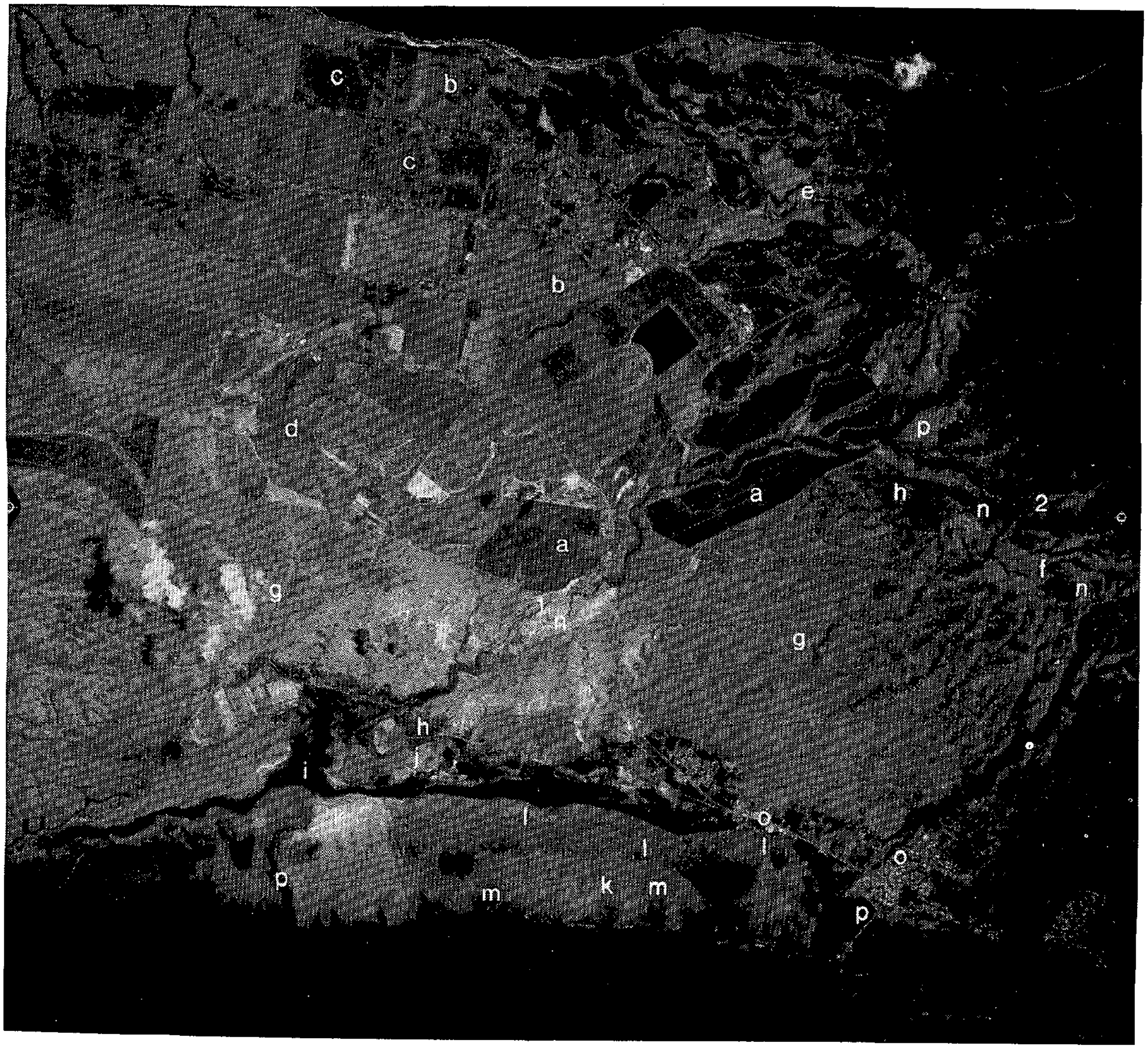
political factors. The following subsections discuss geographically specific problems and attempt to draw the reader through a process which involves the use of remote sensing in detecting, identifying and recommending solutions.

3.4.1 Sedimentation.

A detailed examination of this problem was undertaken over a portion of the Island of Molokai. Stereoscopic (three dimensional) examination of 1:65,000 scale true color (400-700 nm) and color infrared (510-900 nm) imagery obtained on the July 1975 flight, coupled with historical low altitude imagery and field investigation, were used in the analysis. The high altitude imagery was analyzed at scales of 1:65,000 up to 1:6500 (10 times enlargement) using a Bausch & Lomb zoom stereoscope on the positive transparencies. Figure 3-2 is a reproduction of the color infrared photograph and will serve as a reference for the following analysis.[1] The legend accompanying the photograph

[1] Due to reproduction costs, only a limited number of reports contain color photographs. This is unfortunate because the analysis of color infrared imagery is based on the differences in hue and saturation of various objects and backgrounds. Black and white renditions of color infrared imagery do not exhibit these important differences. Furthermore, although black and white reproductions of color infrared photographs appear similar to black and white panchromatic and black and white infrared photographs, they cannot be interpreted as such. The gray scale values of various objects in black and white renditions of color infrared images are <u>not</u> the same as those for the same objects as recorded in standard panchromatic black and white, or standard black and white infrared photographs.

The reader wishing to verify personally discussions concerning the analysis of the imagery presented herein should contact the CZM Data Facility, DPED, 250 S. King Street, to make arrangements to view positive transparencies.



a. Healthy productive pineapple
b. Recent pineapple field, no longer in production
c. Old pineapple field, extensive encroachment of weeds and grasses
d. Potato field
e. Pasture (improved)
f. Grassland, unimproved pasture
g. Open Kiawe (pasture)
h. Dense Kiawe
i. Wetlands, mangrove
j. Wetlands, salt flat/pickle weed
k. Sand and sand/coral mixture
l. Algae covered mud
m. Coral
n. Bare soil
o. Urban commercial, residential, other vegetation types
p. Open water channels

Figure 3-2. Color Infrared Image of Portion of South Molokai Coast (Portion of Entire Photo Shown Scale 1:65,000) identifies various features and will serve to orient the reader who may be unfamiliar with this color infrared imagery.

Coral (annotation M) exhibits a dark blue, even textured response and was readily delineated on the color infrared photographs to depths of approximately 4.5 meters. It was not possible to determine the health of the coral through photo interpretation. A similar signature was found on the true color photograph. Additionally, because of better water penetration capabilities of the true color imagery, coral areas could be delineated from surrounding sand areas to a depth of about 10.5 meters.

Coral, sand and sand-sediment mixture is shown in Figure 3-2 by annotation K. The differences in signature at various locations are due to water depth; the lighter blue and bluish-white hue near the shore is under only .3 meters of water. Again, at depths greater than 3 to 4.5 meters, true color film is a better media for off-shore subsurface sand delineation.

Algae covered mud and sediment are shown by annotation L. The greenish hue and mottled texture is quite well depicted on the color IR photograph.

Extensive mangrove stands are shown at annotation I. Detailed examination under 10X magnification reveals the very bright red area immediately adjacent to the coastline is healthy mangrove 8 to 10.5 meters high. Immediately mauka of this is a dull red response typical of stunted (2 meters high) mangrove. The reason for this was not established.

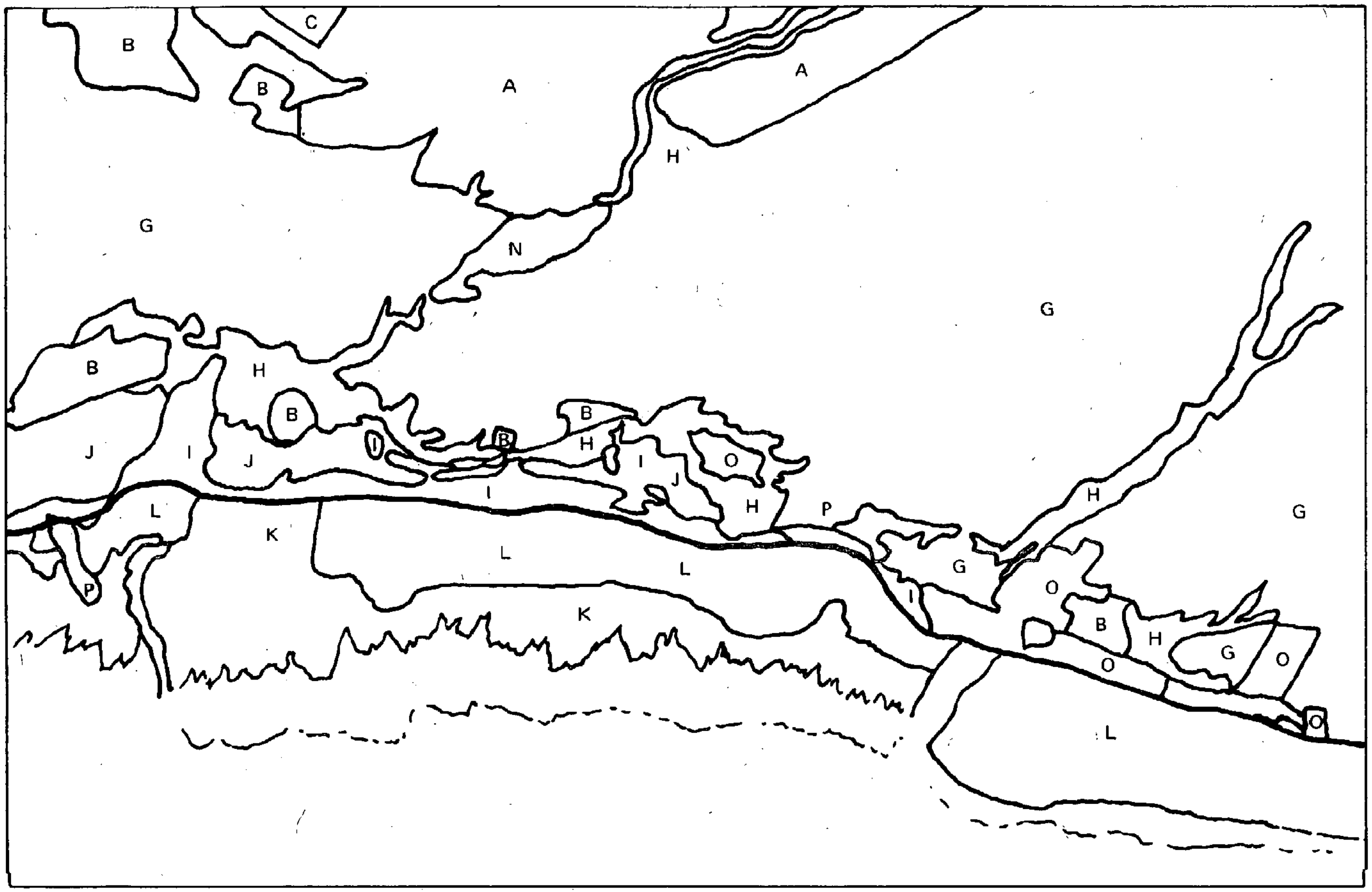
3.4.1 -- Continued.

Pickleweed, occupying extensive areas inland, is shown at annotation J and exhibits a typical mottled pink and blue signature. The blue is due to patches of bare soil (salt flat). Inland of the pickleweed is a stand of dense Kiawe (annotation H) with an understory of grass (*Pennisetum* spp.). Significantly, the dense stand of Kiawe extends inland along the stream bottom where water is available. Upland of the dense Kiawe is extensive open Kiawe/grassland area (annotation G).

Bare soil areas can be seen at annotation N and are very important to the analysis.

Figure 3-3 is a thematic map, scale 1:65,000, that portrays the areal extent of the various features for a portion of the test area.

The degradation of the coral beds on the South Molokai coast is an ecologically complex problem, but it is well known that extensive sedimentation can cause suffocation and environmental changes leading to eventual decline of the living coral beds (Banner and Bailey, 1970). The extent of the problem area can be obtained, in part, with remote sensing and associated field surveys. Additional insight into the cause of the problem can also be obtained. Bare soil (N) response can be seen in the photographs at several points. One particularly large area of exposed soil is due to the rock quarry located at annotation 1 (in Figure 3-2). A ground photograph of this area is shown in Figure 3-4. The quarry is located right on and immediately makai



Legend*

A. Pineapple
B. Other crops
C. Old pineapple
D. Potatoes (not shown)
E. Improved pasture (not shown)
F. Grassland unimproved pasture (not shown)
G. Open Kiawe (pasture)
H. Dense Kiawe
I. Wetlands, mangrove
J. Wetlands, salt flat/pickle weed
K. Sand and sand/coral mixture
L. Mud and algae covered mud
M. Coral
N. Bare soil
O. Urban/residential/other vegetation
P. Open water channels

*Legend consistent with figure 3-2, not all features exist within a mapped area.

Figure 3-3. Thematic Map of Key Resource Feature of Molokai Test Site in 1975 (Nominal Scale 1:65,000)

Figure 3-4. Ground Photograph of Annotation 1 in Figure 3-2

3.4.1 -- Continued.

of Manawainui Gulch. Other bare soil areas can be seen and are caused by extensive overgrazing of the dry land pasture. A ground photograph of the area at annotation 2 in Figure 3-2 is shown in Figure 3-5. Much of the area is exposed soil with little vegetation to protect it from wind and water erosion.

This type of land use practice can cause serious soil erosion and intensify the sedimentation problem in the coastal waters. However, the identification and delineation of the rock quarry and extent of over-grazed pasture through an analysis of remote sensing imagery is not conclusive evidence that these factors have caused the sedimentation. In fact, at the time of the photographs, July 1975, there is no evidence of active sedimentation discharge in the coastal waters. July is the middle of the dry season and there is no surface water in any of the intermittent streams on the South coast of Molokai.

The rainfall in the area is 15 inches per year or less, mostly occurring in winter storms. During intense rains, erosion probably occurs throughout the area, with severe erosion in the exposed soil areas. Table 3-3 lists pertinent parameters for soils in the immediate vicinity. These parameters were taken from the Soil Conservation Service soil survey of Molokai and clearly indicate medium to intensive runoff and moderate to severe soil erosion hazards in the area.

To make some estimate of the rate at which sedimentation is occurring and to obtain another measure of the relationship between current land use practices and the South Coast sedimenta-

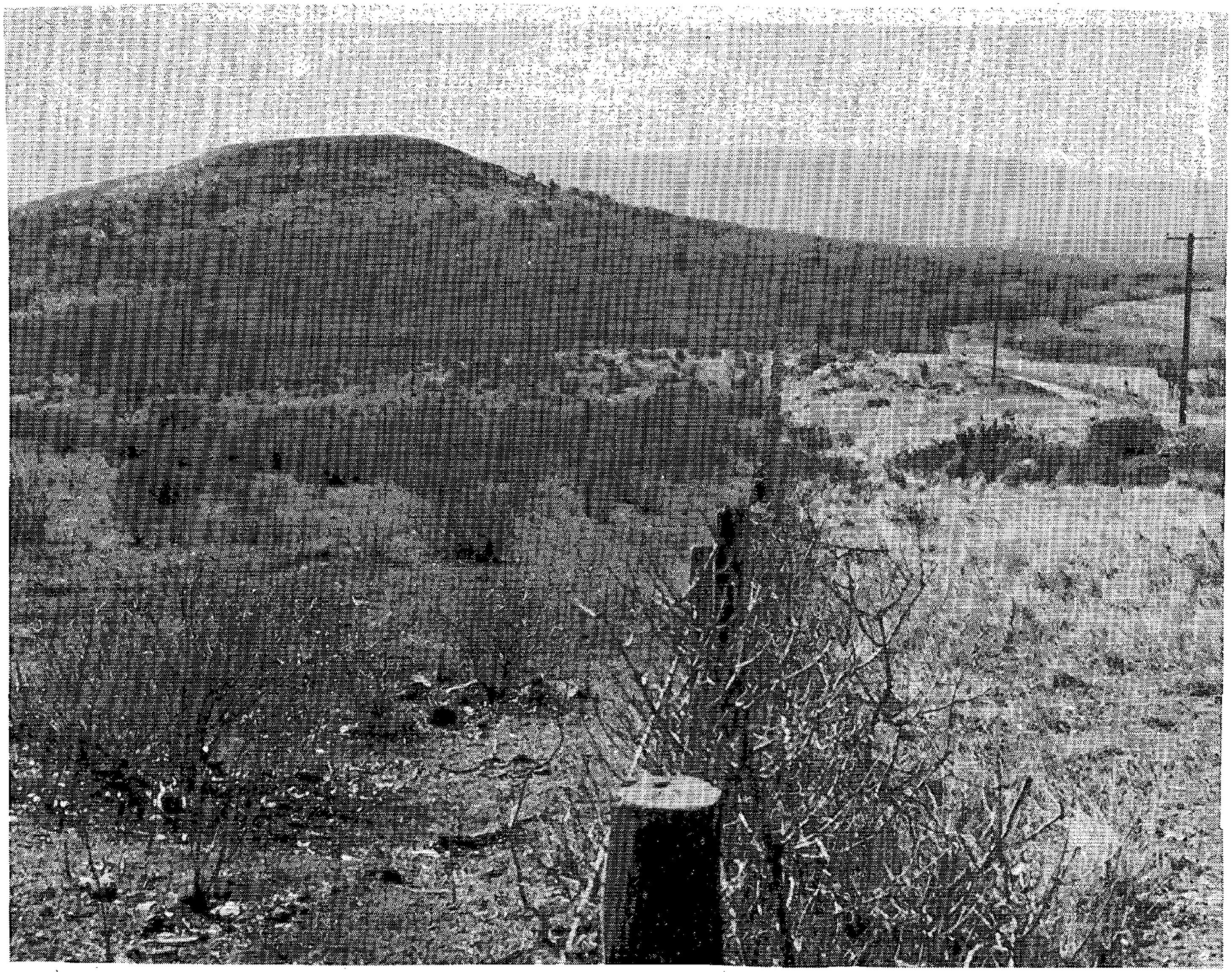


Figure 3-5. Overgrazing of Annotation 2 in Figure 3-2

Table 3-3. Pertinent Soil Parameters for Molokai Test Area (Soil Conservation Service 1972).*

Soil Type Name	Symbol	USDA Capability Class		Pineapple Production Group	Pasture Group	Woodland Group	Run-off	Erosion Hazard
		Irrigated	Non-Irrigated					
Holomua Silt Loam 3 to 7% slope (severely eroded)	H_vB3	IIIe	IVe	Group 2 35 to 45 tons/ac. main crop 25 to 35 tons/ac ratoon crop Mulch crop suggested	Group 2 Unimproved pasture 700-1700 lbs/ac/yr Improved pasture 1400 to 2600 lbs/ac/yr	Group 1 100 to 500 bf/ac/yr	Slow to medium	Moderate
Holomua Silt Loam 7 to 15% slope (severely eroded)	H_vC3	IIIe	IVe	Group 3 35 to 45 tons/ac/yr main crop 25 to 45 tons/ac/yr ratoon crop Grassed waterways needed	Group 1 Unimproved pasture 400 to 1300 lbs/ac/yr Improved pasture 1700 to 2600 lbs/ac/yr	Group 5 700 to 1000 bf/ac/yr	Medium	Severe
Lahina Silty Clay 25 to 40% slope (severely eroded)	LaE3	VIe	VIe	-	Group 3 Unimproved pasture 1000 to 2000 lbs/ac/yr Improved pasture 2000 to 4800 lbs/ac/yr	Group 1 100 to 500 bf/ac/yr	Medium to rapid	Severe
Oli Silt Loam 10 to 30% slope	OME		VIe	-	Group 6 Unimproved pasture 2400 to 3200 lbs/ac/yr Improved pasture 5000 to 9000 lbs/ac/yr	-	Medium	Moderate to severe
Rocky Land (Reconnaissance)	rRK	VIIs	VIIs	-	-	-	-	-
Rough Broken Land (Reconnaissance	rRR	VII	VII	-	-	-	Rapid	-
Very Stony Land (eroded)	rVT2	VII	VII	-	-	-	-	-

* More complete description of each parameter can be found by consulting the cited reference; selected parameters are listed here.

3.4.1 -- Continued.

tion problem, historical photographs were analyzed.* These panchromatic photographs were taken in 1955 at a scale of 1:14,000. Detailed analysis of both the U-2 and low altitude photographs reveals many changes have taken place. Scale difference precludes inclusion of all 1955 photographs, but a small portion of the area is shown in Figure 3-6.

A number of significant changes can be seen: replacement of dense Kiawe with agriculture, reduction of dense Kiawe due to grazing in upland areas, increase of mangrove seaward. However, the sedimentation, algae and mud flat areas are similar in magnitude (although not specific delineations) to the 1975 analysis. The sedimentation problem, although aggravated by current land use, was not solely caused by these activities. No photography earlier than 1955 was found; it would be interesting to examine aerial photographs of this area taken prior to the establishment of the mangrove swamp which has apparently helped to stabilize the area.

This example demonstrates the importance of a systematic data base useful to trend analysis as well as demonstrating how remote sensing can aid in problem definition.

*Taken by R.M. Towill, Honolulu, Hawaii.

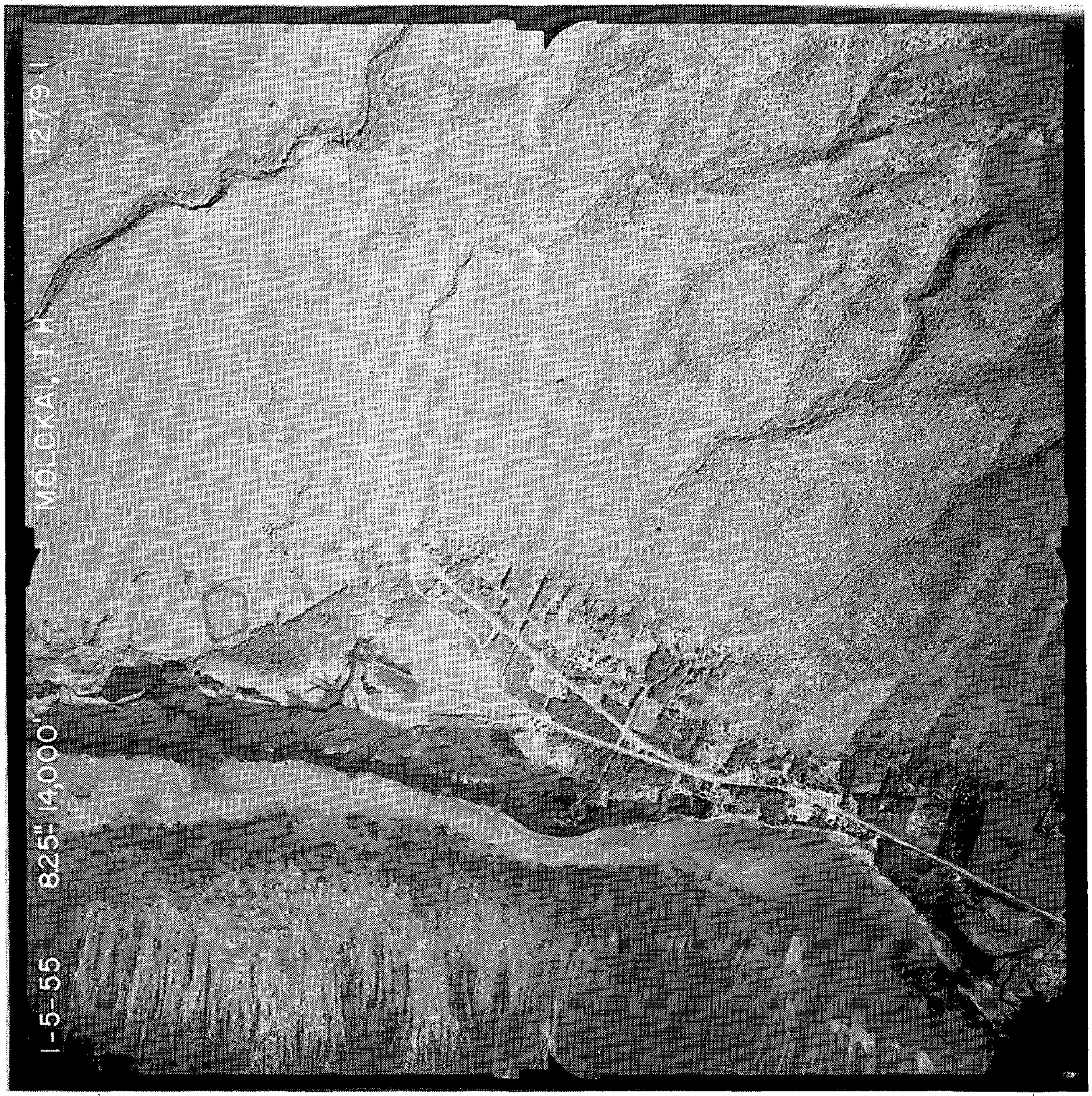


Figure 3-6. Black and White Low Altitude Photograph - Molokai Test Site (R.M. Towill, 1955)

3.4.2 Kauai County Problem Analysis.

Table 3-4 is a compilation of problems encountered in Kauai County having impact or effect on the coastal environment. This list was compiled by PUSPP, the Kauai County citizens, and represents the first cut at identifying coastal concerns on the Island of Kauai. Time has precluded an in-depth analysis of each problem; however ESL is examining these problems to identify those for which remote sensing can contribute to the solution by identifying the location, extent, and/or causes. Preliminary results of our investigation to date follow.

3.4.2.1 Sedimentation, Erosion.

An examination of large scale 1:32,500 multispectral imagery (black and white, color and color IR) taken in 1974 reveals extensive off shore sedimentation (turbid waters) on the southwestern and western waters of Kauai from the mouth of the Waimea Canyon to Barking Sands. Sedimentation plumes several miles off shore can be identified and delineated in the imagery. Analysis to date indicates that erosion and siltation from the Waimea River is not the sole cause of this sedimentation. In fact, at the time of the photographs, October 1974, little if any sediment laden water was coming from the mouth of the river. Extensive erosion, in the form of exposed soil, is common in the southern and southwestern upland areas of the county; and these areas are readily identified in the color IR imagery. However, the relationship between these erosion areas and the offshore sediment patterns has not been established.

Table 3-4. Identified Problems Kauai County Coastal Environment.*

Coastal Ecosystems	Water Quality
• Depletion of near shore fish populations and marine life • Threats to bird habitats (wetlands and non-wetlands) • Massive fish kills • Destruction of forest areas • Destruction of coastal plant life. Sand Resources • Beach erosion and depletion Coastal Recreational Resources (legal/physical) • Conflicting recreational activities Historic and Cultural Resources • Destruction of fish ponds • Destruction of historic Hawaiian settlement sites. • Destruction of post-Cook structures. Scenic and Aesthetic Resources • Loss of shoreline open space.	• Sedimentation • Discharge from secondary treatment plants • Beach park water quality • Fresh water quality (streams) • Toxic materials • Raw sewage discharges • Degradation due to sewage injection into lava tubes • Degradation due to cesspool drainage into coastal waters Shoreline Development • Development conflict with local shoreline use • Development conflict with environmental concern • Development conflict with historic protection • Conflict over boat harbor siting • Conflict over energy facility siting • Conflict over desired level of utilization of shoreline (development versus traditional and open space) • Inadequate public facilities (roads, schools, parks, medical, water, police) • Unplanned development Additional Problems Not Covered Above • Interface with fresh water species migration

*List was compiled from Pacific Urban Studies Planning Program (PUSPP) handouts entitle "Summary of Coastal Concerns, First Problem Lists, January-March 1976" and "Master Problem List PUSPP/CZM" dated 8 March 1976.

3.4.2.2 Destruction of Kiawe Trees, Forest and Coastal Vegetation.

This task requires a baseline inventory such as accomplished by an ESL inventory effort. Periodic assessment through remote sensing image analysis can establish the trend and document quantitatively the amount of forest land by specific type that has been lost and what has taken its place. A similar example was encountered in this year's inventory efforts. Large sections of land formerly in agricultural production (sugar cane, and pineapple) are now idle. Knowing the location and extent of these lands can aid in estimating the long-range development potential and changing economic structure of the Island.

3.4.2.3 Land-Use Conflicts.

A number of the problems concern land-use conflicts (recreation vs. development etc.). Use of the multiple overlay inventory system can help to identify those areas where conflicts may arise. In addition to the attributes mapped during this year's effort, new overlays can be compiled representing important features; e.g., historical, cultural sites and areas of high erosion.

The solution to the conflict itself, however, will require the consideration of legal, economic and organizational factors of the CZM program.

More detailed analysis on all of the listed problems is required and is recommended for consideration as a future objective.

4. INFORMATION DISSEMINATION AND EDUCATION.

"AWARENESS" on the part of both planners and scientists has been discussed previously in this report and in a plethora of publications relating to the interdisciplinary importance of successful planning and management. Germane to this theme, Section 4 expounds on how ESL approached the task of making the technology of remote sensing less mysterious and hence more accessible to everyone participating or interested in the Hawaii Coastal Zone Management Program.

Over and above the numerous scheduled presentations and workshops that ESL took part in, two major educational tasks were accomplished. A data facility or centralized information clearing house feasibility study was begun and partially implemented; and a REMOTE SENSING Seminar was held. The following subsections thoroughly discuss each element.

4.1 Data Facility Alternatives.

4.1.1 Introduction.

Now in its second year, DPED has been working closely with ESL and the National Aeronautics and Space Administration, Ames Research Center, in the area of remote sensing technology. During 1974 and 1975, Ames Research Center obtained over 2600 high-altitude U-2 photographs of large portions of the Hawaiian Islands. This imagery, sent to DPED, represents extremely valuable source information on land use, cultural and natural resources of the state. Furthermore, collected over time, this data provides information on the changing nature of key resources as discussed in the previous sections. The CZM program (as well

4.1.1 -- Continued.

as other long-range planning programs within DPED) is not a one time effort and the established data base can be effectively used for years to come.

The mere physical existence of remote sensing data, however, is no assurance that it will be effectively utilized. Some means must be developed to catalog the data; and suitable equipment must be obtained to carry out the necessary planning, processing, and analysis functions discussed previously (see figure 2-3). The existing U-2 imagery must be used in concert with (not as a replacement for) other types of remote sensing data (satellite, low-altitude aircraft) and ancillary information such as maps, charts, reports, and interpreted results from earlier investigations and field notes in order to derive maximum benefit. This suggests some sort of data facility or information clearinghouse is needed to ensure effective use of the imagery for the CZM and related programs.

A data facility, clearly, would be beneficial in providing (1) an efficient informational storage and interpretation center, (2) uniformity of information format presentation, (3) a capability to update information quickly and effectively, (4) an historical data base to be used for trend analysis, and (5) to establish a mechanism for interdisciplinary communication essential to the success of the CZM program.

4.1.2 Study Objectives.

ESL has undertaken exploration of various alternate data facilities and plans for their implementation. Specifically, this study addresses:

- The type of facility best suited to the needs of the State of Hawaii
- A recommendation for a phased long-range implementation plan
- Specific procedures and data cataloging criteria for the existing in-house U-2 imagery.

4.1.3 Approach.

The CZM information clearinghouse would carry out the following functions:

- Planning for any new data (ground, aircraft, satellite)
- Specify required processing and oversee its accomplishment
- Catalog data and perform necessary analysis and interpreted functions
- Disseminate information to appropriate parties.

4.1.3 -- Continued.

All functions are required, but the relative importance of each is a function of the mission of data facility. The central question revolves around the charter of the data facility with respect to the cataloging and indexing of the data and the analysis of this data.

DPED is definitely interested in the derivation of information required in state planning. This is in contrast to NASA Ames, which emphasizes storage and retrieval of raw data at its data facility. In any case, the interpretation of the imagery requires a certain degree of cataloging and indexing. In order to derive a suitable mix for the State of Hawaii, a matrix showing several different levels of effort of analysis and interpretation against several different levels of storage and retrieval is provided (see Table 4-1).

Level of Analysis Capability

Level 1 in Table 4-1 comprises the data cataloging and review functions only. No interpretation of the data is provided by the data facility, which would be staffed and equipped to serve only a library function. In most instances, analysis would be accomplished at another location by a user, e.g., another agency, another project within DPED.

Level II is data cataloging with limited in-house analysis capability. It provides for some analysis and technical assistance to DPED programs and outside users. However, extensive multiresource analysis efforts could not be undertaken.

Table 4-1. Matrix Rating of Several Levels of Cataloging and Indexing and Resource Analysis Capability

	A U-2 Data only	B U-2 Data Plus Other Types of Remote Sensing Data		C Remote Sensing Data Plus Ancillary Information	
Data Facility Function	All data in-house	All data in-house	Some data in-house, knowledge of the rest	All Data in-house	Some data in-house knowledge of the rest
I Data Cataloging and Review Only	1 acceptable	4 impractical	5 marginally acceptable	10 impractical	11 marginally acceptable
II *Data Cataloging* with Limited In-house Image Analysis	2 marginally acceptable	6 impractical	7 acceptable	12 impractical	13 marginally acceptable
III Data Cataloging with Extensive Image Analysis and Overall Coordination	3 impractical	8 impractical	9 acceptable	14 marginally acceptable	15 acceptable

Impractical -- Not responsive to the needs of the state

Marginally acceptable -- *Has merit but retains inefficiencies of adequate depth*

Acceptable -- Provides highest use of data at reasonable cost

4.1.3 -- Continued.

Level III is data cataloging with major in-house analysis and overall coordination. At this level, the data facility would serve as a primary state CZM information center and could supply information to other agencies on a routine bases. It could also coordinate the data collection functions of other agencies to reduce cost and eliminate redundancy. It is clear that, at some point prior to this level of analysis, considerations should be given to other types of remote sensing data and associated ancillary information sources.

Levels of Cataloging and Indexing

U-2 Data Only -- Level A

DPED has all U-2 imagery of the Hawaiian Islands in-house. This data should be stored in a manner compatible with user requirements.

U-2 Plus All Other Types of Remote Sensing Data -- Level B

This data includes the indexing of low-altitude photographs and satellite imagery that may be used in conjunction with the U-2 data. As the need arises, the facility would also catalog and maintain special types of remote sensing data, such as thermal line-scan, multispectral, and radar imagery data.

4.1.3 -- Continued.

Remote Sensing Data Plus Ancillary Information -- Level C

This data includes the other two levels plus ancillary information. This data would support extensive imagery analysis for major resource or environmental studies. Ancillary information would be systematically stored for given analysis efforts.

The complexity and size of the cataloging function increases significantly at each level, bringing into play the handling of information about the location of various data sources (rather than physical storage of the data). It would not be necessary to store physically all the information sources in the data facility proper, although it may be desirable. For the two lower levels of data, the implication of storing either some or all of the data in-house is explored.*

The matrix formed by these variables (Table 4-1) results in 15 different scenarios for data facilities. Obviously there are other possibilities but the 15 will serve as sufficient alternatives to explore.

Each scenario was evaluated for data types, cataloging and procedures, equipment, personnel, space, utility, inter-governmental, and coordination. The details of this evaluation can be found in Appendix C. Results and recommendations appear in the next section.

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*It is illogical to consider this split for Level A (U-2 only) because all of the data is presently in-house.

4.1.4 Results and Recommendations.

Results

The results of the scenario evaluation are presented in Table 4-1. Scenarios 3, 4, 6, 8, 10, and 12 are eliminated as being impractical or unresponsive to the needs of the State of Hawaii. Scenarios 2, 5, 11, 13, and 14 all have interim merit; but, as described, each falls short of an efficient data facility alternative. Several scenarios of this group have merit for intermediate purposes; others would be suitable after modifications.

That leaves 1, 7, 9, and 15 as acceptance scenarios providing the highest use of the data at reasonable cost. Each of these represents a considerable increase by the state in the effective use of remote sensing technology for planning and resource evaluation. A brief discussion of each of the acceptable scenarios is provided here. The reader desiring a complete discussion of all scenarios should consult Appendix C.

Scenario 1 (Catalog and Review; U-2 Data Only

All of the U-2 data is physically present at DPED as is some of the recommended equipment. Completion of Scenario 1 allows for easy access to the imagery and provides the tools and equipment necessary for reviewing that data. The facility is open to the public and all governmental agencies desiring to review this data bank. Interpretative expertise, however, is not available and must be provided by the reviewing group or agency. (This is seen as a limiting factor, since most potential users come in to be informed, not to ferret out predetermined information from esoteric data.)

4.1.4 -- Continued.

Scenario 7 (Limited Analysis Provided; Multiple Data Sources)

The scope of the data facility is increased in two ways. First, it adds a limited, but important analysis capability to the facility. Second, the existing U-2 imagery is integrated with low-altitude data or other forms of data. A copy of all (high- and low-altitude) imagery collected by the state is not necessarily physically maintained in the facility; only that data actually used in the analysis tasks need be maintained. However, information about other available data is referenced in the facility. Ancillary information needed in the analysis of the imagery is not systematically stored at the facility, although the existing library at DPED undoubtedly contains much of that required. Specific reference material is obtained on a task or project basis.

The primary emphasis of the facility is to support the CZM program; however, any other DPED program could use the facility to address its own special analysis tasks. It is also expected that assistance to other State agencies would be provided.

Scenario 9 (Extensive Analysis Provided; Multiple Data Sources)

This expands on Scenario 7 by adding additional planners or resource analysts with backgrounds in remote sensing to the facility staff. The size of the analysis tasks undertaken is increased substantially. Cooperative programs with other agencies can be undertaken where mutually beneficial, and overall information output is increased.

Scenario 15 (Extensive Analysis Provided; Extensive Data Sources)

This scenario establishes a statewide resource and environmental center supporting a broad spectrum of agencies and projects. Integration of ancillary data with available remote sensing data on a systematic basis allows very expansive evaluation and planning tasks to proceed with a minimum of effort. Coordination of data collection and analysis programs on a state-wide basis can result in reducing costs over time. This scenario postulates data handling and analysis tasks and requires a computer system for efficient operation (as described here, a stand-alone, dedicated system is suggested). This computer system can be an outgrowth of or a supplement to the CZM information system presently under development.

Recommendations

ESL recommends a plan of phased data facility growth with evaluation periods between major phases to determine effectiveness of operation and direction for future growth.

Phase I: Completion of Scenario 1. This phase is presently underway; several steps remain to be completed, the first being to design a data cataloging and a retrieval system sufficient to handle the U-2 imagery and allow for future cataloging of other types of remote sensing data. Details of this design can be found in Section 5. The second step is to complete the purchase of required equipment (see Scenario 1, Appendix C).

4.1.4 -- Continued.

At the completion of this phase, the data facility can quickly determine suitable U-2 coverage for any requestor and have the necessary equipment to allow general review and evaluation of the high-altitude data.

Phase II

A resource planner or analyst with experience in remote sensing data analysis is added. The idea is to obtain quickly expertise for analyzing the data. Phase II is similar to Scenario 7. Initially the primary data available for analysis is the U-2 imagery. As the need arises, additional data sources are tapped and incorporated physically into the system (e.g., U.S. Army Corps of Engineer low-altitude shoreline photographs). In time, a multilevel data base evolves to represent the optimal information system. ESL does not recommend the wholesale cataloging of all available data, rather the cataloging of data required in the analysis of a given problem or resource; however, data facility members should have information regarding the availability and accessibility of other data (references). This is an interim phase leading to Phase III.

At this point, an evaluation should be undertaken to determine the effectiveness of the facility and ascertain what future growth is justified and in what direction.

Phase III

A natural outgrowth of Phase II, Phase III involves cataloging and analysis of all types of available data required.

4.1.4 -- Continued.

Should increased analysis be justified, ESL recommends implementation of Phase III, Scenario 9, which significantly increases the facility's effective output and usefulness. This phase should quickly be followed by additional evaluation and critical review. If justified, Phase IV, Scenario 15, can be implemented.

It could be decided, however, that increased analysis of the data is being accomplished by other agencies or groups. In this case, the data facility's function could support such analyses (as in Scenario 13) where the DPED data facility acts as a central clearing house for other projects or agencies, with each agency responsible for its own analysis and DPED retaining interpretative expertise for its own projects.

Figure 4-1 is a suggested schedule for data facility development. The schedule could, of course, be modified to meet DPED's needs and available funding.

ESL has discussed the concept of a data facility with several County Planning Commissions; several state agencies including the Department of Health, the Department of Land and Natural Resources (DLNR), and interested federal agencies. It was almost unanimously concluded that a data facility could, if set up properly, be of great benefit to the state and to each participating group or agency. The difficulty lies in obtaining the cooperation of various political entities. An entirely apolitical situation is, of course, impossible. Representatives of several agencies thought the facility should fall within their

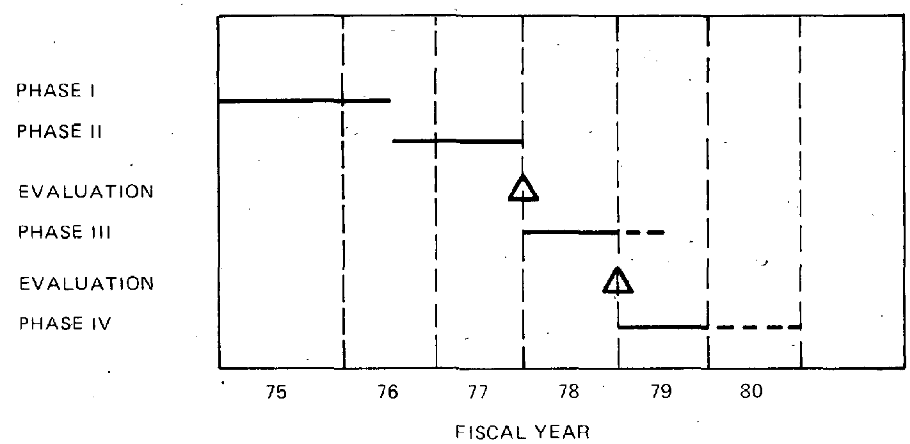

Figure 4-1. Suggested Data Facility Development

4.1.4 -- Continued.

domains; however, none had the mechanism or funds to justify such an undertaking.

The DLNR Division of Forestry has a second copy of most of the available U-2 imagery and the basic equipment necessary to carry out interpretation. Additionally, several staff members have had some experience in photo interpretation and are presently receiving additional training in some of the more advanced digital analysis techniques. However, the agency interest and charter is limited to forestry related matters on conservation lands. The suggested CZM information clearing house requires a wider view of Hawaii's environment.

4.1.4 -- Continued.

The DPED, the present lead agency for CZM planning, has been suggested to be the state agency responsible for CZM administration. At present, expertise in remote sensing analysis is supplied by contractors. DPED has established a basic facility and is planning to increase its physical facilities and analysis support. Should DPED retain its role as lead agency in the CZM program, it would require support from some information/data section. The broad nature of Coastal Zone Management would surely justify a statewide information clearing house under CZM auspices and, thus, qualify it for Section 306 funding. An information clearing center plan coordinated with the Section 305 Plan at the time of Section 306 application will certainly facilitate funding and Section 306 application approval.

Before the various state and county agencies turn to the DPED facility for support information, a strong facility coordinator will have to develop a meaningful, two-way flow of information. For long-term success, this should be considered by the DPED. To achieve even minimal success in accomplishing Phase I, a real commitment to the concept of a data facility must be made. Allocation of space, purchase of equipment, and proper staffing are real requirements and cannot be accomplished by a haphazard approach.

Summary of Benefits

The benefits of a central data facility are summarized here:

4.1.4. -- Continued.

- Storage and retrieval of data is centralized.
- The center offers phtographic/image interpretation; some expertise and equipment are available.
- The coordination of data collection for agencies increases the cost/benefit ratio and avoids redundant effort.
- Expertise in analyzing information needs and defining optimal data collection procedures and alternatives is available. This refers not only to CZM participation in Section 306 information requirements but also to precise sensor definition, and film types, instructions as to sensor arrangement, and filter combinations.
- The state is able to liaison easily with federal agencies such as NASA.
- Requirements of many users (CZM, land use, general plan, forestry) are consolidated.
- There is opportunity for in-house training of DPED and other personnel.
- The center provides DPED CZM support staff with resource expertise necessary for thorough participation in Section 306 work.

4.1.4 -- Continued.

- There is liaison between technical, planning, legal, and political elements of the CZM program.

4.1.5 Data Facility Cataloging System.

It is essential that any type of data to be stored be cataloged in a manner allowing easy access for a broad spectrum of applications. The following photographic data indexing system has been devised to aid DPED in cataloging the existing U-2 data and to accommodate any future U-2 data obtained. In addition, other types of data, such as low-altitude aircraft photography and satellite imagery, can be readily incorporated into the the cataloging system. This allows for maximum future expansion of the data facility with minimum cataloging and indexing conflicts.

Use of this system for the existing U-2 imagery places the data facility in a position equivalent to that described in Scenario 1. It is the first step towards the creation of an expanded and highly useful facility. In addition, this manual system may be easily incorporated into any future computerized system.

Description

Film identification and storage is to be based on the following parameters: (1) coverage by island, (2) platform, (3) year of coverage, (4) spectral band (film-filter type), and (5) source identification number (NASA, Corps, etc.).

4.1.5 -- Continued.

Each island is assigned a different identification parameter as follows:

Oh - Oahu
Ma - Maui
Ha - Hawaii
Ka - Kauai
Mo - Molokai
La - Lanai
Hk - Kahoolawe (including Molokini)
Ni - Niihau (including Lehau)

The second parameter is platform. A two-digit code allows for up to 99 different platform designations. The code 01 is reserved for the NASA high-altitude U-2 aircraft. The code 02 will be used to designate specific U.S. Army Corps of Engineer photographs. As other data such as Landsat C Satellite imagery or thermal line scans become available, a permanent designation number will be assigned.

The third parameter is the year of the data coverage. For example, all U-2 photographic coverage obtained over Oahu in 1974 will be coded Oh-01-74. U-2 coverage of Maui in the same year is coded Ma-01-74.

The fourth parameter is spectral band or film-filter combination. The actual spectral limits on film filter combination could be included in an identifier; however, a two-digit spectral band code is suggested. The number of different film

4.1.5 -- Continued.

filter types is limited, and the data facility personnel will quickly remember the code. Existing codes are shown in Table 4-2.

Table 4-2. Present Film-Filter/Spectral Band Combinations

Codes	Spectral Band	Film/Filters
01	510-900 nm	EK SO-127-Aerochrome Infrared (color) film Wratten 12 built-in Additional CC filters for response calibration
02	400-700 nm	EK SO-242-Aerial Color film. No filters.
03	510-700 nm	EK 3400-Panatomic X Film. Wratten 12 filter
04	460-580 nm	EK FE-3432-Experimental Water penetration film W4 filter
05	475-575 nm	EK 3400-Panatomic X Film/ Schott GG-475 and Schott BG 18 filters
06	580-680 nm	EK 3400-Panatomic X Film/ Schott OG 570 and Schott BG 38 filters
07	540-590	EK 3400-Panatomic X Film/ Wratten 21 and Wratten 57 filters

Additional codes can be added as required.

4.1.5 -- Continued.

The advantages of including spectral band as a direct indexing (storage) parameter (rather than as a secondary parameter) lie in the comparative analysis of two different film rolls over the same area. In 1975 the dual RC-10 sensor on board the NASA U-2 obtained both true color and color infrared over the islands; these will be stored in separate cans to facilitate simultaneous analysis.

An example of this parameter is given by Oh-01-75 01, Oh-01-75-02. The first code indicated coverage of Oahu (Oh) by the U-2 (01) in 1975 using color infrared film (01). The second code is Oahu coverage by the U-2 in 1975 with true color film.

Additionally, a 4-digit source identification number will be included. Should, for example, the platform be U-2, the NASA accession number would be retained in order to identify any given portion of a film roll with a specific U-2 flight. Retention of this number facilitates easy ordering of the data from NASA or the EROS Data Center, USDI or referencing to specific NASA flight documentation (Flight Summary Reports). Furthermore, the need for unnecessary cross-referencing and document storage within the data facility is eliminated if new roll numbers are assigned to the data.

The NASA accession number then becomes part of the data identifier as follows: Oh-01-74-01-1951. The roll number may refer to an entire photographic roll or only a specific portion.[1]

[1] The NASA rolls typically criss-cross several islands. These will be broken down by island to facilitate analysis.

4.1.5 -- Continued.

All data of a given film type taken over one specific island in any given year should then be spliced together into one or more film storage cans. These cans should be clearly labeled on the outside indicating the island of coverage, platform year of coverage, NASA roll number and frame numbers contained within. Figure 4-2 illustrates a sample label.

The label indicates that five different film rolls (or portions of them) are contained and that they constitute color infrared, U-2 coverage of Oahu for 1974. If multiple cans are necessary to store all of the photographic coverage over one island in a given year, they should be clearly labeled as Part A, Part B, and so on.

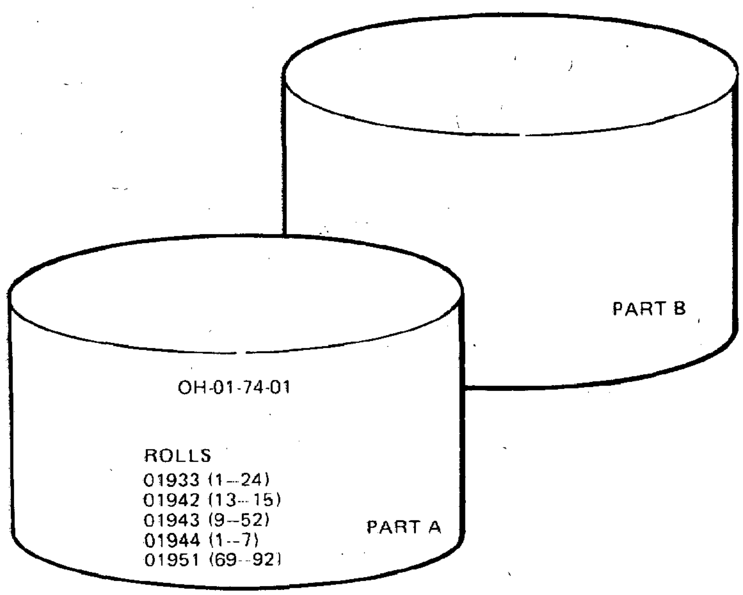

Figure 4-2. Typical Film Cannister Storage Label

4.1.5 -- Continued.

In addition, each roll, or portion of a roll contained within a can, should be identified with a leading frisket so that the user will know exactly which roll he is looking at. The combination of a roll and the frame number (which is imaged directly on the frame) will enable the user to identify a specific photographic scene for study purposes or order additional copies of the data (prints or transparencies) from the proper agencies. Flight summary reports and NASA flight track maps should be available to aid in the identification of other data parameters of a given film roll which are not necessarily printed on the film roll frisket. These parameters include such things as camera focal length, flight altitude, and scale of imagery. In many cases, however, the data manager should have sufficient familiarity with the data to answer many questions without going to the documentation.

Associated with each film can will be a series of page-size maps indicating the exact coverage of the data. These maps will be of two specific types; the first will show all the coverage over a given island for a specific year (detailed in flight line format, similar to the format produced by NASA). Each line on this map will be clearly labeled with the associated roll number (see Figure 4-2). These maps will consist of a single primary coverage map (PCM) per storage cannister to identify generally the photographic coverage (see Figure 4-3A).

The second map types show the individual roll coverage (one map per roll) in frame outline format indicating exactly the area of coverage. Figure 4-3B shows Oahu coverage by the U-2 in 1974 with color infrared NASA roll number 01951 frames 69-92.

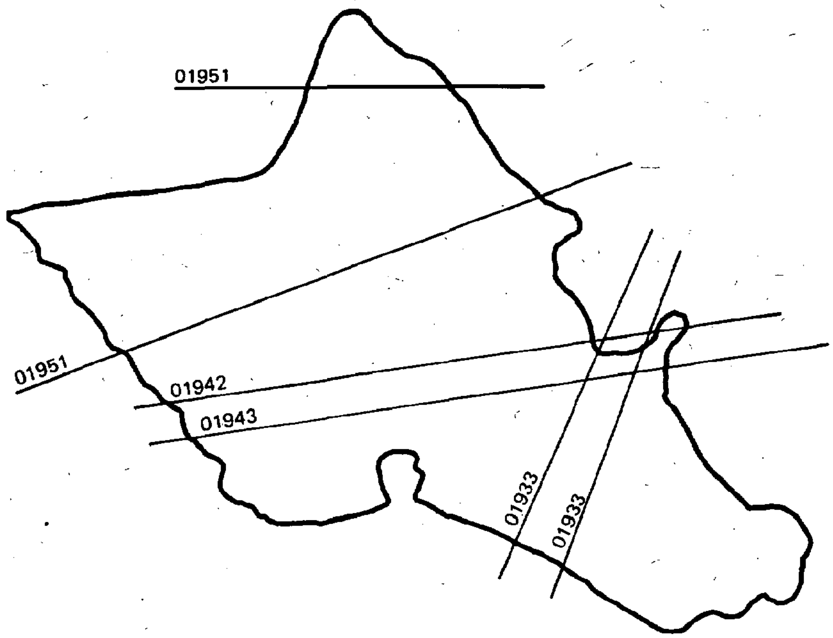

Figure 4-3A. Example of a Primary (Flight Line) Coverage Map (PCM).

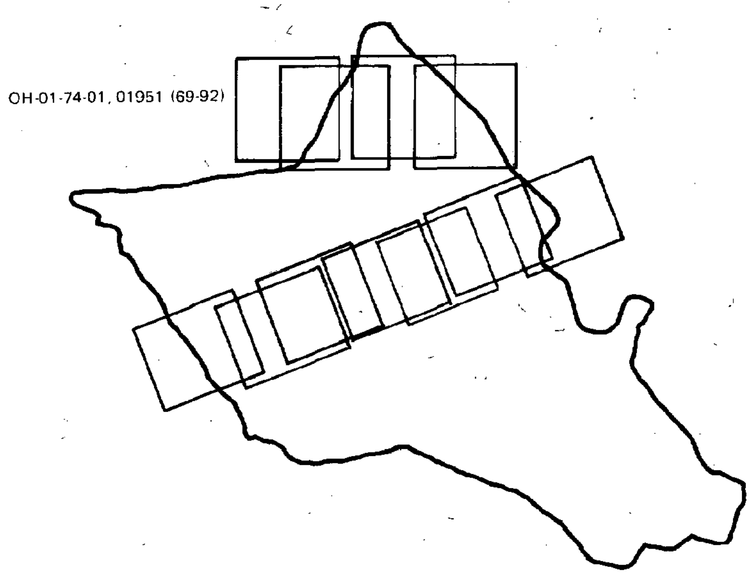

Figure 4-3B. Example of Individual (Frame by Frame) Coverage Map (ICM)

4.1.5 -- Continued.

Thus, a set of maps comprises all of the photographic coverage over a given island in a specific year and refers to only that data stored within the film can labeled with similar parameters. A set of such maps appears in Figure 4-4.

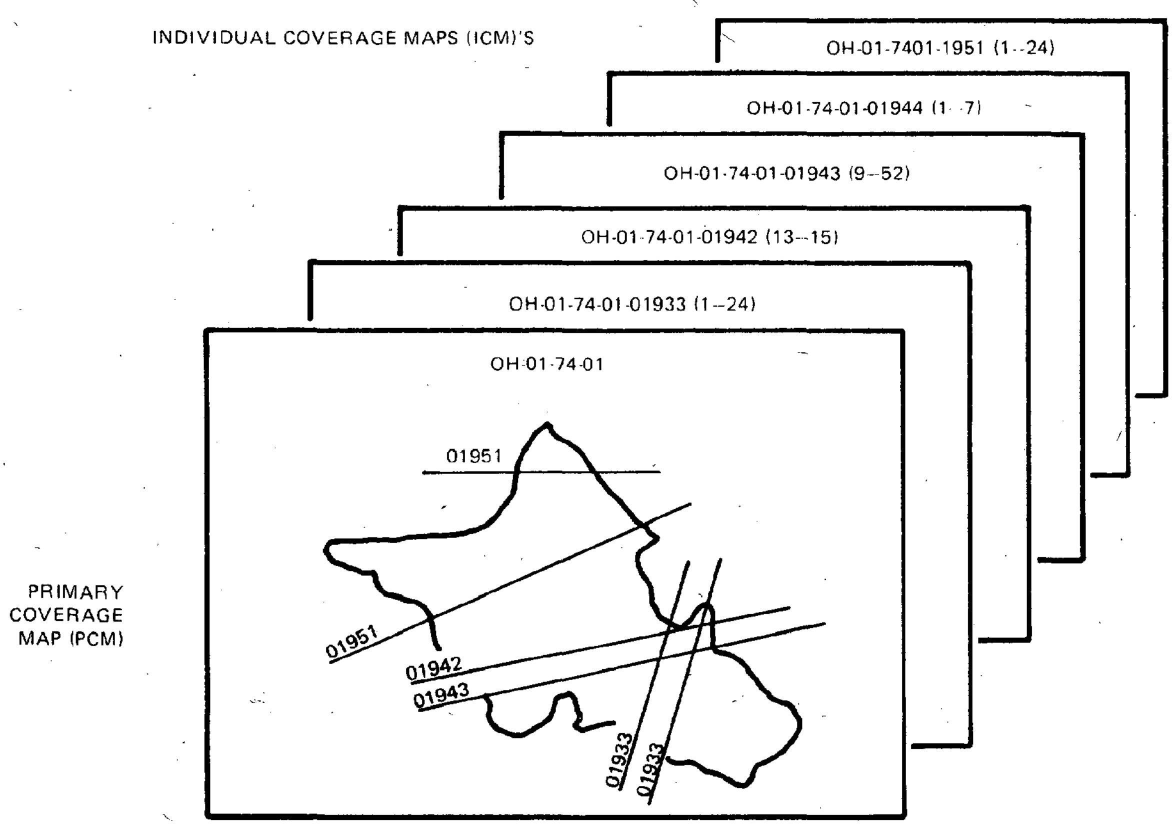

Figure 4-4. Illustration of Map Coverage Set

4.1.5 -- Continued.

The four digit U-2 assession number on the identifier can be used for other data source identifiers. The initial two digits identify source, and the last four digits can add to the precision of any data source identification.

The combination of these maps and the use of the previously mentioned film labeling and storage procedure will facilitate efficient data handling and search procedures. This system is designed, at present, to handle U-2 photography available at DPED. It readily converts to the storage of other types of data. To do this it is necessary only to substitute the specific data identifier for the NASA assession number.

4.2 Seminar.

On March 24-25, 1976, ESL conducted a Remote Sensing Seminar at the Ala Moana Hotel, Honolulu, under the direction and guidance of the DPED/CZM staff. The primary purpose for conducting a seminar of this type was to aquaint interested citizens in Hawaii with the remote sensing technology available for inventorying natural resources within the state. In addition, the seminar provided the latest information available regarding the "state-of-the-art" and projects in remote sensing technology anticipated in the future.

There were numerous participating agencies and groups each of whom demonstrated various methods of application and uses of remote sensing data. Table 4-3 contains a list of these participants and their topics of presentation.

Table 4-3. List of Speakers at Hawaii CZM Remote Sensing Seminar

Hideto Kono Director Department of Planning & Economic Development	"Welcome"
Gary Gnauck Senior Resource Scientist Electromagnetic Systems Laboratories, Inc.	"General Introduction to Remote Sensing"
Ed Van Vleck Research Scientist NASA/Ames Research Center	"NASA's Remote Sensing Programs; Present and Future Examples of NASA's Remote Sensing Applications"
Ray Tabata Marine Environment Specialist Sea Grant Program, University of Hawaii	"NOAA's 'It's Your Coast' Movie"
Virginia Macdonald Planner Department of Planning & Economic Development	"CZM Hawaii Slide Show"
Len Zuras Technical Staff Electromagnetic Systems Laboratories, Inc.	"Applications of Aircraft Photographic Data"
Richard Witmer Geography Program Geological Survey U.S. Department of the Interior	"USGS Land Use Mapping"
Leonard Gaydos Geography Program Geological Survey U.S. Department of the Interior	"USGS Land Use Mapping"

Table 4-3. -- Continued.

Ed Petteys Forester Forestry Division State Department of Land & Natural Resources	"Application of Remote Sensing in Hawaiian Forestry"
Jim Nichols Manager, Earth Resources Application Electromagnetic Systems Laboratories, Inc.	"LANDSAT Multi-Level Inventory; Procedures & Applications" (Pacific Northwest Regional Commission)
Art Reed Professor Department of Zoology University of Hawaii	"U-2 Photos and Marine Education"
Bill Liggett System Management Coordinator Pacific Urban Studies & Planning Program University of Hawaii	"CZM Data Inventory System Slide Show"
Chris Christoffels Planner DPED Seminar Moderator & Coordinator Department of Planning & Economic Development	"DPED Data Facility Status and Availability"
Larry Chime Resource Scientist Electromagnetic Systems Laboratories, Inc.	"Relationship of Remote Sensing Technology and the Hawaii CZM Program"

4.2 -- Continued.

The seminar was well received and emphasized the use of many formats and types of data and how to best apply specific data types to individual application problems. Attendees were given ample opportunity at the end of each session to question the speakers via a panel discussion format. Most sought information on how to obtain certain types of data (e.g., low altitude photography, U-2 photography, skylab, and ERTS imagery, etc.) and how to make the most beneficial use of the imagery for their specific applications. Such questions were answered by the panel members or, if necessary, referred to other sources for more precise information.

The following is a list of the primary speakers at the seminar and a brief synopsis of each topic:

1. General Introduction to Remote Sensing

Gary E. Gnauck
Sr. Technical Scientist, ESL Incorporated
Hawaii CZMP Consultant

Mr. Gnauck defined remote sensing and explained the fundamentals upon which the technology is built including: (a) introduction to the theory with emphasis of the properties of electromagnetic energy, (b) the various types of sensors and detectors that are used to record the energy, (c) the data analysis techniques employed to derive useful information, and (d) an overview of applications.

4.2 -- Continued.

2. NASA's Remote Sensing Programs; Present and Future Examples of NASA's Remote Sensing Applications

Ed Van Vleck
Research Scientist
NASA/Ames Research Center

Remote sensing capabilities of current satellites and aircraft and near future satellites were discussed to familiarize the workshop participants with NASA's efforts in this area.

A short overview of NASA's diverse remote sensing applications activities were discussed. Several on-going projects, such as the Pacific Northwest Land Resources Inventory Demonstration Project, and the Hawaii-DPED Coastal Zone Management Project, were discussed to show how NASA works with state governments in transferring the technology for using remotely sensed data.

3. Applications of Aircraft Photographic Data

Leonard Zuras
Member Technical Staff, ESL Incorporated

Topics of discussion included the interpretive applications of high and low altitude aircraft derived photographic data. The various applications of specific film types including color, color infrared, and black and white, as well as their spectral characteristics, were presented. The use of these films as data sources for determining land use and land inventory analysis in Hawaii was emphasized through visual presentation. Additionally, information regarding the past and future deployments of the NASA U-2 aircraft to Hawaii were discussed. This included description of the project itself and availability of U-2 photographic data to the general public and governmental agencies.

4. USGS Land Use Mapping

Richard Witmer and Leonard Gaydos
Geography Program
Geological Survey
U.S. Department of Interior

Topics of discussion included the interpretation and processing of remotely sensed data for the production of Land-Use maps on the eastern coast of the U.S. Typical maps were presented and reviewed. Discussion included future areas to be mapped covered by this program and the availability of these maps. Additionally, examples of on-going ERTS analysis and machine processing techniques were reviewed including a discussion of the results.

5. Application of Remote Sensing in Hawaiian Forestry

Edwin Q. P. Petteys
Timber Survey Forester

The use of remote sensing techniques and materials is not new to the Hawaii Division of Forestry and its cooperator, the U.S. Forest Service. Aerial photographs and their ancillary equipment have been in use since the late 1950's. Products resulting from the use of these photographs include three major forest inventories, a forest type map set, a forest plantation map set, countless small inventories, referencing aids, and forest condition information. They have recently completed a forest trend and condition study as part of the ohia decline project, and a similar job is underway for the mamane forest type on Mauna Kea. They have been using the U-2 high altitude imagery in some of the recent ohia work, and anticipate more intensive use of this material as familiarity with it grows. They are cooperating with the EROS Data Center in investigating new methods for our future condition studies, and the possible use of satellite imagery in their programs.

6. LANDSAT Multi-Level Inventory; Procedures and Applications

James D. Nichols
Manager, Resource Applications Department
ESL Incorporated
Hawaii CZMP Consultant

An interdisciplinary interagency renewable resource survey, inventory, and mapping system based on computer-analyzed LANDSAT multi-spectral scanner data is a cost-effective alternative as support to the independent information gathering procedures now being used. This statement is supported by the increasing evidence that through proper human-computer analysis of LANDSAT multispectral data, much of the information necessary for resource allocation, management, inventory assessment, and mapping can be obtained very cost-effectively. By complementing this LANDSAT derived data base, through the use of minimal analysis of small-scale photography, large-scale photography, and ground data, one can meet or exceed the current information gathering standards imposed on the various agencies involved in the management of our renewable natural resources. This presentation discussed the general theory and methodology for integrating the multiple information sources with an example of its implementation.

7. U-2 Photos and Marine Education

S. Arthur Reed
Zoology Department
University of Hawaii

In 1975 and 1974 the NASA Earth Resources Aircraft Project (ERAP) performed high-altitude photographic overflights of some coastal areas of the Hawaiian Islands in the U-2 reconnaissance aircraft. Resulting 9" x 18" transparencies on Aerochrome Infrared film (SO-127) and aerial color film (SO-242) are of excellent image quality and show multiple overlapping wave swell and sea patterns in the open ocean and near shore.

4.2 -- Continued.

Smaller sections of these photo images were rephotographed on 35 mm Kodachrome 25 color film, using color balancing filters and camera support, and employed as a teaching resource in a unit on ocean waves in the Hawaii Marine Studies Science Curriculum Project now being developed for high school students.

In the wave unit, students were introduced to fundamentals of wave phenomena through observations and measurements taken in wave tanks, ripple tanks, 8 mm film loops, and reading materials. As a culminational for the unit, the students were asked to analyze the complex wave patterns shown in the NASA aerial photos. Such wave phenomena as long period ocean sweels; short wind driven wave chop; interference patterns of wave energies; reflection, refraction, and diffraction of waves; focusing of wave energy on beaches; effect of harbor design on wave patterns are all vividly shown with great clarity on these photographs.

Details of techniques for photocopying onto 35 mm film and the use of these photos by students were presented.

8. DPED Data Facility Status and Availability

Chris Christoffels
Planner
DPED Seminar Moderator & Coordinator
Department of Planning and Economic Development
State of Hawaii

Topics of discussion included presently available remote sensing information sources retained at the DPED data facility. Future data source availability, and opportunities for obtaining remote sensing imagery from other agencies were also presented.

9. Relationship of Remote Sensing Technology and the Hawaii CZM program

Lawrence R. Chime
Resource Scientist, ESL Incorporated
Hawaii CZMP Consultant

Summarizing remote sensing techniques and applications presented at the seminar, Mr. Chime correlated how these could be and are being utilized in planning, implementing and monitoring the Coastal Zone Management Program in Hawaii. Also discussed were new sensors, film types and display techniques, previously unavailable, and how they offer opportunities to produce accurate, documented and persuasive management tools for presentation to concerned public, private and governmental agencies. Examples of CZM output products were exhibited and efficiency parameters which optimize utilization addressed.

4.2 -- Continued.

The seminar represented a significant opportunity for ESL to demonstrate the efficiency and cost-effectiveness remote sensing data for resource inventory purposes. A significant amount of resource information has already been gathered over the state of Hawaii through this technology and is currently available for CZM utilization in addressing the information requirements germane to proper planning and management of the Coastal Zone.

Table 4-4 represents a list of those persons registered at the seminar and the various groups or agencies each represented.

Table 4-4. ESL Seminar - Attendees

No.	Agency	Names
1.	U.H., Zoology Dept.	S. Arthur Reed
2.	Dept. Defense	Robert E. Schank, Civil Def.
3.	U.H., Botany Dept.	Linda L. Smith
4.	U.S. Fish & Wildlife Serv.	Maurice H. Taylor, Ecol. Div.
5.	U.H., Agronomy & Soil Sc.	Haroyoshi Ikawa
6.	U.S. Soil Conservation Serv.	Oran F. Bailey
7.	U.S. Agric. Research Serv.	Kiichi Ohinata
8.	Dept. of Land & Nat. Res. State Parks	R. Sue
9.	DLNR, Forestry Div.	Edwin Q. P. Petteys
10.	Mogi Planning & Res.	H. Mogi, H.P. McGuire, Jr.
11.	Tryck, Nyman & Hayes	David Cook, Douglas Lucas
12.	U.H., Hawaii Institute of Geophysics	J. Frisbee Campbell
13.	Kauai,Water Dept.	Walter L. Briant, Jr., Wayne Hinazumi
14.	DLNR, Forestry Div.	Carl T. Masaki
15.	U.H., J.K.K. Look Lab. Ocean Engrs.	George Weber
16.	DPED, CIP Branch	Robert Hee, Norm Shiroma
17.	U.H., Hawaii Instit. of Marine Biology	John Corbin, Dick Brock
18.	U.H., J.K.K. Look Lab. Ocean Engrs.	John T. O'Brien
19.	Bishop Museum, Pacific Scientific Info. Center	Lee S. Moteler
20.	Hawaii Co., Dept. of Water Supply	William H. Sewake
21.	DPED, State Policy Plan Div.	Patrick Ribellia
22.	Hawaii Co., Planning Dept.	Sydney Fuke, Norm Hayashi, Lani Bowmann
23.	U.H., Geography Dept.	Sen. Dou Chang, Geo. Sakasegame, Michael Thomas
24.	C. & Co., Bd. of Water Supply	Chester Lao, Glenn Bauer
25.	Sam O. Hirota, Inc.	Dr. Dennis Hirota
26.	U.H., Water Res. Res. Ctr.	Henry Gee, Edwin T. Hurabayashi
27.	DPED, Land Use Comm.	Ah Sung Leong

Table 4-4. -- Continued.

No.	Agency	Names
28.	Office of Marine Affairs Coord.	Howard Pennington
29.	Maui Co., Planning Dept.	John Min
30.	Kauai Co., Planning Dept.	Bert Matsumoto, Tomoo Hiranaka
31.	Bishop Museum, Anthropology Dept.	Dr. Patric G. McCoy
32.	U.S. Corps of Engrs.	James E. Maragos, James A. Roy, Kalino Vernon
33.	DPED, Long Range Planning Bureau	R. Poirier, V. MacDonald, C. Takahashi, C. Christoffels, B. Lew
34.	Health Dept., Environ. Hlth.	Eugene Akazawa, Edwin Kubeta, Kazuto Sheshido
35.	DPED, Land Use Div.	Tatsuo Fujimoto, Gordan Furutani
36.	DOT, Habors Div.	Melvin Lepine, Dan Tnaka, John Lee
37.	Hawaii Co., Dept. of Res. & Development	Marvin Uda, Yoehio Watmiase
38.	DPED, Res. & Econanalysis Div.	Paul J. Schwino, Lynn Y.S. Zane
39.	U.H., PUSPP	Kem Lowrey, Margo Stahl, Bob Stanfield, Vern Umebu
40.	U.S. Dept. of Agric. Statistical Reporting Serv.	Lloyd Garrett
41.	U.H. HESL	Bill Leggett, Kurt Von Nieder, Dieter M. Dumbois, John Rookie
42.	U.S. Naval Facil. Engrg. Com., Pacific Div.	Allen Matsuoka
43.	DOT, Statewide Trans. Planning Office	Bennett Mark
44.	R.M. Towill Corp.	Douglas Mukai, F.D. "Bud" Vuillemot
45.	U.H., Dept. of Geography	Margaret Elliott
46.	DOT, Highways Div.	Dennis Santo, Nardess Awana, Douglas Obimoto, Harold Zane
47.	C. & Co., Dept. of Land Utilization	1 rep.

Table 4-4. -- Continued.

No.	Agency	Names
48.	(Various) DPED/USGS/NASA/ ESL	H. Kono, F. Skrivanek, R. Witmer, L. Gaydos, L. Zuras, J. Nichols, L. Chime, G. Gnauck, E. Van Vleck
49.	Office of Environ. Quality Control	Richard Scudder, Mike Lim Geo. Matsumoto, Lesue Asari, Thomas Nakama, Nancy Brown
50.	DLNR	Walter Watson, Dan Lum, Paul Makuo, Noboru Kaneguro
51.	Dept. of Agriculture	Robert Miura, Robert Nagao, Larry Nakahara
52.	Haw. Water Resources Reg. Study	Harry Sato
53.	C. & Co., Dept. of Land Utilization	Robert Duncan
54.	Hawaii Co., Dept. of Parks & Recreation	Glenn Miyao
55.	U.S. Geological Survey Water Resources	Frank Hidaka, Sauvyn S.W. Ghinn, Robert Dale, Chas. Ewart, Iwao Matsuoka, Richard Nakahara, Harold Sexton, Kiyoshi Takasaki, Santos Valenciano
56.	U.H., Kewalo Marine Lab.	Shepard Williams
57.	U.S. Geological Survey	Pete Peterson (Retired)
58.	C. & Co., Honolulu, Dept. Public Works, Sewers Div.	Robert Ishida, J. Hamai

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APPENDIX A

STATEWIDE WETLANDS MAPPING

This appendix provides the phase one wetland data sheets for each county in the state. The reader desiring to review actual wetlands maps should contact Department of Planning and Economic Development, Kamaulu Building, Honolulu, Hawaii.

KAUAI COUNTY WETLANDS (PHASE ONE)

Twenty three (23) wetland or possible wetland areas have been identified on Kauai and Niihau Islands.

Number Designation.

Each wetland is designated by number and its corresponding USGS 7 1/2 minute quadrangle map. An accompanying mylar overlay registered to the quadrangle map illustrates each wetland delineation.

Letter Designation.

Letter designations indicate that a wetland identified on existing USGS quadrangle maps no longer exists. Agriculture, urban expansion or some other use has resulted in its disappearance.

Photographic Information.

Phase One's task was to locate wetland and possible wetland areas through the use of aerial photographic techniques. Two sources of information were utilized:

1. 1974 and 1975 NASA U-2 High Altitude Aircraft Color Infrared (SO-127) photographs at scales of 1:65,000 and 1:32,500.

2. 1975 and 1976 U.S. Army Corps of Engineers Low Altitude Black and White photographs at a scale of 1:6,000.

All information required for locating the precise photograph utilized is included. To observe particular sites with a stereoscopic viewer, the frames preceding or following those listed should also be obtained. Photography is available at DPED, Coastal Zone Management offices or at the offices of the U.S. Army Corps of Engineers.

Corps Imagery Overlay No.

To identify a wetland boundary with further precision an overlay of the 1:6,000 scale imagery is included. Overlay the correct mylar with its corresponding photograph for a detailed delineation of the wetland. These low altitude photographs exist only along the shoreline areas; inland wetlands are covered with U-2 imagery only. These are identified in the "Corps Imagery Overlay No. column.

	Wetland Number	Corps Imagery Overlay No.
Hanapepe Quad	1. Definite wetland - salt marsh/pond NASA Flight #74185, Access #01951, Frames 1155 (10/74) (1:65,000 scale) Corps - Kauai, Frame 1-287 (4/10/75) (1:6000 scale)	C1
	Comment: Little or no vegetation, mostly salt mud flat.	
	2. Possible wetland - Poopueo Reservoir NASA Flight #74185, Access #01951, Frames 1155 (10/74)	
	Comment: This is a reservoir area, not typically included in "wetlands." Reservoir appears to be filling in with vegetation.	
Koloa Quad	A. Wetland marked on USGS Quad (Koloa 1963); however, photo interpretation identifies that area as pasture. NASA Flight #85108, Access #02147 (1:65,000 scale) Frame 2965 (7/75).	
	3. Possible wetland - Waita Reservoir NASA Flight #75108, Access #02147, Frame 2965 (7/75)	
	Comment: Marsh type vegetation on North rim and Western bay of reservoir.	

	Wetland Number	Corps Imagery Overlay No.
Koloa/Hanapepe Quads	4. Possible wetland - Nomilo fishpond (south end)	
	Corps Kauai, Frame 1-306 (4/10/75)	C2
	Corps Kauai, Frame 1-304 (4/10/75)	C3
	NASA Flight 75-115, Access 02155, Frame 3207 (7/75) (1:65,000 scale)	
	Comment: A possible, very small, wetland on the South end of Nomilo fishpond. The heavy dense brush vegetation on the steep sides of the fishpond is probably Koa-hoale/Kiawe. Also in vicinity are several additional possible wetlands that are small, but should be field checked.	
Lihue Quad	5. Wetland Menehune fishpond/Huleia stream area; mangrove and marsh vegetation; inland turns into lowland meadow.	
	NASA Flight #75108, Access #02147, Frame #2960 (1:65,000 scale)	
	Corps Kauai Frame 1-13 (4/12/75)	C4
	Comment: Riparian type wetland.	
	6. Wetland, Niumalu Flat	
	NASA Flight 75108, Access #02147, Frame 2960	
	Corps Kauai Frame 1-17 (4/12/75)	C5
	Comment: Signature on U-2 suggests rush and Californiagrass.	

	Wetland Number	Corps Imagery Overlay No.
Lihue/Koloa Quads	7. Possible wetland - Huleia Tributary - coming through upland pasture area. NASA Flight #75108, Access #02147, Frame 2960 (7/75) Comment: Some wet soil and standing water is evident, but area is heavily pastured. Area may contain sparse marsh plants.	
Kapaa Quad	B. Called out on USGS Quad (Kapaa, 1963) as wetland. Photo interpretation identifies much of this area now in agriculture. NASA Flight #75108, Access #02147, Frame 2960 (7/75) Comment: This area is used as a pasture, overstudy is Hau and Java plum. Many of the trees have been cut to encourage forage production.	
	8. Possible wetland - NASA Flight #75108, Access #02147, Frame 2960 Corps Kauai 1-37 (NASA Flight 74-179, Access #01942, Frame 64) Comment: This area consists of various grasses and herbaceous vegetation. The high altitude U-2 imagery exhibits a dark bluish signature typical of wet soil. This is probably a temporary condition, but area should be field checked.	C6

	Wetland Number	Corps Imagery Overlay No.
Kapaa Quad (continued)	9. Wetland - Mauka of Kapaa NASA Flight #75105, Access #02147 (1:65,000 scale) Frame 2958 (7/75)	

Comment: Wetland consists of open water and marsh vegetation surrounded by woody brush species. The area was not field checked. Infrared signature analysis indicates a mixture of species with various rushes and Californiagrass probably dominating. Woody vegetation is probably Hau, Christmas berry, Pluchea with Java plum and possibly ironwood.

Anahola Quad	10. Wetland - Anahola Valley NASA Flight #75105, Access #02147, Frame #2957 (7/75) (1:65,000 scale) Corps Kauai - Frame 1-70 (4/12/75)	C7

Comment: Wetland area gradually changing into waste field as one progresses Mauka of wetland. Probable vegetation types in wetland are various grasses and sedges with Californiagrass predominating. Pluchea, Christmas berry and Java plum in surrounding area with ironwood, castor bean and *Caesalpinia* sp. also present. The area appears to have been partially drained.

	Wetland Number	Corps Imagery Overlay No.
Hanalei	11. Wetland - near Hanalei Bay NASA Flight #74-179, Access #01942 Frame #0022 (10/74) (1:32,500 sacle) Corps Kauai - Frame 1-134 (4/10/75)	C8
	Comment: Open water marsh wetland area grading into mixed forest. Specific wetland not field-checked, but likely vegetation in wetland proper would be rushes, sedges, grasses and Pluchea with Java plum, guava, Hau, scattered mango, ironwood, palm trees and banana.	
	12. Possible Wetland NASA Flight #74-179, Access #01942, Frame #0022 (10/74) (1:32,500 scale) Corps Kauai Frame 1-129	C11
	Comment: Signature on U-2 and low altitude Corps imagery is lowland grass and marsh area; should be field-checked.	
	C. Called out on USGS Quad (Hanalei) as wetland - appears on photography to be developed into agriculture area. NASA Flight #74-179, Access #01942, Frame #0022 (10/74) (1:32,500 scale)	
	13. Wetland - nearing climax stage - pasture and spotted marsh areas - near Kalihiwai Stream NASA Flight #75108, Access #02147, Frame #2970 (7/75) (1:65,000 scale)	

	Wetland Number	Corps Imagery Overlay No.
Hanalei (continued)	Comment: This is a remnant upland marsh area. The area is a mixture of brush, meadow and marsh and the plant species highly variable. Field check revealed region contains a few scattered wet marshy areas about 1/4 to 1 acre in size. The remainder of the area appears well drained due to good natural drainage system. Area is lightly pastured. Plant species present include common guava, strawberry guava, Kikui, Ohia-Lehua, false staghorn fern, Pandanus, Malabar melastome, shoebutton ardisia, various grasses (Paspalum sp., Digitaria sp., Axonopus sp.); ferns (Nephorlepis exaltata) and club moss (Lycopodium cernuum) are also common.	
	14. Possible Wetland - lowland meadow near Wainiha Stream, NASA Flight #75115, Access #02155, Frame 3200 (7/75) (1:65,000 scale) Corps Kauai 1-142 (4/10/75)	C9
	Comment: Area is a lowland meadow used for pasture. Remnant marsh plant species may be found. (If this area is designated as wetland after field check, other stream mouth lowland areas should also be field checked for possible inclusion.)	
Haena	15. Wetland NASA Flight #75115, Access #03255, Frame 3200 (7/75) (1:65,000 scale)	
	Comment: Signature indicates primary species as Californiagrass and rush.	

Quads	Wetland Number	Corps Imagery Overlay No.
Haena Waimea Waialeale Quads	16. Wetland - Alakai Swamp NASA Flight #75115, Access #02155, Frames 3198, 3199, 3200 (7/75) (1:65,000 scale) Comment: Swamp as outlined on quad sheets follows contour lines and is only approximate. Similarly, exact limits of swamp not discernible on U-2 photos, however, treeless areas within swamp are easily delineated. In the open areas the dominant plant species are Kuolohia, Hillebrand's panicgrass, Forbes' panicgrass and *Panicum oreoboloides*. In the stunted island or hummack areas, common species included Ohia-Lehua, *Cheirodandron* sp., Kawa'u, Pilo, Pokehiwa, and lousestrife. In the marginal areas around the bog portions, typical species include Ohia-Lehua, *Cheirodandron* sp., Kawa'u, Naupuka, Pilo, Kauai sandalwood, Pukiawe, several Ohelo (*Vaccinium dentatum* vr. *minutifolium*, and *Vaccinium calycirum*).	
Hanapepe Quad	17. Wetland by Waimea River NADA Flight #75115, Access #02155, Frame 3205 (7/75) (1:65,000 scale) Corps Kauai 1-273 (4/10/75) Comment: Former pond, now filled in with vegetation; probably Californiagrass, rushes and sedges.	C10

	Wetland Number	Corps Imagery Overlay No.
Koloa Quad	18. Wetland - Kanaele Swamp NASA Flight #75115, Access #02155, Frame 3207 (7/75) (1:65,000 scale) Comment: Mountain marsh, similar to Alakai.	
Niihau (15 min.) Quad	19. Possible wetland - Halalii Lake NASA Flight #75-115, Access #02155, Frame #3215 (7/75) (1:65,000 scale) NASA Flight #74-185, Access #1951, Frame 1963, 1964 (10/74) (1:65,000 scale) Comment: This wetland consists of several mud flats and associated plant species on the borders of Halalii Lake, Halulu Lake and other unnamed "dry" dashed lines as the perimeters fluctuate with the rain-fall; On the 1975 U-2 imagery (Access, #2155), Halulu Lake is nearly dry as is the one immediately to the south, while Halalii Lake retains some water. The situation is reversed in 1974 (Access, #1951). The most dominant vegetation surrounding the wetland is Kiawe, or Kiawe and Koa-haole. Pickleweed will probably be found in the mud flat areas.	
	20. Possible wetland - Kaununui Point area NASA Flight #75-115, Access #02155 Frame #3214 (7/75) (1:65,000 scale)	

	Wetland Number	Corps Imagery Overlay No.
Niihau (15 min.) (continued)	Comment: Possible wetland Mauka of dammed area. Vegetation appears to be "flooded" Kiawe. (There are several additional very small, apparently temporary, wetlands along this coast of Niihau considered too small to map.)	/
Hanalei Quad	21. Wetland - adjacent to Hanalei River NASA Flight #74-179, Access #01942, Frame #0022 (10/74) (1:32,500 scale) Comment: U-2 signature indicates grasses and rushes are primary species.	
	22. Wetland adjacent to Hanalei River NASA Flight #74-174, Access #01942, Frame #0022 (10/74) (1:32,500 scale) Comment: Similar to Wetland #21, mostly grass and rush.	
Kekaha Quad	23. Wetland - small separated patches near Barking Sands. NASA Flight #74-185, Access #01951, Frame #1157 (10/74) (1:65,000 scale) Comment: This wetland contains *Sesbania tomentosa* H. & A., a rare and endangered species.	

OAHU COUNTY WETLANDS (PHASE ONE)

Sixteen (16) wetland or possible wetland areas have been identified on Oahu Island.

Number Designation.

Each wetland is designated by number and its corresponding USGS 7 1/2 minute quadrangle map. An accompanying mylar overlay registered to the quadrangle map illustrates each wetland delineation.

Letter Designation.

Letter designations indicate that a wetland identified on existing USGS quadrangle maps no longer exists. Agriculture, urban expansion or some other use has resulted in its disappearance.

Photographic Information.

Phase One's task was to locate wetland and possible wetland areas through the use of aerial photographic techniques. Two sources of information were utilized:

1. 1974 and 1975 NASA U-2 High Altitude Aircraft Color Infrared (SO-127) photographs at scales of 1:65,000 and 1:32,500.

2. 1975 and 1976 U.S. Army Corps of Engineers Low Altitude Black and White photographs at a scale of 1:6,000.

All information required for locating the precise photograph utilized is included. To observe particular sites with a stereoscopic viewer, the frames preceding or following those listed should also be obtained. Photography is available at DPED, Coastal Zone Management offices or at the offices of the U.S. Army Corps of Engineers.

Corps Imagery Overlay No.

To identify a wetland boundary with further precision an overlay of the 1:6,000 scale imagery is included. Overlay the correct mylar with its corresponding photograph for a detailed delineation of the wetland. These low altitude photographs exist only along the shoreline areas; inland wetlands are covered with U-2 imagery only. These are identified in the "Corps Imagery Overlay No." column.

	Wetland Number	Corps Imagery Overlay No.
Kanehoe Quad	1. Coastal Wetland NASA Flight #74-179, Access #01942 Frame #0103 (10/74) (1:32,500 scale) Corps Oahu-2-252 (4/13/75)	C7
	2. Coastal Wetland Same (N-1) Corps Oahu-2-245 (4/13/75)	C6
	3. Coastal Wetland - some mangrove by Heeia Fishpond. Same (N-1) Corps Oahu-2-232 (4/13/75)	C5
Mokapu Quad	4. Kawainui Swamp - sedge/reed marsh NASA Flight #74-179, Access #01942 Frame #0087 (10/74) (1:32,500 scale) Comment: Predominant species are Californiagrass and great bullrush.	
	5. Possible wetland near Kaelepulu Pond Comment: Remnant marsh, part of Kawainui swamp.	
	A. Wetland marked on USGS quads, no longer observed - housing development.	
Kaneohe Quad	6. Possible wetland - borders sewage treatment plant. Corps Oahu-2-214 (4/13/75)	C4

	Wetland Number	Corps Imagery Overlay No.
Mokapu Quad	7. Wetland - on Mokapu Peninsula (Federal land) NASA Flight #74-179, Access #01942, Frame #0089 (10/74) (1:65,000 scale) Corps Oahu-2-167 (4/13/75) Corps Oahu-2-201 (4/13/75) Comment: Remnant marsh, U-2 signature indicates bare soil/salt flat.	 C2 C3
Honolulu Quad	8. Possible wetland - inside Diamondhead crater. NASA Flight #75-108, Access #02147 Frame #2912 (7/75) (1:65,000 scale) Corps Oahu-2-68 (3/25/75)	 C1
Waipahu and Ewa Quad	9. Series of small wetlands - West Lock - Pearl Harbor NASA Flight #75-108, Access #02147, Frame #2916 (7/75) (1:65,000 scale) Comment: U-2 signature indicates grasses and mangrove.	
Waianae Quad	10. Wetland - reservoirs filling in NASA Flight #75-108, Access #02147, Frame #2941 (7/75) (1:65,000 scale)	
Kaena Quad	11. Wetland - middle of Dillingham Air Force Base NASA Flight #75-108, Access #02147, Frame #2941 (7/75) (1:65,000 scale)	

Location	Wetland Number	Corps Imagery Overlay No.
Haleiwa	12. Remnant wetland - NASA Flight #75-108, Access #02147, Frame #2947 Corps Oahu-1-252 (4/11/75)	C12
	B. Behind Kaiaka Bay - marsh/wetland indicated on quad but P.I. shows development.	
	13. Wetland - Ukoa Pond NASA Flight #75-108, Access #02147, Frame #2947 (7/75) (1:65,000 scale) Corps Oahu-1-257 (4/11/75)	C11
Waimea Quad	14. Possible wetland - Waimea River, Estuarine Sit. Mouth NASA Flight #75-108, Access #02147, Frame #2948 (7/75) (1:65,000 scale) Corps Oahu-1-267 (4/11/75)	C10
	Comment: Remnant; being taken over by U.H. Agricultural Experiment Station.	
	15. Kalou Marsh NASA Flight #75-108, Access #02147, Frame #2955 (7/75) (1:65,000 scale) Corps Oahu-1-279 (6/3/75)	C9
Kahuku Quad	16. Wetland areas near Kahuku Point (significantly reduced) NASA Flight #75-108, Access #02147, Frame #2954 (7/75) (1:65,000 scale) Corps Oahu-2-325 (6/3/75)	C8

	Wetland Number	Corps Imagery Overlay No.
Kahana Quad	C. Kahana Quad - coastal wetland indicated; U-2 imagery cloud covered; should be checked on low altitude Corps of Engineers photography when available.	

HAWAII COUNTY WETLANDS (PHASE ONE)

Fourteen (14) wetland or possible wetland areas have been identified on Hawaii Island.

Number Designation.

Each wetland is designated by number and its corresponding USGA 7 1/2 minute quadrangle map. An accompanying mylar overlay registered to the quadrangle map illustrates each wetland delineation.

Letter Designation.

Letter designations indicate that a wetland identified on existing USGS quadrangle maps no longer exists. Agriculture, urban expansion or some other use has resulted in its disappearance.

Photographic Information.

Phase One's task was to locate wetland and possible wetland areas through the use of aerial photographic techniques. Two sources of information were utilized:

1. 1974 and 1975 NASA U-2 High Altitude Aircraft Color Infrared (SO-127) photographs at scales of 1:65,000 and 1:32,500.

2. 1975 and 1976 U.S. Army Corps of Engineers Low Altitude Black and White photographs at a scale of 1:6,000.

All information required for locating the precise photograph utilized is included. To observe particular sites with a stereoscopic viewer, the frames preceding or following those listed should also be obtained. Photography is available at DPED, Coastal Zone Management offices or at the offices of the U.S. Army Corps of Engineers.

Corps Imagery Overlay No.

To identify a wetland boundary with further precision an overlay of the 1:6,000 scale imagery is included. Overlay the correct mylar with its corresponding photograph for a detailed delineation of the wetland. These low altitude photographs exist only along the shoreline areas; inland wetlands are covered with U-2 imagery only. These are identified in the "Corps Imagery Overlay No." column.

	Wetland Number	Corps Imagery Overlay No.
SOUTH HAWAII COUNTY		
Kapoho Quad	1. Fishpond filling in, near Haleka Mahina NASA Flight #75-110, Access #02149, Frame #3111 (7/75) (1:65,000 scale) Corps Hawaii-2-79 (1/22/76)	C1
Punaluu	2. Pond area - possible wetland near Punaluu Harbor NASA Flight #74-173, Access #01934, Frame #0053 (10/74) (1:32,500 scale) Corps Hawaii-3-62 (11/4/75)	C2
Kalae	3. Near Kaiole Bay - possible wetland; coastal ponds with aquatic vegetation. NASA Flight #74-173, Access #01934, Frame #0059 (10/74) (1:32,500 scale) Corps Hawaii-2-110 (11/4/75)	C3
Puu Okeokeo	4. "Na Manua Haalou" wetland - aerial photography indicates forest canopy with possible wetland type understory. Photography also indicates reduction of wetland area noted on USGS quad. NASA Flight #74-185, Access #01951, Frame #1107	
Kaunene Quad	5. Wetland indicated on Kaunene Quad NASA Flight #74-185, Access #01951, Frames #1068-1069 (stereo) (10/74) (1:65,000 scale)	

Wetland Number			Corps Imagery Overlay No.
SOUTH HAWAII COUNTY (Continued)			
Kaunene Quad		Comment: No spectral change indicated by vegetation; however, distinct and easily delineated tree height difference is seen in stereoscopic analysis, probably due to wet soil.	
NORTH HAWAII COUNTY			
Keaau Ranch Quad	6.	Small coastal wetland around pond; near Haena NASA Flight #75-110, Access #02159, Frame #3034 (7/75) (1:65,000 scale) Corps Hawaii-3-62 (11/4/75)	C10
Hilo Quad	7.	Kionakapahu and Lokoaka Ponds; may be classified as wetlands based upon surrounding vegetation. NASA Flight #75-110, Access #02149, Frame #3031 (7/75) (1:65,000 scale) Corps Hawaii-1-274 (1/22/76)	C4
Kukuihaele Quad	8.	Waipio Valley wetland NASA Flight #75-110, Access #02149, Frame #3099 (7/75) (1:65,000 scale NASA Flight #75-120, Access #02158, Frame #0028 (7/75) (1:32,500 scale) Corps Hawaii-1-9 (12/11/75)	C5

		Wetland Number	Corps Imagery Overlay No.
NORTH HAWAII COUNTY (Continued)			
Honokane Quad	9.	Waimanu Valley wetland NASA Flight #75-120, Access #02158, Frame #0028 (7/75) (1:32,500 scale) Corps Hawaii-1-79 (12/11/75)	C6
		Comment: Primarily sedge surrounding a pocket of rush/reed vegetation. Bordered by guava, hau, mountain apple, etc. See ESL First Year Report for further description.	
	10.	Pololu Valley wetland NASA Flight #75-120, Access #02158, Frame #0023 (7/75) (1:32,500 scale) Corps Hawaii-1-53 (12/11/75) NASA Flight #74-173, Access #01934, Frame #0134 (10/74) (1:32,500 scale)	C7
Hawi Quad	11.	Wetland area at base and within Puuiki Cone NASA Flight #74-173, Access #01934, Frame #0133 (10/74) (1:32,500 scale)	
Kiholo Quad	12.	Wetland near Kiholo Bay NASA Flight #74-185, Access #01951, Frame #1128 (10/74) (1:65,000 scale) (Corps Hawaii-4-224 (6/29/75)	C11

	Wetland Number		Corps Imagery Overlay No.
NORTH HAWAII COUNTY (Continued)			
Makalawena Quad	13.	Mixahaline Pond undergoing heavy sedimentation near Kawikohale Point NASA Flight #74-185, Access #01951, Frame #1063 (10/74) (1:65,000 scale) Corps Hawaii-4-194 (6/29/75)	C8
Keahole Pt.	14.	Near Honokohau Bay - coastal wetland NASA Flight #74-185, Access #01951, Frame #1065 (10/74) (1:65,000 scale) Corps Hawaii-4-162 (6/29/75)	C9

MAUI COUNTY WETLANDS (PHASE ONE)

Twenty-two (22) wetland or possible wetland areas have been identified on Maui, Molokai, Lanai and Kahoolawe Islands.

Number Designation.

Each wetland is designated by number and its corresponding USGS 7 1/2 minute quadrangle map. An accompanying mylar overlay registered to the quadrangle map illustrates each wetland delineation.

Letter Designation.

Letter designations indicate that a wetland identified on existing USGS quadrangle maps no longer exists. Agriculture, urban expansion or some other use has resulted in its disappearance.

Photographic Information.

Phase One's task was to locate wetland and possible wetland areas through the use of aerial photographic techniques. Two sources of information were utilized.

1. 1974 and 1975 NASA U-2 High Altitude Aircraft Color Infrared (SO-127) photographs at scales of 1:65,000 and 1:32,500.

2. 1975 and 1976 U.S. Army Corps of Engineers Low Altitude Black and White photographs at a scale of 1:6,000.

All information required for locating the precise photograph utilized is included. To observe particular sites with a stereoscopic viewer, the frames preceding or following those listed should also be obtained. Photography is available at DPED, Coastal Zone Management offices or at the offices of the U. S. Army Corps of Engineers.

Corps Imagery Overlay No.

To identify a wetland boundary with further precision an overlay of the 1:6,000 scale imagery is included. Overlay the correct mylar with its corresponding photograph for a detailed delineation of the wetland. These low altitude photographs exist only along the shoreline areas; inland wetlands are covered with U-2 imagery only. These are identified in the "Corps Imagery Overlay No." column.

	Wetland Number	Corps Imagery Overlay No.
MAUI		
Wailuku/ Paia Quads	1. Wetland - Kahana Pond - Waterfowl Refuge NASA Flight #75-115, Access #02155, Frame #3234 (7/75) (1:65,000 scale) Corps Maui-2-73 (3/26/75)	C5
Wailuku Quad	2. Wetland - much filled in - remnants remain Paukukalo NASA - same Corps Maui-2-62 (3/36/75)	C6
	3. Possible Wetland - Coastal - May be inundated with sand. NASA - same Corps Maui-2-60 (3/26/75)	C7
	4. Possible Wetland - near Waihee Pt. NASA - same Corps Maui-2-55 (3/26/75)	C8
	5. Keahikauo and Eke Crater - no photographs available (cloud cover on all). Comment: Delineations made from Wailuku quadrangle map.	
Haiku Quad	6. Possible Wetland - NASA Flight #75-115, Access #02155, Frame #3178 (7/75) (1:65,000 scale) Comment: U-2 signature indicates bare soil wetland located in stream bottom, may be burned over meadow.	

	Wetland Number	Corps Imagery Overlay No.
MAUI (Continued)		
	7. Possible Wetland - NASA - same Comment: Possible small lake.	
Keanae Quad	8. Possible Wetland Area near Waiakuna Pond NASA Flight #75-115, Access #02155, Frame #3175 (7/75) (1:65,000 scale) Comment: Upland area may be marshland due to springs.	
Kaupo Quad	9. Kipahulu Valley - wetland - no good imagery of actual marsh site.	
Maalea Quad	10. Wetland - salt marsh - Kealia Pond Area NASA Flight #75-115, Access #02155, Frame #3247 (7/75) (1:65,000 scale)	
	Corps Maui-1-80 (3/26/75)	C1
	Corps Maui-1-82 (3/26/75)	C2
	Corps Maui-1-85 (3/26/75)	C3
	Comment: Primary species are pluchea and pickleweed.	

	Wetland Number	Corps Imagery Overlay No.
MAUI (Continued)		
Lanaina Quad	11. Wetland NASA Flight #75-115, Access #02155, Frame #3160 (1:65,000 scale) Corps Maui-1-41	C4
	Comment: NASA imagery exhibits bare soil response, Corps imagery indicates lake and mud flat.	
MOLOKAI (MAUI COUNTY)		
Molokai Airport/ Kaunakakai Quads	12. Coastal Wetland NASA Flight #75-115, Access #02155, Corps Molokai-1-283 (C11) to 1-300 (C12) (5/12/75) includes all frames in between and Corps - Molokai 1-276 (C13) (7/4/75)	C11 C12 C13
	Comment: Seaward to pure mangrove swamp with salt marsh with extensive pickleweed inland.	
Kaunakakai Quad	13. Possible Wetland - similar to 1 Corps Molokai-1-272 (7/4/75)	C14
	14. Wetland - fishpond area filling in Corps Molokai-1-268 (7/4/75)	C15
	15. Coastal Wetlands - fishpond fill NASA Flight #75-115, Access #02155, Frame #3183 (1:65,000 scale) Corps Molokai-1-263 (7/4/75)	C16

	Wetland Number	Corps Imagery Overlay No.
MOLOKAI (MAUI COUNTY) (Continued)		
Kaunakakai Quad (continued)	16. Wetland NASA - same Corps Molokai-1-256 (7/4/75)	C17
	17. Fishpond fill-in NASA - same Corps Molokai-1-246 (5/12/75)	C18
	18. Fishpond fill-in NASA - same Corps Molokai-1-243 (5/12/75) Corps Molokai-1-241 (5/12/75)	C19 C20
	19. Coastal Wetland NASA - same Corps Molokai-1-235 (5/12/75)	C21
	20. Coastal Wetland - fishpond sedimented in. Corps Molokai-1-311 (5/12/75)	C9
	21. Coastal Wetland - fishpond sedimented in. Corps Molokai-1-305 (5/12/75)	C10
	22. Coastal wetland - fishpond remnant Corps Molokai-1-225 (5/12/75)	C22

APPENDIX B. KAUAI INVENTORY OVERLAY CLASSIFICATIONS AND DESCRIPTIONS.

Overlay #1 - Land Use Districts.

Discussion of Land Use Districts as described in the State Land Use Commission Rules of Practice and Procedure and District Regulations, 1975.

Part II. Establishment of State Land Use Districts.

2-1. Districts and District Maps.

In order to effectuate the purposes of the Land Use Law, all the lands in the State shall be divided and placed into one of the four (4) Land Use Districts:

"U"	Urban District
"A"	Agricultural District
"C"	Conservation District
"R"	Rural District

The boundaries of the above-mentioned Districts are shown on the maps on file in the Commission office. Not all ocean areas and off-shore and outlying islands of the State in the Conservation District are shown when deemed unnecessary to do so. The maps shall be designated as the "Land Use District Maps of the State of Hawaii."

In establishing the boundaries of the districts in each County, the Commission shall give consideration to the General Plan of the County.

2-2. Standards for Determining District Boundaries.

The following standards shall be used in establishing the district boundaries.

1. "U" Urban District. In determining the boundaries for the "U" Urban District, the following standards shall be used:

   a. It shall include lands characterized by "city-like" concentrations of people, structures, streets, urban level of services and other related uses.

   b. It shall take into consideration the following specific factors:

      1. Proximity to centers of trading and employment facilities except where the development would generate new centers of trading and employment.

      2. Substantiation of economic feasibility by the petitioner.

      3. Proximity to basic services such as sewers, water, sanitation, schools, parks, and police and fire protection.

2-2. -- Continued.

4. Sufficient reserve areas for urban growth in appropriate locations based on a ten (10) year projection.

c. Lands included shall be those with satisfactory topography and drainage and reasonably free from the danger of floods, tsunami and unstable soil conditions and other adverse environmental effects.

d. In determining urban growth for the next ten years, or in amending the boundary, lands contiguous with existing urban areas shall be given more consideration than non-contiguous lands, and particularly when indicated for future urban use on State or County General Plans.

e. It shall include lands in appropriate locations for new urban concentrations and shall give consideration to areas of urban growth as shown on the State and County General Plans.

f. Lands which do not conform to the above standards may be included within this District:

1. When surrounded by or adjacent to existing urban development; and

2. Only when such lands represent a minor portion of this District.

g. It shall not include lands, the urbanization of which will contribute towards scattered spot urban development, necessitating unreasonable investment in public supportive services.

h. It may include lands with a general slope of 20% or more which do not provide open space amenities and/or scenic values if the Commission finds that such lands are desirable and suitable for urban purposes and that official design and construction controls are adequate to protect the public health, welfare and safety, and the public's interests in the aesthetic quality of the landscape.

2. "A" Agricultural District. In determining the boundaries for the "A" Agricultural District, the following standards shall apply:

a. Lands with a high capacity for agricultural production shall be included in this District except as otherwise provided for in other sections of these regulations.

2-2. -- Continued.

b. Lands with significant potential for grazing or for other agricultural uses shall be included in this District except as otherwise provided for in other sections of these regulations.

c. Lands surrounded by or contiguous to agricultural lands and which are not suited to agricultural and ancillary activities by reason of topography, soils and other related characteristics may be included in the Agricultural District.

d. Lands in intensive agricultural use or lands with a high capacity for intensive agricultural use shall not be taken out of this District unless the Commission finds either that:

1. such action will not substantially impair actual or potential agricultural production in the vicinity of such lands, and/or

2. such action is reasonably necessary for urban growth.

3. "C" Conservation Districts. In determining the boundaries for the "C" Conservation District, the following standards shall apply:

2-2. -- Continued.

a. Lands necessary for protecting watersheds, water sources and water supplies shall be included in this District except as otherwise provided for in other sections of these regulations.

b. Lands susceptible to floods, and soil erosion, lands undergoing major erosion damage and requiring corrective attention by the State or Federal Government, and lands necessary for the protection of the health and welfare of the public by reason of the lands' susceptibility to inundation by tsunami and flooding, to volcanic activity and landslides may be included in this District.

c. Lands used for national or state parks may be included in this District.

d. Lands necessary for the conservation, preservation and enhancement of scenic, historic or archaeologic sites and sites of unique physiographic or ecologic significance shall be included in this District except as otherwise provided for in other sections of these regulations.

2-2. -- Continued.

e. Lands necessary for providing and preserving parklands, wilderness and beach reserves, and for conserving natural ecosystems of endemic plants, fish and wildlife, for forestry, and other related activities to these uses shall be included in this District except as otherwise provided for in other sections of these regulations.

f. Lands having an elevation below the maximum inland line of the zone of wave action, and marine waters, fish ponds and tide pools of the State shall be included in this District unless otherwise designated on the district maps. All offshore and outlying islands of the State of Hawaii are classified Conservation unless otherwise indicated.

g. Lands with topography, soils, climate or other related environmental factors that may not be normally adaptable or presently needed for urban, rural or agricultural use, shall be included in this District, except where such lands constitute areas not contiguous to the Conservation District.

2-2. -- Continued.

h. Lands with a general slope of 20% or more which provide for open space amenities and/or scenic values shall be included in this District except as otherwise provided for in other sections of these regulations.

i. Lands suitable for farming, flower gardening, operation of nurseries or orchards, growing of commercial timber, grazing, hunting, and recreational uses including facilities accessory to such uses when said facilities are compatible with the natural physical environment, may be included in this District.

4. "R" Rural District. In determining the boundaries for the "R" Rural District, the following standards shall apply:

a. Areas consisting of small farms; provided that such areas need not be included in this District if their inclusion will alter the general characteristics of the areas.

b. Activities or uses as characterized by low density residential lots of not less than one-half (1/2) acres and a density of not

2-2. -- Continued.

more than one single-family dwelling per one-half (1/2) acre in areas where "city-like" concentration of people, structures, streets, and urban level of services are absent, and where small farms are intermixed with the low density residential lots.

c. Generally, parcels of land not more than five (5) acres; however, it may include other parcels of land, which are surrounded by, or contiguous to this District and are not suited to low density residential uses or for small farm or agricultural uses.

Overlay #2 - Transportation.

The thick lines represent major transportation networks.

Thin lines represent paved roads.

Dashed lines represent jeep trails or foot paths.

Much transportation information already exists in other places. This overlay provides a base upon which that portion of the transportation network revelant to CZM planning can be illustrated.

The information on this overlay was obtained via USGS Quadrangle maps and updated by analysis of aerial photographs. As more data is incorporated into this overlay system, documentation should be made to indicate its accuracy.

Transportation networks are essential to any economic planning. Access to a given resource or area is required for utilization of resources; but may also contribute to a decline in resources.

Transportation classification systems were not investigated in depth; and this remains an area for further study and expansion. Such systems could include, for example, road type, load carrying capacity, traffic density, and critical intersections (note points). Review and comments are encouraged to define needed categories more precisely.

In the maps prepared the heavy black lines represent major public transportation routes. Medium black lines indicate secondary black-topped private and public roads. Dirt roads and trails were not mapped, but could be added easily.

In several instances, roads portrayed on the U.S.G.S. quadrangle map were not evident on current photographs; in other cases new roads found on the photographs were added to the overlay.

Overlay #3 - Land Use Classification.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
1 Urban			
	11 Residential		
		111 Single Family	
		112 Multi-Family	
	12 Commercial Complex		
		121 Business/Government	
		122 Commercial/Light Industrial	
		123 Institutional	
			1231 School
			1232 Hospital
			1233 Cemetery
		124 Resort/Hotel	
		125 Other	
	13 Industrial Complex		
		131 Light Industry	
		132 Heavy Industry	
		133 Petroleum/Chemical Processing	
		134 Food Processing	
		135 Other	
	14 Transportation		
		141 Airport	
		142 Ferry Service/Facility	
		143 Other	

Overlay #3 - Land Use Classification -- Continued.

LEVEL I	LEVEL II	LEVEL II	LEVEL IV
	15 Communications/Utilities		
		151 Radio/Broadcasting Facility	
		152 Tracking Facility	
		153 Power Generation Facility	
		154 Water Treatment/Storage Facility	
			1541 Water Supply
			1542 Sewage Treatment
		155 Other	
	16 Recreational		
		161 Park/Athletic Facility	
		162 Golf Course	
		163 Other	
	17 Harbor/Port Facility		
		171 Commercial Cargo/Shipping	
		172 Marina	
		173 Other	
	18 Construction/Under Development		
		181 Residential	
		182 Commercial	
		183 Industrial	
		184 Other	
	19 Mixed Complex		
2 Agriclture			
	21 Row and Field Crops		
		211 Sugar Cane	
		212 Truck Farming	
		213 Taro	
		214 Other	

Overlay #3 - Land Use Classification -- Continued.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
	22 Orchards/Vineyards		
	23 Grazing Area/Pasture		
	24 Facilities/Equipment		
	25 Irrigation Pond		
	26 Other		
3 Undeveloped Areas			
	31 Urban Zone		
		311 Vegetative Ground Cover	
		312 Open Land	
	32 Rural Zone		
		321 Vegetative Ground Cover	
		322 Open Land	

Land Use Classification System Description.

1 Urban

Includes all units and complexes usually associated with the urban environment. This Level I class is divided into the following groups:

11 Residential

Contains units of habitation and domestic dwellings within the urban environment.

111 Single Family

Includes only single family residences such as tract-type homes and individual dwellings.

112 Multi-Family

This category includes complexes such as duplexes, triplexes, apartments and condominiums. It does not include complexes such as resorts which are transient in nature.

12 Commercial Complex

Includes all structures and facilities normally associated with the business sector of the urban environment although not specifically limited to retail/wholesale business.

121 Business/Government

Areas of mixed structures including both retail and wholesale businesses. This category also includes structures and facilities associated with govermental operations since such facilities are generally mixed among the retail business structures.

122 Commercial/Light Industrial

Areas of mixed uses generally associated with small production facilities and wholesale business trade although not exclusively limited to such endeavors. These areas are generally located on the perimeter of the urban area and not in the central business district.

123 Institutional

Facilities generally associated with public aid, education, and/or other such endeavors. This category is further subdivided into the following specific facilities:

1231 School

Including all buildings and fields associated with elementary, intermediate, and high schools.

1232 Hospital

Includes all buildings and associated grounds.

1233 Cemetery

Self-explanatory.

124 Resort/Hotel

Includes all structures and facilities related to the tourist or transient trade. This category includes certain recreational facilities associated with the resort/hotel and not normally available for public use, such as private tennis courts, golf courses, etc.

125 Other

This category includes all commercial complex structures and facilities which are not specifically associated with classes 121 through 124.

13 Industrial Complex

This category includes all structures, facilities, and associated grounds used for manufacturing or processing purposes. Such facilities are generally not associated with the retail trade and are usually located on the perimeter of the urban area.

131 Light Industry

Generally associated with manufacturing processes such as electronics production, textile manufacturing, small parts production, and so forth. Complexes generally have small ratio of waste per unit produced.

132 Heavy Industry

Generally associated with larger manufacturing complexes and facilities and includes such endeavors as steel production and fabrication, heavy equipment fabrication and so forth. The ratio of waste per unit produced is generally higher than in light industrial complexes.

133 Petroleum/Chemical Processor

Includes all associated structures, facilities and grounds.

134 Food Processing

Includes such facilities as sugar processing mills, grain facilities, fruit and vegetable canning operations and so forth.

135 Other

This category includes all industrial complex structures and facilities which are not specifically associated with classes 131 through 134.

14 Transportation

This category includes only complexes associated with a transportation service. It does not include roadways and streets, which are included on the Transportation Overlay #2.

141 Airport

Includes both public and private airports and all such associated facilities and grounds.

142 Ferry Service/Facility

Includes structures and facilities associated with inner-island and inter-island, over-water ferry service.

143 Other

This category includes all transportation facilities not specifically associated with classes 141 or 142.

15 Communications/Utilities

Includes all facilities and grounds associated with communications and public service utilities.

151 Radio/Broadcasting Facility

Includes all associated structures and grounds including antenna farms.

152 Tracking Facility

Includes all structures and grounds associated with radar and other types of tracking facilities.

153 Power Generation Facility

Includes hydroelectric, petroleum-based, and nuclear type power generation facilities and structures.

154 Water Treatment/Storage Facility

Includes the following categories:

1541 Water Supply

All associated facilities used for processing of urban water supply including residential, commercial, and industrial.

1542 Sewage Treatment

Includes all facilities and equipment used in the processing of municipal waste regardless of level (primary, secondary, tertiary).

155 Other

This category includes all communication/utilities type facilities not specifically associated with classes 151 through 154.

16 Recreational

Includes all structures, facilities, and grounds associated with public recreational activities. Private facilities associated with resorts or hotels are not included in this category.

161 Park/Athletic Facility

Includes all public facilities for recreational activities, such as picnic areas, campgrounds, athletic fields, and so forth.

162 Golf Course

Self-explanatory.

163 Other

Includes all categories of recreational facilities not specifically included in categories 161 or 162.

17 Harbor/Port Facility

Includes water based shelters and facilities whether natural or man-made, or used for either large ships or small boats.

171 Commercial Cargo/Shipping

Includes those facilities and structures associated with large ships and commercial cargo operations.

172 Marina

Includes all facilities and structures associated with small boat operations. These operations may be either private in nature, such as pleasure craft, or commercial in nature, such as sight-seeing or commercial fishing operations.

173 Other

Includes all categories of harbor/port facilities which are not specifically included in categories 171 or 172.

18 Construction/Under Development

Includes all areas under some stage of urban development at the time of interpretation. The stage of development is not defined but the type of development may be defined in one of the following categories:

181 Residential

May include single or multi-family structures.

182 Commercial

May include business structures or governmental facilities. This category may also include such facilities as resorts or hotels under construction as well as institutional facilities.

183 Industrial

Includes such areas as light and/or heavy industrial complexes as well as food, chemical, or petroleum facilities under construction.

184 Other

Includes those areas under construction which are not specifically included in categories 181 through 183.

19 Mixed Complex

This category includes those areas of urban structures and facilities that are very mixed in nature and are too complex to be separated into individual categories. Such areas are generally a mix of residential and commercial categories but may also include industrial, recreational, transportation, and communication/utilities facilities.

2 Agriculture

This category includes thos lands not normally associated with the urban environment, although small plots of agricultural land may be located within the urban area. This category includes both fallow and cultivated farm lands used in the raising of crops or animal husbandry.

21 Row and Field Crops

This category includes those agricultural lands both fallow and under cultivation in which the primary crop is planted and harvested on a random basis depending on the crop type. This category includes only large areas of row and field crops and also includes small truck-farming operations.

211 Sugar Cane

Includes areas of sugar cane production, regardless of whether the land is fallow or under cultivation at the time of interpretation.

212 Truck Farming

Includes areas of rotational croppings generally used for growing vegetables or other highly perishable crops. Truck farms are usually labor intensive and small in acreage, although there may be large areas of truck farming. The products grown may be for private consumption or commercial sales and/or distribution.

213 Taro

Includes those lands either fallow or under cultivation used in the production of taro.

214 Other

Includes those categories of row and field crops not specifically included under categories 211 through 213.

22 Orchards/Vineyards

Includes those areas under cultivation used for growing and production of tree crops and vine crops. These areas are usually enclosed and used for the production of various kinds of fruit.

23 Grazing Area/Pasture

Includes those areas, used for grazing of cattle, sheep, and/or goats, which are predominantly grassland in nature. These grasslands may be either irrigated or reliant on natural water sources.

24 Facilities/Equipment

The category includes those areas used for the storage and/or maintenance of farm related equipment. It includes all such related structures, facilities and grounds.

25 Irrigation Pond

Includes all water holding facilities used for the storage of irrigation water. These facilities may be either man-made or natural ponds and include settling and catch basins.

26 Other

This category includes all agricultural structures, facilities, and grounds not specifically defined by categories 21 through 25.

3 Undeveloped Areas

Includes those areas of land not presently used for development of either an urban or agricultural resource. These lands are essentially undisturbed in nature and may be either barren or covered in varying degrees by different types of vegetative ground cover.

31 Urban Zone

Those areas which are undeveloped and essentially contained within the urban zone. These areas may be developed at some future time depending on suitability due to their proximity to the urban zone.

311 Vegetative Ground Cover

Includes those undeveloped areas within the urban zone which contain some form of vegetative ground cover. This may range from open grasslands to forest stands.

312 Open Land

Includes those undeveloped areas within the urban zone which are essentially barren soil devoid of any significant vegetative ground cover.

32 Rural Zone

Includes those areas which are undeveloped and essentially contained within the rural zone.

321 Vegetative Ground Cover

Includes those undeveloped areas within the rural zone which contain some form of vegetative ground cover. This may range from open grasslands to forest stands.

322 Open Land

Includes those undeveloped areas within the rural zone which are essentially barren soil devoid of any significant vegetative ground cover.

Overlay #4 - Vegetation Classification System.

Four levels of detail are provided when this could be consistently provided by photo interpretation. The primary emphasis has been in defining the vegetation types in the coastal area. It will be helpful to read the description of each type prior to analyzing the vegetation overlays. Type names are generalized; the description provides more detail.

The general classification system used here can easily be modified to respond to the CZM requirements. Quantitative vegetation surveys may be required to fulfill requirements under the 306 portion of the CZM Act. This vegetation survey is intended to provide a general overview of major vegetation communities in the Kauai coastal areas.

Overlay #4 - Vegetation Classification Scheme.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
1 Urban			
	11 Golf course		
	12 Idle waste field and/or woodlot		
2 Agriculture			
	21 Row and field crops		
		211 Sugar cane	
		212 Truck farming	
		213 Taro	
		214 Other	
	22 Orchards and vineyards		
	23 Idle field (not in production)		
		231 Sugar cane	
		232 Abandoned pineapple	
3 Grassland			
	31 Open grassland		
	32 Mixed grassland shrub		
	33 Grassland/forb		
4 Forest			
	41 Exotic plantations		
		411 Eucalyptus	
		412 Cedrela-Albizia	
		413 Conifers	
		414 Other and mixed	
	42 Native or naturalized forest		
		421 Koa	
		422 Ohia-lehua	
		423 Ohia-Koa	
		424 Ohia-Koa/Staghorn fern	
		425 Riparian	

Overlay #4 - Vegetation Classification Scheme -- Continued.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
			4251 Hau-Java plum-Guava
			4252 Pandanus
			4253 Kukui
			4254 Mixed riparian
		426 Silk-oak	
		427 Mixed forest	
		428 Kiawe	
		429 Coastal stand and other	
			4291 Coastal stand
			4292 Other
5 Shrub			
	51 Lowland shrub		
		511 Koa-haole	
		512 Koa-haole/Kiawe	
		513 Lowland complex	
		514 Ironwood/Staghorn fern	
		515 Staghorn fern/forb	
		516 Other	
	52 Upland shrub		
	53 Mixed		
6 Barren land			
	61 Pali or hillside		
	62 Bare soil-sand-rock		

Vegetation Classification Descriptions.

1 Urban

Areas in which the vegetation consists of horticultural, ornamental and shade trees associated with urban areas. Two Level II subtypes are recognized.

11 Golf Course

Self-descriptive.

12 Idle Waste Fields and/or Woodlots

Open fields and/or woodlots, generally within an urban area. Species found in these areas are quite variable. Common woody species are Christmas berry, ironwood, Java plum, exotic trees, indigo Pluchea, Desmodium, and numerous grasses and forbs.

2 Agriculture

The primary vegetation in these areas are cultivated and managed croplands. Agriculture does not include grassland. Three Level II subtypes are described.

21 Row and Field Crops

Areas are devoted to row and field crops. Four Level III subtypes are described. Fallow field under planned rotation and those newly planted are included in the respective subtypes where known (e.g., sugar cane).

211 Sugar Cane

Self- descriptive.

212 Truck Farming

Areas containg papaya, commercial bananas, tomatoes, squash, melons and other vegetables.

213 Taro

Self- descriptive.

214 Other

Areas planted to crops other than those described above.

22 Orchards and Vineyards

Self- descriptive.

23 Idle Field (Not in Production)

These areas were once in production and various crops are still present though not under management (fallow field under planned rotation not included in this category); two Level III subtypes are described.

231 Abandoned Sugar Cane

Old abandoned sugar cane fields being invaded by grasses, forbs and trees and shrubs. Java plum, Christmas berry, californiagrass, morning glory, Paspalum sp. and varied forb species.

232 Abandoned Pineapple

Old abandoned pineapple field being invaded by grasses, forbs and trees. Those species typically found encroaching were African tulip tree, Christmas berry, gold fern, californiagrass, morning glory, Paspalum spp., Digitaria sp.

3 Grassland

Area consisting primarily of grass or grass shrub mixtures where grass and forbs comprise 75% or more of the area. Three Level II subtypes are described.

31 Open Grassland

Grass areas consisting predominantly of grass with forbs. Major grasses include californiagrass, Kikuyugrass, Digitaria sp., Cyonodon sp., and Paspalum sp. Brush or woody vegetation comprise 20 percent or less of these stands. Various forb species are also common, but are not predominant vegetation.

32 Mixed Grassland Shrub

Grassland areas in which woody species such as Hau, Java plum, Christmas berry, Koa-haole comprise 20 to 50 percent of the area either in isolated dense patches or in combination with the grasses. Grass species are similar to those under 31 Open Grassland.

33 Grassland/Forbs

Areas generally containg both grass and forbs, but where forbs comprise at least 50% of the area. Typically these types are found on moist hillsides and in meadow areas.

4 Forest

Large homogeneous areas of forest vegetation; two Level II subtypes are described.

41 Exotic Plantations

Forest planations comprised of various species of exotic trees. These stands have been planted by man and typically are under some form of management. The following Level III subtypes are described.

411 Eucalyptus

Forest plantations and plantings composed predominantly of Eucalyptus, including swamp mahogany, red mahogany, blackbutt, lemon-scented gum, and flooded gum, singly or in combination.

412. Cedrela-Albizzia

Forest planting composed predominantly of cedrela, toona, albizia, ash or alder species, singly or in combination.

413 Conifers

Forest planting composed predominantly of conifer species including Cook and Norfolk Island pines, redwood, pines and Crytomeria singly or in combination.

In some cases naturalized Ironwood will also be found intermixed in these stands.

414 Other and Mixed

Forest plantings of species other than those above or intermixed stands of the above too small to delineate separately.

42 Native or Naturalized Forest

Forested areas with natural reproduction of native or naturalized tree species. The following Level III subtypes are described.

421 Koa

Forested areas in which Koa trees predominate and comprise 25 percent or more of the stands and in which Koa trees comprise less than 25 percent of the stands. This includes both commercial and non-commercial stands.

422 Ohia-Lehua

Forests in which Ohia-lehua trees predominate and comprise 25 percent or more of the stands. This includes commercial and non-commercial stands.

423 Ohia-Koa

Forests in which Ohia-lehua and Koa trees are predominant and each comprise 25 percent or more of the stand. This includes both commercial and non-commercial stands.

424 Ohia-Koa Staghorn Ferns

Open forested area where the predominant trees are Ohia-lehua and Koa with extensive understory of staghorn fern. Other tree and brush types found in these areas include Kukui, ironwood (at lower elevations), Christmas berry, lantana, malabar melastome and an occasional Hala.

425 Riparian

Forest communities typically found in valleys and stream bottoms on the windward side of the Island where they tend to grow quite dense and vigorous (closed canopy). The following subtypes are described.

4251 Hau-Java Plum-Guava

Riparian vegetation in low elevation stream bottoms consisting of tall shrubs to tree-like stands in

4251 -- Continued.

which Hau, Java plum and common guava, singly or in combiantion, are the predominant species. Mangrove ironwood, monkeypod, Hala are found occasionally, along with Christmas berry and pluchea.

4252 Pandanus

Riparian vegetation where Hala is the predominant species in combination with Hau, Java plum, guava and associated shrub species.

4253 Kukui

Riparian or moist mountain hillside in which Kikui trees comprise 75% or more of the stand.

4254 Mixed Riparian

Very complex riparian stands in valley and stream bottoms at low elevation. Species include Hau, Java plum, Christmas berry, Hala, ironwood, conifers, mangrove, common and strawberry guava. Also frequent but not abundant are mango, African tulip tree, bananas, monkeypod. These stands grade into 4251 where the Hau, Java plum and guava are predominant and also into 427 Mixed Forest which occupy the mountainside. Absent from the mixed riparian are the Ohio-lehua and Koa and associated shrub types.

426 Silk-Oak

Forest comprised predominantly of naturalized silk-oak stands. These forests tend to be open and associated species include, Aalii, lantana, Pukiawe, acacia and sandalwood, strawberry guava. Ohia-lehua and Koa can also be found at the higher elevations.

427 Mixed Forest

Forested areas comprised of a wide variety of tree and brush types. Typically these will include Koa, Ohia-lehua, Kukui, Java plum, albizia, monkeypod, Christmas berry, common guava, strawberry guava, Noni, Hala, lantana. Forbs and grasses are also mixed including Hilograss, californiagrass (in wet areas, ferns). Specific mixture varies from stand to stand.

428 Kiawe

Forested area comprised of 75 percent or more dense Kiawe trees usually found on lower moist sites (kiawe is also typically found in shrub form; see category 513).

429 Coastal Strand and Other

Forest stands consisting of either coastal stands or other forest stands as described below.

4291 Coastal Strand

Vegetative strips on or near the coast consisting of ironwood, and Naupaka, singly or in combination, and scattered exotic species. In most areas little or no ground cover is present.

4292 Other

Other undifferentiated forest stands not described in the forest types.

5 Shrub/Brushland Forest

Areas consisting primarily of shrubs or tree types with shrub-like morphology. This basic type is quite variable. Three Level II subtypes are described.

51 Lowland Shrub

These are areas at the lower elevations with 10% tree cover or less; however, in some cases tree species are very common, e.g., Kiawe, but growing in a shrub-like form. Five Level III subtypes are described.

511 Koa-Hoale

Area where Koa-hoale comprise 75% or more of the vegetation stand.

512 Koa-Hoale/Kiawe

Areas in which Koa-hoale and Kiawe comprise 70% or more of the vegetation in combination.

513 Lowland Complex

An extremely diverse shrub mixture consisting of Christmas berry, guava, ironwood, Malabar melostom, shoebutton ardesia, Caesalpina sp. in varying combinations from pure stands to standard mixtures, Java plum and guava are found at lower elevations with shrub-like Ohia-lehua at intermediate elevations. One may also find small patches of forest or scattered forest trees in these areas. This type grades into forest types 427, 424, and 425.

514 Ironwood/Staghorn Fern

Areas contain a mixture of trees and brush similar to type 513, but where ironwood and/or staghorn fern comprise 50% of the vegetation.

515 Staghorn Fern/Forb

This type has some morphological similarities to 33 Grassland/Forbs. However, grasses comprised 10% or less of the area with staghorn fern and other herbaceous types comprising 50% or more of the stand. Ironwood and other trees and brush types present, but do not dominate.

516 Other

Other lowland vegetation types are defined above.

52 Upland Shrub

Shrub types consisting of Mamane Pukiawe, Aalii, Naio, Ohelo and raillardia, singly or in combination.

53 Mixed

Area containing a mixture of upland and lowland varieties, appears most common on western slopes where Aalii, lantana and Koa-haole intermix at intermediate elevations.

6 Barren Land

Areas with 15% or less ground cover. Two Level II subtypes are described.

61 Pali and Hillside

Very steep or rocky hillsides.

62 Bare Soil-Sand-Rock

Areas mostly void of vegetation not in category 61 above. This category does not include fallow or plowed agricultural fields; see category 2.

Overlay #5 - Shoreline Habitat.

To use the shoreline habitat classification, note there are four levels of detail. The two major levels, I (protected and exposed) and II (open coast, bay, estuary), are given a line symbol such as a dotted line, dashed line, etc. in addition to a number designation. On the overlay map, a double symbol line parallels the shoreline. The inner (Mauka) line represents Level I; the outer (Makai) line represents Level II. Levels III and IV are indicated, in respective order, directly on the overlay with numerical symbols. Prior to using the classification scheme, read the classification description. This will clarify meanings which might otherwise be misconstrued.

Overlay #5 - Shoreline Habitat Classification Scheme.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
1. Protected	1. Open coast	1. Rocky shoreline	1. Rocky seacliff 2. Boulder beach 3. Cobble beach 4. Outcrop/ terrace
		2. Sandy beach	1. Black (lava) 2. White (calcareous) 3. Terrestrial sediment 4. Mix
		3. Lava	1. Shallow bench 2. Basalt outcrop
		4. Mud flat	1. Tidal mud flat 2. Vegetated
		5. Man altered	1. Docks/piers 2. Breakwater 3. Coral land fill 4. Dredged area 5. Sea wall 6. Other
		6. Other	(see vegetation and wetlands overlays)
	2. Bay	1. Rocky shoreline	1. Rocky seacliff 2. Boulder beach 3. Cobble beach 4. Outcrop/ terrace

Overlay #5 - Shoreline Habitat Classification Scheme -- Continued.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
		2. Sandy beach	1. Black (lava) 2. White (calcareous) 3. Terrestrial sediment 4. Mix
		3. Lava	1. Shallow bench 2. Basalt outcrop
		4. Mud flat	1. Tidal mud flat 2. Vegetated
		5. Man altered	1. Docks/piers 2. Breakwater 3. Coral land fill 4. Dredged area 5. Sea wall 6. Other
		6. Other	(see vegetation and wetlands overlays)
	3. Estuary	1. Rocky shoreline	1. Rocky seacliff 2. Boulder beach 3. Cobble beach 4. Outcrop/ terrace
		2. Sandy beach	1. Black (lava) 2. White (calcareous) 3. Terrestrial sediment 4. Mix

Overlay #5 - Shoreline Habitat Classification Scheme -- Continued.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
		3. Lava	1. Shallow bench 2. Basalt outcrop
		4. Mud flat	1. Tidal mud flat 2. Vegetated
		5. Man altered	1. Docks/piers 2. Breakwater 3. Coral land fill 4. Dredged area 5. Sea wall 6. Other
		6. Other	(see vegetation and wetlands overlays)
2. Exposed	1. Open coast	1. Rocky shoreline	1. Rocky seacliff 2. Boulder beach 3. Cobble beach 4. Outcrop/ terrace
		2. Sandy beach	1. Black (lava) 2. White (calcareous) 3. Terrestrial sediment 4. Mix
		3. Lava	1. Shallow bench 2. Basalt outcrop
		4. Mud flat	1. Tidal mud flat 2. Vegetated

Overlay #5 - Shoreline Habitat Classification Scheme -- Continued.

LEVEL I	LEVEL II	LEVEL III	LEVEL IV
		5. Man altered	1. Docks/piers 2. Breakwater 3. Coral land fill 4. Dredged area 5. Sea wall 6. Other
		6. Other	(see vegetation and wetlands overlays)
	3. Estuary	1. Rocky shoreline	1. Rocky seacliff 2. Boulder beach 3. Cobble beach 4. Outcrop/ terrace
		2. Sandy beach	1. Black (lava) 2. White (calcareous) 3. Terrestrial sediment 4. Mix
		3. Lava	1. Shallow bench 2. Basalt outcrop
		4. Mud flat	1. Tidal mud flat 2. Vegetated
		5. Man altered	1. Docks/piers 2. Breakwater 3. Coral land fill 4. Dredged area 5. Sea wall 6. Other
		6. Other	(see vegetation and wetlands overlays)

Shoreline Habitat Classification Description.

Figure B-1 illustrates Kauai Island and its dominant wind and wave pattern. The northeast tradewinds ensure a generally predominant wave direction from the northeast. Arctic storms also send storm waves toward Hawaii from this direction. The general result is a high energy wave force impacting the portion of Island exposed to the northeast. This is the windward side of Kauai. If the waves do not strike directly against the land, they refract or bend, losing force as they do so. The result is a lower energy wave force directed against the opposite or leeward side of the Island. Kona winds, equatorial storms and high energy wave refraction do occur and occasionally strike the lee side with high energy. However, this is not the norm. Thus Figure B-1 divides Kauai into windward and leeward portions, each with its own general wave force relationship. When using the shoreline habitat classification first determine whether your specific geographic location is windward or leeward. This done, proceed to Level I, II, II, and IV respectively.

Level I.

1. PROTECTED: This category deals with semi-sheltered coast and open bays where the wave shock is somewhat attenuated prior to reaching the shoreline. These areas provide a protected habitat and usually abound with floral and faunal species. They are usually concave. These areas are also among the most attractive to man since wave force destructive to his shoreline alterations is reduced.

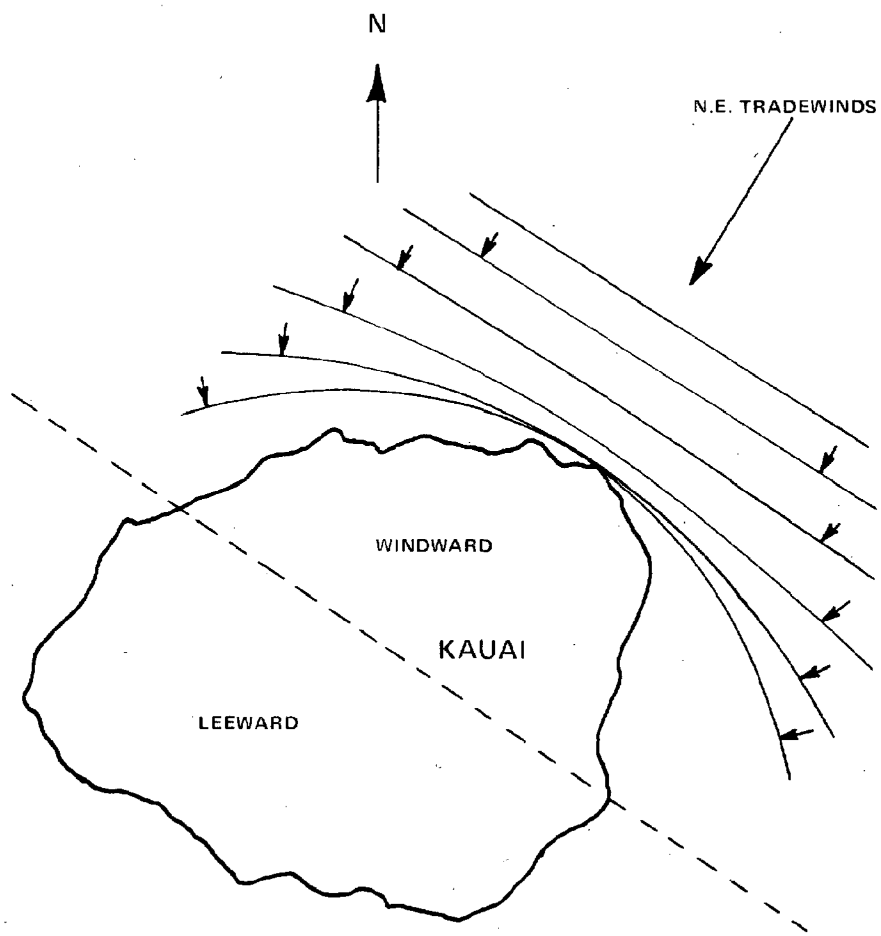


Figure B-1. Preliminary Classification Level - Windward, Leeward Designations

U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY 1

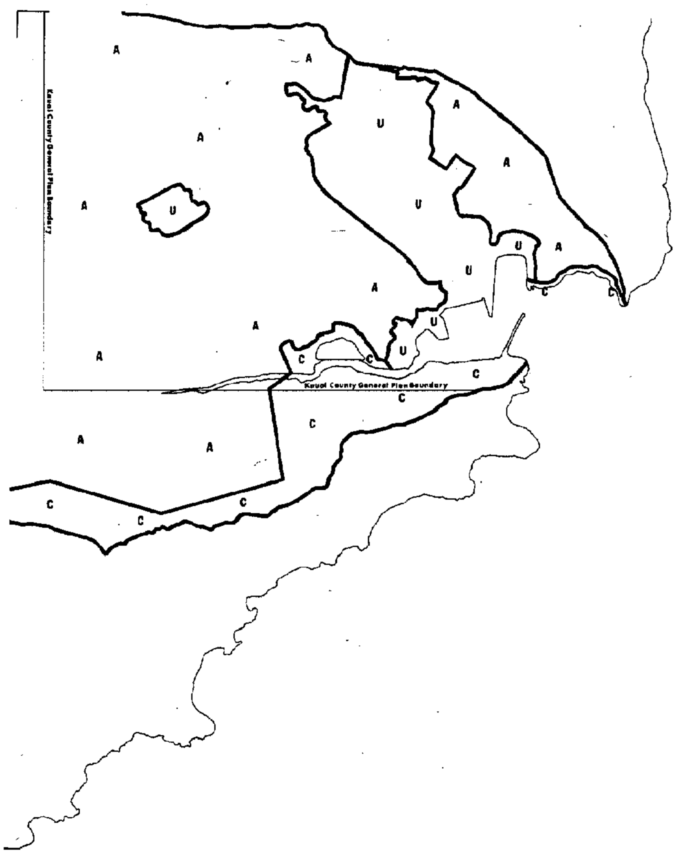
LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIRP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline black and white photography.

This map is financed in part through a coastal zone management program development grant from the United States Department of Commerce.

This map is for planning purposes only and should not be used for engineering survey applications.



U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY **2**

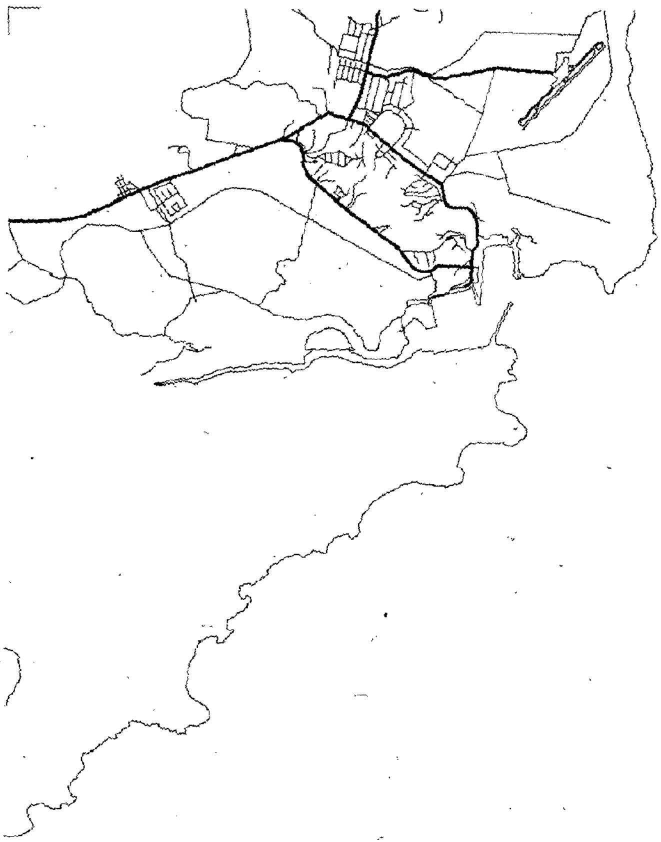
LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

[illegible]

[illegible]

[illegible]



U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY 3

LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AERP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline, black and white photography.

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U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

COASTAL ZONE MANAGEMENT
PROTOTYPE

LIHUE QUAD

KAUAI COUNTY

OVERLAY **4**

LEGEND AND DESCRIPTION KEYS SEPARATE

Prepared by E.S.L. Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIRP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline, black and white photography.

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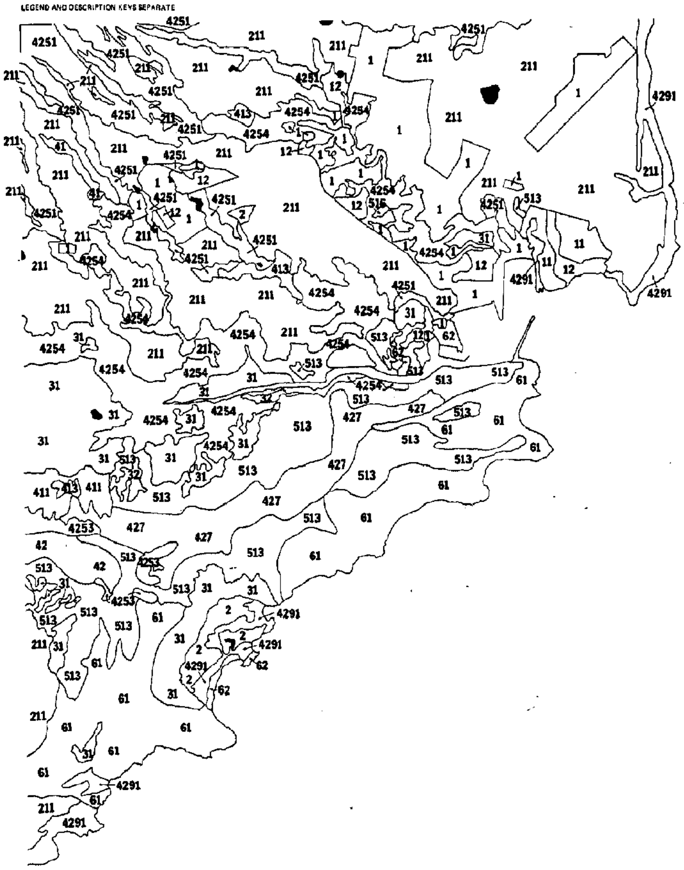

U.S.G.S. 7 1/2 MINUTE MAP
SCALE 1 24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY **5**

LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIRP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline, black and white photography.

This map is financed in part through a coastal zone management program development grant from the United States Department of Commerce.

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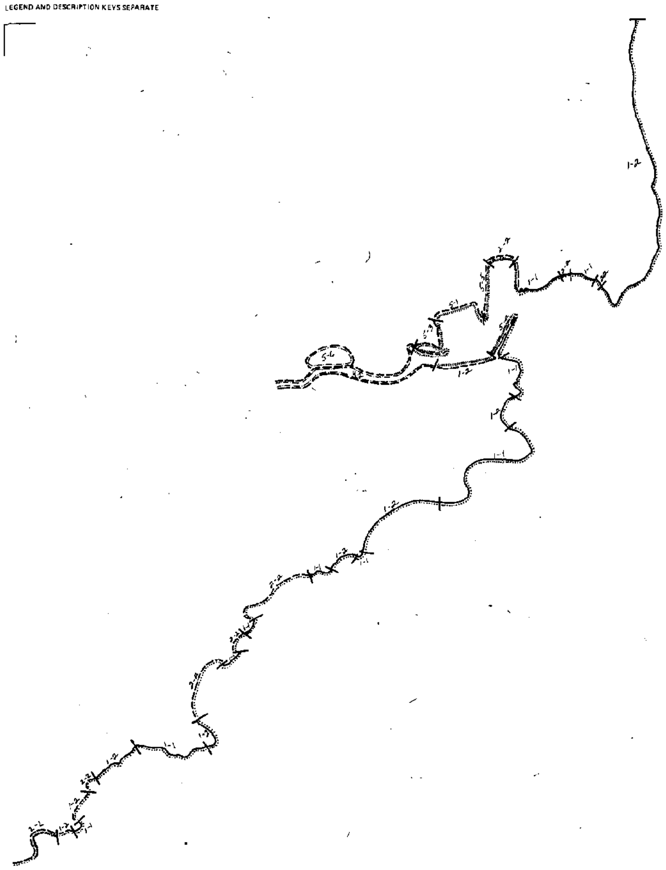

U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY **6**

LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIRP U-2 infrared photography, and U.S. Army Corps of Engineers low altitude, shoreline, black and white photography.

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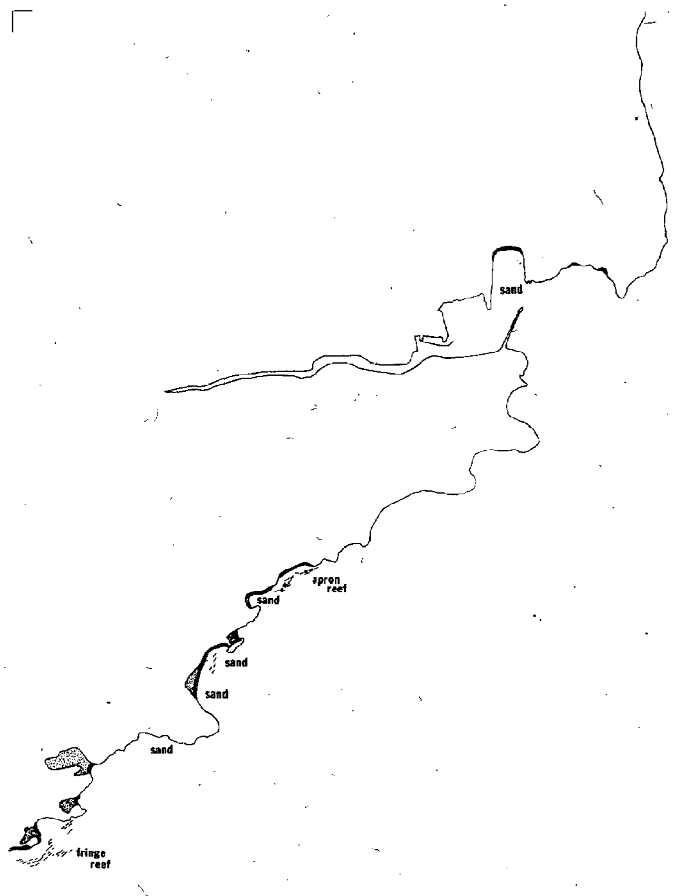
ESL



U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY 7

LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIHP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline, black and white photography.

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U.S.G.S. 7-1/2 MINUTE MAP
SCALE 1:24,000

LIHUE QUAD

KAUAI COUNTY

OVERLAY **8**

LEGEND AND DESCRIPTION KEYS SEPARATE

COASTAL ZONE MANAGEMENT
PROTOTYPE

Prepared by ESL, Incorporated for the Department of Planning and Economic Development, State of Hawaii from October 1974 and July 1975 NASA/AIRP U-2 infrared photography, and U.S. Army Corps of Engineer low altitude, shoreline, black and white photography.

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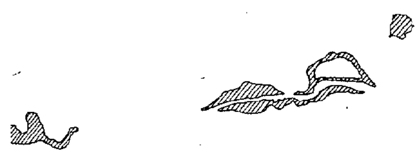

Level I. -- Continued.

2. EXPOSED: Entirely unprotected, surf swept shores. These areas bear the full, unimpeded force of the waves. This area is generally less attractive to both man and animal due to the difficulty in maintenance.

Level II.

1. OPEN COAST: This category is similar to exposed areas but does not necessarily receive direct wave impact. Reefs may absorb wave force far offshore. Nonetheless this area would appear to be unprotected, lacking the benefit of a headland or bay. In periods of heavy wave action the direction of the wave would be straight on (excepting windward side refraction).

2. BAY: Bays are naturally protected areas which in time often develop sand bars, mudflats or wetland areas. Strictly speaking, there would be little if any fresh water intrusion and, in fact, an increase in salinity. Bays are attractive to man for recreation, commercial enterprise and industrial development because of their natural protection from the sea.

Level II. -- Continued

3. ESTUARY: This classification defines marine areas with fresh water intrusion as estuarine. They are associated with rivers and streams. In Hawaii many are intermittent but nonetheless support a unique habitat. Estuaries are similar to bays in that they are naturally protected from wave action, and are additionally attractive to man because of their waterway inland.

Level III.

1. ROCKY SHORELINE: Land/sea interface comprised primarily of rock. Since the Hawaiian Islands were formed through volcanic activity, this category refers to rock which has been sufficiently weathered to distinguish it from recent volcanic action.

2. SANDY BEACH: Shoreline comprised of small particles (generally follows the Wentworth scale) which most of us think of as sand.

3. LAVA: Rocky material differentiated from "rocky shoreline" in that it was deposited within the last fifty years. This category found only on the Island of Hawaii (recent lava flows).

Level III.-- Continued.

4. MUD FLAT: This area is necessarily well protected allowing the very fine mud particles (see Wentworth scale) to settle out. Generally the result of sedimentation of terrestrial material often giving rise to a wetland and eventually shoreline alteration (extension). Usually indicates erosion, excessive runoff or particular current pattern.

5. MAN ALTERED: Indicates areas where man has altered the natural land/sea interface.

6. OTHER: Includes everything not described above. E.g., vegetation type.

Level IV.

ROCKY SHORELINE.

1. ROCKY SEA CLIFF. Describes a steep rock cliff greater than fifty (50) feet high. This area may have boulders accumulated at its base but the inhospitable sea cliff is being emphasized.

2. BOULDER BEACH. Lacks rock cliff greater than fifty (50) feet associated with it. Generally large rock juts and boulders greater than fifteen (15) centimeters across.

Level IV. -- Continued.

3. COBBLE BEACH. Similar to boulder beach but rocks generally smaller than fifteen (15) centimeters across.

4. OUTCROP/TERRACE. A continuous rock terrace. Generally smooth and solid lacking the interstitial component of individual boulders or cobbles.

SANDY BEACH.

1. BLACK (LAVA). Sand composed almost entirely of weathered lava. Black or dark in color.

2. WHITE (CALCAREOUS). Sand composed almost entirely of calcareous material from reef, molluscan or foraminiferous remains.

3. TERRESTRIAL SEDIMENT. Distinct from mudflat by larger particle size. Origin from terrestrial soils. Again erosion and runoff indicator.

4. MIX. Some combination of the above. Ancillary information should quickly define the proper combination.

MAN ALTERED.

1. DOCKS/PIERS. Private, commercial and industrial harbors and marinas.

Level IV. -- Continued.

2. BREAKWATER. Man-constructed extension of shoreline, generally designed to create additional protection to harbor, marina, bay or estuary.

3. CORAL LANDFILL. Extension of the shoreline by filling in nearshore with coral rubble.

4. DREDGED AREA. Cleared and/or deepened area, usually in harbor or channel areas.

5. SEA WALL. Area paralleling existing shoreline which offers additional support and protection to land.

6. OTHER.

For additional detail, examine the photographs referenced on the following pages. These are available for examination at the DPED. Call Mr. Cris Christofells at 548-3044.

Overlay #6 - Sand and Reef.

Sand is broken into three groupings:

1. Sandy Beach. This category is delineated on the overlay and marked with a slanted line. On the original overlay it is colored orange. This facilitates visual examination but will be lost in reproduction unless the new copies are hand colored. The sandy beach is, by definition, bordered on at least one side by the sea and subject to its dynamics.

2. Dune Area. A dune is set back from the sea, for the most part free from direct interaction with the sea. Wind will affect the sand dunes but after times this area is semipermanently anchored by dune vegetation. This category, too, is delineated and indicated by multiple dots. It is colored orange on the original once again to facilitate use.

3. Offshore sand channels and deposits are indicated but not delineated. This is due to (a) limited amount of time and data available, and (b) the availability of the data source (aerial photographs) for users with highly detailed requirements.

Offshore reefs are indicated on the overlay by a series of dashed lines. Reefs that abut the shore are delineated with a solid line and labeled. This map locates only reef areas and refrains from comment on reef viability or type. Additional detail can be obtained by studying the photographs referenced in this appendix.

The following is an excerpt from one of PUSPP's technical papers (Maragos et. al., 1975) in which reef ecologist Dr. James Maragos summarized the physical reef in Hawaii.

> "The characteristics of the reef flat habitat are largely dependent upon the type of and degree of development of the reef. Apron reefs are the smallest and most discontinuous reefs growing along shallow coastlines. These may fuse and grow out laterally with time to form the broad fringing reefs which characterise Lanai, Molokai, and Oahu. Barrier reefs frequently form from fringing reefs, if the reef itself becomes separated from the coast by a deep lagoon. There is only one extant barrier reef in Hawaii (Kaneohe Bay, Oahu) and this structure may have developed directly without the "intermediate" stage of a fringing reef. . . . Within the lagoons of atolls or barrier reefs are commonly found patch reefs which resemble inverted truncated cones. The only example of patch reefs among the main (windward) Hawaiian Islands is located in Kaneohe Bay, Oahu. All these categories of reefs may show the shallow reef flat habitat.
>
> "The reef flat consists predominantly of sand, coral rubble, and coralline and fleshy benthic algae. Reef corals are not important components of the reef flats presumably due to unfavorable temperature, wave, and salinity conditions near the level of the sea surface (Edmondson, 1928; Maragos, 1972; Littler, 1973).

> "It is important to make the distinction between coral reefs, the physical structures produced over thousands of years from the remains of calcareous organisms, and coral communities, the biological assemblages which may or may not cover the upper surface of the reef. While many of the Hawaiian Islands show extensive reef development, few show flourishing coral communities."

This description should help the layman in understanding the reef type indicated on the mylar maps.

Overlay #7 - Rivers and Streams.

Hawaii's drainage patterns remain largely unchanged over the short term. This overlay is designed to facilitate studies utilizing this kind of information. In addition to normal surface streams, the high altitude infrared photographs distinctly indicate that underground water flows through vegetation indicators. Solid lines represent perrenial streams; dashed lines represent intermittent streams.

This overlay can be readily updated to follow changes in drainage patterns over time.

Overlay #8 - Wetlands.

Refer to Appendix A.

Aerial Photography Utilized for Overlay Composition.

LIHUE QUAD.

U-2 High Altitude Aircraft

A. Color Infrared Film (SO-127), July, 1975, 1:65,000 scale, RC-10(12") sensor. Flight #75-108; Accession #02147; Frame #2959, 2960, 2961, 2962

B. Aerial Color Film (SO-242), July 1975, 1:65,000 scale; RC-10(12") sensor. Flight #75-108; Accession #02148; Frame #2012, 2013, 2014, 2015.

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. Black and White Film, April 1975, 1:6,000 scale; Kauai County Roll #1 Frame #1-1 to 1-31 and 1-332 to 1-354.

KOLOA QUAD.

U-2 High Altitude Aircraft.

A. Color Infrared Film (SO-127), July 1975, 1:65,000 scale; RC-10(12") sensor. Flight #75-108; Accession #02147; Frame #2962, 2963 and 2964.

KOLOA QUAD-- Continued.

B. Aerial Color Film (SO-242), July 1975, 1:65,000 scale; RC-10(12") sensor. Flight #75-108; Accession #02148, Frame #2015, 2016, 2017, 2018.

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. Black and White Film, April 1975, 1:6000 scale; Kauai County Roll #1, Frame #1-302 to 1-334.

HANAPEPE QUAD.

U-2 High Altitude Aircraft

A. Color Infrared Film (SO-127) 1:65,000 scale; RC-10(12") sensor. Flight #74-185; Accession #01951, October 1974 Frame #1153, 1154.

1:65,000 scale; RC-10(12") sensor. Flight #75-115; Accession # 02155, July 1975 Frame #3205, 3206, 3207.

B. Aerial Color Film (SO-242) 1:65,000 scale; RC-10(12") sensor. Flight #75-115; Accession #02156 Frame #2259, 2260, 2261.

HANAPEPE QUAD -- Continued.

U. S. Army Corps of Engineers

A. Black and White Film, April 1975, 1:6000 scale; Kauai County Roll #1, Frame #1-272 to 1-302.

KEKAHA QUAD.

U-2 High Altitude Aircraft.

A. Color Infrared Film (SO-127)
1:65,000 scale, RC-10(12") sensor.
Flight #74-185; Accession #01951, October 1974
Frame #1156, 1157, 1158.

1:65,000 scale; RC-10(12") sensor.
Flight #75-115; Accession #02155, July 1975
Frame #3204, 3205

1:32,500 scale, HR 732 (24") sensor.
Flight #74-179; Accession #01942; October 1974
Frame #0012 to 0018.

B. Aerial Color Film (SO-242)
1:65,000 scale, RC-10(12") sensor.
Flight #75-115; Accession #02156; July 1975,
Frame #2258, 2259.

KEKAHA QUAD -- Continued.

1:32,500 scale, HR-732(24") sensor.
Flight #74-179; Accession #01943; October 1974
Frame #0009 to 0014.

C. Black and White Film (Panchromatic X)
1:32,500 scale, HRC-732(24") sensor.
Flight #74-129; Accession #01944; October 1974

U.S. Army Corps of Engineers, Low Altitude Aircraft

A. Black and White Film, April 1975
1:6000 scale; Kauai County Roll #1,
Frame #1-228 to 1-272.

MAKAHA POINT QUAD.

U-2 High Altitude Aircraft

A. Color Infrared Film (SO-127)
1:65,000 scale, RC-10(12") sensor, July 1975
Flight #75-115; Accession #02155,
Frame #3201, 3202, 3203.

B. Aerial Color Film (SO-242)
1:65,000 scale, RC-10(12") sensor, July 1975
Flight #75-115; Accession #02156,
Frame #2255, 2256, 2257.

MAKAHA POINT QUAD -- Continued.

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. Black and White Film, April 1975.
1:6000 scale, Kauai County Roll #1,
Frame #1-183 to 1-228.

HAENA QUAD.

U-2 High Altitude Aircraft.

A. Color Infrared Film (SO-127)
1:65,000 scale, RC-10(12") sensor, July 1975
Flight #75-115; Accession #02155,
Frame #3200

B. Aerial Color Film (SO-242)
1:65,000 scale; RC-10(12") sensor, July 1975
Flight #75-115; Accession #02156
Frame #2254.

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. Black and White Film, April 1975,
1:6000 scale, Kauai County Roll #1,
Frame #1-156 to 1-183.

HANALEI QUAD.

U-2 High Altitude Aircraft

A. Color Infrared Film, (SO-127)
1:65,000 scale, RC-10(12") sensor, July 1975,
Flight #75-115; Accession #02155,
Frame #3200.

1:65,000 scale, RC-10(12"0 sensor, July 1975,
Flight #75-108; Accession #02147,
Frame #2970, 2971, 2972.

1:32,500 scale, HRC-732 (24") sensor, October 1974
Flight #74-179; Accession #01942,
Frame #0070, 0071, 0072, 0073, 0074.

B. Aerial Color Film (SO-242)
1:65,000 scale, RC-10(12") sensor, July 1975,
Flight #75-115; Accession #02156,
Frame #2254.

1:65,000 scale, RC-10(12") sensor, July 1975,
Flight #75-108; Accession #02148
Frame #2023, 2024, 2025.

1:32,500 scale, HRC-732(24") sensor, October 1974
Flight #74-179; Accession #01943,
Frame #0017, 0018, 0019, 0020.

HANALEI QUAD -- Continued.

C. Black and White Panatomic-X (3400) film, 1:32,500 scale, HRC-732 (24") sensor, October 1974
Flight #74-179; Accession #01944, Frame #0070, 0071.

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. 1:6000 scale, Kauai County Roll #1, April 1975
Frame #1-109 to 1-156.

ANAHOLA QUAD.

U-2 High Altitude Aircraft.

A. Color Infrared Film (SO-127)
1:32,500 scale; HRC-732(24") sensor, October 1974
Flight #74-149; Accession #01942, Frame #0068, 0069. 0070.

B. Aerial Color Film (SO-242)
1:32,500 scale, HRC-732 (24") sensor, October 1974
Flight #74-179; Accession #01943, Frame #0064, 0065, 0066.

ANAHOLA QUAD -- Continued.

U. S. Army Corps of Engineers, Low Altitude Aircraft.

A. 1:6000 scale, Kauai County Roll #1, April 1975
Frame #1-62 to 1-109.

KAPAA QUAD.

U-2 High Altitude Aircraft.

A. Color Infrared film (SO-127)
1:32,500 scale, HRC-732 (24") sensor,
October 1974
Flight #74-179: Accession #01942,
Frame #0064, 0065, 0066, 0067.

B. Aerial Color Film (SO-242)
1:32,500 scale, HRC-732 (24") sensor,
October 1974
Flight #74-109; Accession #01943,
Frame #0061, 0062, 0063, 0064,

U.S. Army Corps of Engineers, Low Altitude Aircraft.

A. 1:6000 scale, Kauai County Roll #1, April 1975
Frame #1-1 to 1-62.

Table B-1. List of Common and Scientific Names of the Dominant Plant Species Encountered in the Test Area

Aallii [Dodonea sp.]

Acacia [Acacia spp.]

African tulip tree [Spathodea campanulata Beauv.]

Albizia [Albizia sp.]

Alder [Alnus sp.]

Ash [Fraxinus sp.]

Banana [Musa spp.]

Blackbutt [Eucalyptus pilularis Sm.]

Californiagrass [Brachiaria mutica (Forsk.) Stapf.]

Cedrela [Cedrela sp.]

Christmas berry [Schinus terebinthifolius Raddi]

Common guava [Psidium Guajava L.]

Cook Pine [Araucaria columnaris Hook]

Cryptomeria [Cryptomeria joponica (L.f.) D. Don]

Eucalyptus [Eucalyptus spp.]

Flooded gum [Eucalyptus saligna sm.]

Gold fern [Pityogrammie calomelanus]

Guava [Psidium spp. L.]

Hala [Pandanus odoratissimus L. f.]

Hau [Hibiscus tiliaceus L.]

Hilo grass [Paspalum conjugatum Berg.]

Ironwood [Casuarina spp.]

Java Plum [Eugenia cumini (L.) Druce]

Kiawe [Prosopis chilensi Stunz]

Kikui [Aleurites moluccana (L.) Wild.]

Kikuyugrass [Pennisetum clandestinum, Hoshst ex Choiv]

Koa [Acacia koa Gray]

Koa-haole [Leucaena latisligua (L.) Gillis]

Table B-1. -- Continued.

Lantana [Lantana Camara L.]
Lemon-scented gum [Eucalyptus citridora Hook, in Mitchell]
Malabar melastome [Melastoma malabathricum L.]
Mamane [Sophora Chrysophylla (Salisb.) Seem]
Mangrove [Rhizophora spp.]
Monkeypod [Albizia Lobbeck (L.) Benth.]
Morning glory [Ipomoea spp.]
Naupaka [Scaerola Kauiensis (Deg) St. John]
Noni [Morinda citrifolia L.]
Norfolk Island Pine [Araucaria heterophylla (Salisb.) Franco]
Ohelo [Erica spp.]
Ohia-lehua [Metrosiderous collina var. polymorpha N.]
Papaya [Carica papaya L.]
Pepper Tree [Schinus molle L.]
Pickleweed [Batis maritima L.]
Pine [Pinus spp.]
Plantain [Plantago sp. L.]
Pluchea [Pluchea spp.]
Pukiawe [Styphelia Tameiameiae F. Muell.]
Railliardia [Railliardia spp.]
Red mahogany [Eucalyptus resinifera sm.]
Redwood [Sequoia sempervirens (D. Don in Lamb) Endl.]
Rush [Juncus spp.]
Sandalwood [Santalum spp.]
Silk-oak [Grevillea robusta A. Gunn]
Staghorn fern [Dicranopteris linearis]
Strawberry guava [Psidium Cattleianum Sabine]
Sugar cane [Saccharum officinarum L.]
Swamp mahogany [Eucalyptus robusta Sm.]
Toon [Toona ciliata M. Roen]

APPENDIX C

DATA FACILITY STUDY

This appendix discusses each individual scenario examined for the Data Facility Study.

APPENDIX C. DATA FACILITY: SCENARIO DISCUSSIONS.

C.1 Scenario 1.

Facility Function	Data Type: A	B: a	B: b	C: a	C: b
I	1				
II					
III					

<u>Data</u>: U-2 data only, in-house. Some other data and reference material will be on hand but only as a supplement to U-2 photographs.

<u>Cataloging and Procedures</u>:

The limited physical number of U-2 photographs would make cataloging relatively simple, and a manual system would suffice (see Section 5).

<u>Equipment</u>:

Light table (1) - Richard 30 x 40 or equivalent
Large work table (4' x 6')
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)

C.1 -- Continued.

Equipment -- continued.

Film cannisters (10)
White gloves (1 gross)
File cabinet (1)
Desk (1)
3 x 5 card file (1)
Complete set of Island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)

Personnel:

One half-time employee with organizational ability should suffice. No photographic interpretation expertise would be required at this level, although basic knowledge of the characteristics of the data (camera type, focal length, spectral bands, films, filters) should be available.

Space:

A room 20' x 20' is adequate. This amount of space anticipates a rapid growth and avoids relocation later.

Utility:

Utilization will come primarily from CZM requirements via ESL Inc. interpretation (under contract to DPED). Utilization will not necessarily be limited to CZM in that other DPED programs and/or outside agencies would

C.1 -- Continued.

have access to data but little assistance in interpretation or use of data.

Intergovernmental Coordination:

The extent of this facility will not exceed the scope of the CZM program and could be limited to that program's control.

Comments:

CZM has already obtained, at no acquisition cost, all pertinemt U-2 data, and some of the required viewing equipment is presently in-house. At this level, 90 percent or more of the utilization is accomplished by CZM program through contractor expertise. Projected benefits will only be as far-reaching and extensive as that program's requirements dictate.

C.2 Scenario 2.

	Data Type	A	B		C	
Facility Function			a	b	a	b
I						
II		2				
III						

Data: In-house storage of U-2 data only. Some other data and reference material may be on hand but only incidental to U-2 photographs. No systematic attempt to include this data will be made.

Cataloging and Procedures:

The limited physical number of U-2 photographs would make cataloging relatively simple and a manual indexing system would suffice (see Section 5).

Equipment:

Light table (1) - Richards 30 x 40 or equivalent
Large work table (1) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (10)
White gloves (1 gross)

C.2 -- Continued.

File cabinet (1)
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Light table (1) - Richards MIM 3 (or equivalent) equipped with a zoom 95 stereo magnifier
Film splicing equipment and supplies

Personnel:

One half-time employee with organizational ability and a basic knowledge of the characteristics of the data (camera type, focal length, spectral bands, films, filters). Additionally, this scenario requires a full-time prefessional resource analyst with experience in photographic interpretation. This expertise can be gained through use of contractor support or by an addition to the in-house staff.

Staff:

A room 20' x 20' should suffice. This amount of space anticipates rapid growth and avoids relocation later.

C.2 -- Continued.

Utility:

Utilization will come primarily from CZM requirements via ESL Inc. interpretation (under contract to DPED). However, the addition of in-house expertise would allow support to other DPED projects. Outside agency utilization should also increase but on a space/time available level.

Intergovernmental Coordination:

At this level the principal utilization would come through CZM with DPED keeping use, control, and funding in-house. Outside agency use would be complementary or funded by specific project. Little coordination would be necessary on a legislative level.

Comments:

The addition of a trained resource analyst significantly increases the use of and benefit from the data. The analyst could be tasked with specific projects directed at providing needed information on a broad spectrum of planning functions. Some analysis inefficiencies are expected, however, as this scenario includes only U-2 data. Some assistance could also be given to outside agencies.

C.3 Scenario 3.

Data Type	A	B		C	
Facility Function		a	b	a	b
I					
II					
III	3				

Data: In-house storage of U-2 data only. Some other data and reference material may be on hand but only incidental to U-2 photographs. No systematic attempt to include this data will be made.

Cataloging and Procedures:

The limited number of U-2 photographs would make cataloging relatively simple, and a manual indexing system would suffice (see Section 5).

Equipment:

Light tables (2) - Richards 30 x 40 or equivalent
Large work table (1) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (10)
White gloves (1 gross)

C.3 -- Continued.

File cabinet (1)
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Light table (1) - Richards MIM 3 (or equivalent) equipped with a zoom 95 stereo magnifier
Film splicing equipment and supplies
Map-O-Graph (1) or equivalent
Portable mirror stereoscope
Additional film storage equipment

Personnel:

One half-time employee with organizational ability and a basic knowledge of the characteristics of the data (camera type, focal length, spectral bands, films, filters). Additionally, this scenario requires at least two full-time trained planning and/or resource analysts with experience in photographic interpretation. Both analysts should have formal backgrounds in different resource disciplines to increase the depth and breadth of the image interpretation capability.

Space:

Space requirements would increase to include office space for the two full-time analysts and half-time data handling person plus the 20' x 20' work room.

C.3 -- Continued.

Utility:

The utility of the data could increase dramatically, and at this stage support many in-house programs as well as the needs of other agencies. However, limiting the cataloging and analysis to U-2 data only would severely limit the output of useful information from the staff.

Intergovernmental Coordination:

Because of the wide use of the facility by projects outside the auspices of DPED, some coordination with the other agencies will be necessary. Funding by project, grant, or state would probably be required to alleviate the financial burden on DPED.

Comments:

This level strives for major analysis capability, but it is limited to use of only U-2 data. Such an effort would face all of the coordination and funding problems of a major facility while outputting limited information because of the limited data base. More complete and effective analysis and a broader range of tasks could be undertaken, however, if additional data types were to be cataloged and utilized.

C.4 -- Continued.

Space:

Space requirements for this scenario include office space plus a film review area (20' x 30'). This film review area could initially double as a storage area, although more storage area is likely to be needed within a few years.

Utility:

Data utility is increased because of ready availability of the data to the users. However, the extent of this improvement over Scenario 1 is expected to be small.

Intergovernmental Coordination:

The need for coordination with other agencies would be high because copies of all types of imagery would be stored in-house.

Comments:

This scenario is impractical from a CZM-DPED requirements viewpoint. To assemble all remote sensing data (here including all low-altitude imagery and satellite data) without an analysis capability is not recommended. The volume of material to be stored and cataloged would indicate high costs, and lack of in-house analysis would minimize utilization. This is not a practical approach to an information center.

C.5 Scenario 5.

Facility Function \ Data Type	A	B a	B b	C a	C b
I			5		
II					
III					

Data: All remote sensing data (satellite, U-2, low-altitude, field photos, digital images, thermal data) to which the government has access. Availability, cost, need, and relevance would govern (not an arbitrary collection of every photo or image ever taken in the state).

Cataloging and Procedures:

Remote sensing data other than U-2 data would be cataloged but not necessarily stored in-house. A manual system could probably handle the data, but computer systems should be considered. Retention of data in-house would increase slowly as used. In order to index data which is not stored in-house, reference files containing agency, location, and availability of each data type would be used.

C.4 Scenario 4.

Facility Function \ Data Type	A	B		C	
		a	b	a	b
I		4			
II					
III					

Data: U-2 imagery, low-altitude aerial photographs, satellite data, and any specialized imagery such as thermal line-scan data.

Cataloging Procedures:

To catalog and maintain all of the remote sensing data in-house would require two full-time data handling specialists, perhaps more, if extensive use of the data by other agencies resulted in many retrieval requests. As an alternative to manual storage and retrieval, a computerized system should be given serious consideration at this level. An operational computerized storage and retrieval system could reduce manpower requirements to one half-time data handling specialist.

C.4 -- Continued.

Equipment:

Light tables (2) - Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (30)
White gloves (1 gross)
File cabinets (3) 5 drawer type
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Film filing cabinets/shelves (5)
Computer (optional), stand-alone system or access to time-sharing service network

Personnel:

Two full-time data handling specialists. If a computer system is considered, the level drops to one half-time person, but familiarization with computer systems and processes would be necessary.

C.5 -- Continued.

Equipment:

This scenario differs somewhat from Scenario 4 because only part of the data cataloged and indexed would be physically stored in-house. Although fewer film storage cabinets and file cabinets are needed, the basic equipment remains the same as that needed in Scenario 4.

Light tables (2) - Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (10)
White gloves (1 gross)
File cabinets (2) 5 drawer type
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Film filing cabinets/shelves (3)
Computer (optional), stand-alone system or access to time-sharing service network

C.5 -- Continued.

Personnel:

The volume of data, even if only some of it were physically in-house, would require one full-time data handling specialist for cataloging, organization, and general service. There is no analysis expertise available.

Space:

One work room 20' x 20', as in Scenario 1, and one storage are 20' x 30' would handle all data for several years.

Utility:

Lack of photographic interpretation personnal would keep utility at a minimum; only contractors for CZM are highly used. The large amount of data centralized could draw experienced interpreters from other agencies.

Intergovernmental Coordination:

Inclusion of information on all remote sensing data would increase the need for cooperation with other agencies. Each agency that obtained remote sensing data would now supply information to the data facility; for selected data, an in-house copy would also be on file at the facility.

C.5 -- Continued.

Comments:

This secnario would provide for a large data facility and a large amount of data available, but there would be little interpretation capability in-house. This type of facility would best serve as an intermediate phase of a long-term growth plan.

C.6 Scenario 6.

Facility Function \ Data Type	A	B a	B b	C a	C b
I					
II		6			
III					

Data: U-2 imagery, low-altitude aerial photographs, satellite data and any specialized imagery such as thermal line-scan data, to be stored in-house.

Cataloging Procedures:

To catalog and maintina all of the remote sensing data in-house could require two full-time data handling specialists, perhaps more, if extensive use of the data by other agencies resulted in many retrieval requests. As an alternative to manual storage and retrieval, a computerized system should be given serious consideration. An operational computerized storage and retrieval system could reduce manpower requirements to one full-time data handling specialist. In addition, limited in-house analysis would be an additional burden to the staff because more extensive use of the imagery (a much greater number of retrieval requests) would likely result. Depending on the level of use, the cost incurred to automate the data handling function could well be justified at this level.

Equipment:

Light tables (2) - Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (30)
White gloves (1 gross)
File cabinets (3) 5 drawer type
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (5)
Computer (optional), stand-alone system or access to time-sharing service network

Personnel:

Two full-time data handling specialists and one professional-level resource analyst with remote sensing and photo interpretation experience.

C.6 -- Continued.

Space:

Office space for three full-time people, one work area 20' x 20', and a storage area 10' x 30'

Utility:

The utility of this scenario is considerably improved over Scenario 4; analysis of the data is provided as will as data handling. The benefits of this scenario outweigh those discussed in 2, because all types of remote sensing data are now included, allowing much more flexibility in the type of project that can be undertaken. Major limitations exist, however. The needed ancillary data is not cataloged, and a single resource analyst would limit the extent of the projects undertaken. The CZM program as well as other DPED efforts would benefit considerably.

Intergovernmental Coordination:

There would be extensive intergovernmental coordination because a copy of all state data would be sent to the data facility for cataloging and indexing.

Comments:

In spite of increased usefulness over all other options described thus far, this scenario is not practical

C.6 -- Continued.

because of extensive in-house data handling cost coupled with the lack of readily available ancillary data and a small analysis staff.

C.7 Scenario 7.

Data Type	A	B		C	
Facility Function		a	b	a	b
I					
II			7		
III					

Data: All remote sensing data (satellite, U-2, low-altitude, field; photos, digital images, thermal data) to which the government has access. Availability, cost, need, and relevance would govern collection (not an arbitrary collection of every photo or image ever taken in the state).

Cataloging and Procedures:

Remote sensing data other than U-2 data would be cataloged, but not necessarily stored, in-house. A manual system could probably handle the data, but computer systems should be considered seriously. Retention of data in-house would increase slowly as used. That is, as data was used internally for an analysis program, copies would be retained in-house for easy access.

C.7 -- Continued.

Equipment:

Light tables (2) - Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (15)
White gloves (1 gross)
File cabinets (2) 5 drawer type
Desks (2)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (3)
Computer (optional), stand-alone system or access to time-sharing service network

Personnel:

One full-time data handling specialist and one full-time professional resource analyst with remote sensing experience.

C.7 -- Continued.

Space:

Office space for two people, one 20' x 20' work area, and one 10' x 20' storage area.

Utility:

The utility is increased considerably over that of Scenario 5 (equivalent to Scenario 6). Lack of ancillary data and limited analysis staff would preclude in-depth data use.

Intergovernmental Coordination:

Operation could still remain DPED-funded and controlled. However, increased outer agency data use and contribution would require close coordination and cooperation. Grant or project funding may become necessary for outer agency use.

Comments:

This scenario increases use at lower cost than Scenarios 1 through 6, and it is one that deserves serious consideration as an effective data facility or an intermediate step towards a more expanded facility.

C.8 Scenario 8.

Facility Function \ Data Type	A	B		C	
		a	b	a	b
I					
II					
III		8			

Data: U-2 imagery, low-altitude aerial photographs, satellite data, and any specialized imagery such as thermal line-scan data, all of which is to be stored in-house.

Cataloging and Procedures:

To catalog and maintain all of the remote sensing data in-house would require two full-time data handling specialists, perhaps more, if extensive use of the data by other agencies resulted in many retrieval requests. As an alternative to manual storage and retrieval, a computerized system should be given serious consideration at this level. An operational computerized storage and retrieval system could reduce manpower requirements to one of one half-time data handling specialist. In addition, the extensive increase in interpretive capability and staff required by this scenario would make use of a computerized cataloging system much more cost effective. Implied heavy use and large numbers of data inquiries point toward a computer handling system.

C.8 -- Continued.

Equipment:

A computer system to perform the data handling function should be given serious consideration. It could serve as part of the University CZM information system previously discussed or as a stand-along system. Because of the heavy emphasis on analysis, the computer system could be used to support the information extraction tasks; digital image processing and geographical information systems are important design considerations.

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (40)
White gloves (1 gross)
File cabinets (3) 5 drawer type
Desks (4)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (5)
Computer (optional), stand-alone system or access to time-sharing service network

C.8 -- Continued.

Personnel:

Addition of two resource analysts with remote sensing experience. The specific resource training of these analysts should reflect different disciplines to broaden the scope of analysis efforts. In addition, two full-time data handling specialists would be required (one with a computer background if the system were automated).

Space:

This scenario requires a storage area 10' x 30' (rapidly increasing), office space for four to six individuals, a word area of 20' x 20', a computer room (optional) 10' x 20'

Utility:

Heavy use by all state agencies. Funding would support all users, not just the administrative agency. The extensive analysis capability suggests the need for ancillary information for optimum output.

Intergovernmental Coordination:

As the need for coordination and cooperation would be high, legislative action to define fiscal, administrative and contributive roles would be required. Copies of all data at data facility would increase costs and coordination.

C.8 -- Continued.

Comments:

With this scenario, we describe a multiple-project data facility for the first time. The major limiting factor is a lack of ancillary data as a support to the analysis function. Because of extensive analysis capability, the physical existence of all the imagery in the data facility would not be totally impractical; however, careful study of this factor would be necessary to determine if it were justified.

C.9 Scenario 9.

Facility Function / Data Type	A	B		C	
		a	b	a	b
I					
II					
III			9		

Data: All remote sensing data (satellite, U-2, low-altitude, field photos, digital images, thermal data) to which the government has access. Availability, cost, need, and relevance govern collection (not an arbitrary collection of every photo or image ever taken in the state).

Cataloging and Procedures:

Remote sensing data other than U-2 data would be cataloged but not necessarily stored in-house. A manual system could probably handle the data, but computer systems should be considered. Retention of data in-house would increase slowly as used. That is, as data was used internally for an analysis program, copies would be retained in-house for eacy access.

C.9 -- Continued.

Equipment:

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (20)
White gloves (1 gross)
File cabinets (2) 5 drawer type
Desks (4)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (3)
Computer (optional), stand-alone system or access to time-sharing service network

Personnel:

One full-time data handling specialist and three full-fime resource analysts representing different disciplinary backgrounds.

C.9 -- Continued.

Space:

This scenario requires a storage area 10' x 20', office space for four individuals, a work area 20' x 20', and a computer room (optional) 10' x 20'

Utility:

As with Scenario 8, this scenario describes multiprogram data facility. In addition to DPED programs, major support for other givernment agencies could be provided. Lack of systematically cataloged ancillary data is the only limiting factor. It is possible that some of this ancillary data would be on hand as it was collected over a period of time for other projects.

Intergovernmental Coordination:

The need for coordination would be high, and considerable emphasis would be placed on reducing costs by combining requests for aerial photographic coverage. Information on all flights would be kept in the data facility; selected hardcopies of that coverage would be used in the analysis.

Comments:

This scenario presents a cost factor lower than that presented in Scenario 8, although the data utilization

C.9 -- Continued.

is equivalent. Because of the increased interpretation capability, the usefulness of the data is much better than in Scenario 7; the increased cost is due to the addition of two more resource analysts.

C.10 Scenario 10.

Facility Function \ Data Type	A	B		C	
		a	b	a	b
I				10	
II					
III					

Data: The data pertinent to this scenario would include all the remote sensing data previously discussed under levels A and B plus the necessary ancillary information sources such as maps, special charts, reports, published research, interpretation results from earlier investigation, field notes, environmental impact reports, and other quantitative information.

Cataloging and Procedures:

The magnitude of the data and required cross-referencing would definitely require a computerized system with manual backup. Integration with the existing DPED library would significantly reduce cost and redundancy.

Equipment:

In this case, computer-oriented operation would be essential. The computer could be a dedicated stand-along system or part of a time-sharing service.

C.10 -- Continued.

Interactive analysis would be necessary if prompt response to inquiries were to be maintained.

Light tables (2) Richards 30 x 40 or equivalent

Large work tables (2) - 4' x 6'

Portable stereo viewers (2)

7X loop magnifiers (minimum of 2)

Film cannisters (40)

White gloves (3 gross)

File cabinets (3) 5 drawer type

Desks (3)

3 x 5 card file (1)

Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)

Map file cabinet (1)

Rewind table (1)

Microfilm viewer (1) for satellite data

Film filing cabinets/shelves (5)

Computer system (dedicated or time-sharing).

Personnel:

One full-time computer operator/maintenance person, two data handling specialists with one of the people with a library science background.

Space:

Storage area 20' x 20', second room needed within few years, a work area 20' x 20', library room 10' x 10', office space for three people.

C.10 -- Continued.

Utility:

A small increase in usefulness over Scenario 1 or 4 because ancillary information would be available. However, since no analysis is provided, the need for this ancillary information as part of the data facility is questionable.

Intergovernmental Coordination:

Much data acquisition by other organizations would be coordinated by the data facility. A copy of all data would be kept in-house, increasing data handling costs.

Comments:

Very high cost and little utility makes this scenario impractical.

C.11 Scenario 11.

Facility Function \ Data Type	A	B		C	
		a	b	a	b
I					11
II					
III					

Data: U-2 imagery, low-altitude aerial photographs, satellite data and any specialized imagery such as thermal line scan data, plus a significant amount of reference, resource, and ancillary data, which will enhance or supplement interpretation of the raw data.

Cataloging and Procedures:

Much of the available reference material or previous study material must now be included in the cataloging system. In addition to the large amount of remote sensing data stored in-house, reference to out-of-house ancillary data will be available. The cross-reference complexity will become too much for manual filing. At this level a computer system should be implemented. The difference between this scenario and Scenario 10, previously discussed, is the quantity of material physically stored at the data facility, which will be large, although much less than in Scenario 10.

C.11 -- Continued.

Nevertheless, a more complex computer indexing and retrieval system may be necessary because one must know the agency and physical location of the out-of-house photographs or library material.

Equipment:

In this case, computer operation would be essential. The computer could be a dedicated stand-alone system or part of a time-sharing service. Interactive analysis would be necessary if prompt response to inquiries were to be maintained.
Light tables (2) Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewer (1)
7X loop magnifiers (minimum of 2)
Film cannisters (20)
White gloves (2 gross)
File cabinets (3) 5 drawer type
Desks (3)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Film filing cabinets/shelves (5)
Computer system (dedicated or time-sharing).

C.11 -- Continued.

Personnel:

One full-time data handling specialist with library science training and one full-time computer operator or person with computer training.

Space:

Storage area 20' x 20' with second room needed within a few years, work area 20' x 20', library room 10' x 10', office space for three people.

Utility:

Relative to cost, the utility will be low because no analysis capability exists in-house (see comments).

Intergovernmental Coordination:

High. Cost would involve statewide cooperation in areas of funding, data gathering, and usage. In this scenario, the data facility would not control statewide data collection, but it would monitor all such activities to maintain an up-to-date data base.

Comments:

This scenario is similar to Scenario 10 and could be considered impractical on the same basis. However,

C.11 -- Continued.

under some conditions, a data facility such as described here could serve a very useful function within the State of Hawaii. If the various agencies each maintained an independent resource and planning specialist with remote sensing experience, the central data facility could serve to quickly and efficiently provide them with all available information requested. Thus, independent analysts and planners could contact one agency or group, rather than a number of organizations within the state.

C.12 Scenario 12.

Facility Function	Data Type	A	B		C	
			a	b	a	b
I						
II					12	
III						

Data: The data pertinent to this scenario would include all the remote sensing data previously discussed under levels A and B plus the necessary ancillary information sources such as maps, special charts, reports, published research, interpretation results from earlier investigation, field notes, environmental impact reports, and other quantitative information.

Cataloging and Procedures:

The amount of data and required cross-referencing would definitely require a computerized system with manual backup. Integration with the existing DPED library would significantly reduce cost and redundancy.

Equipment:

Computer operation would be essential. The computer could be a dedicated stand-alone system or part of a time-sharing service. Interactive analysis would be

C.12 -- Continued.

necessary if prompt response to inquiries were to be maintained.

Equipment:

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (3) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (40)
White gloves (3 gross)
File cabinets (3) 5 drawer type
Desks (3)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (2)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film splicing equipment and supplies
Film filing cabinets/shelves (5)
Computer system (dedicated or time-sharing)

Personnel:

One full-time computer operator/maintenance person, one full-time data handling specialist, one full-time resource analyst with remote sensing experience.

C.12 -- Continued.

Space:

Storage area 20' x 20' with second room needed within few years, work area 20' x 20', library room 10' x 10', office space for three people.

Utility:

There is small increase in usefulness over that for Scenarios 1 or 4 because ancillary information would be available. There is also some improvement over Scenario 10 because of the addition of an interpreter/resource analyst.

Intergovernmental Coordination:

Very high data use by other organizations would be coordinated by the data facility. A copy of all data would be kept in-house, increasing data handling costs.

Comments:

The addition of one analyst does not outweigh excessive cost for data handling. This scenario is impractical.

C.13 Scenario 13.

Facility Function \ Data Type	A	B a	B b	C a	C b
I					
II					13
III					

Data: U-2 imagery, low-altitude aerial photographs, satellite data, and any specialized imagery such as thermal line scan data, plus a significant amount of reference, resource, and ancillary data, which will enhance or supplement interpretation of the raw data.

Cataloging and Procedures:

Much of the available reference material or previous study material must now be included in the cataloging system. In addition to the large amount of remote sensing data stored in-house, references to out-of-house ancillary data will be avaible. The cross-reference complexity will become too much for manual filing. At this level a computer system should be implemented. The difference between this scenario and Scenario 10, previously discussed, is the quantity of material stored at the data facility, which will be large, although less than Scenario 10. Nevertheless, a more complex computer indexing and retrieval system may be necessary because one must know the agency and physical location of the out-of-house photographs or library material. Additionally, this scenario provides for limited analysis by in-house staff and this information must be incorporated into the system.

Equipment:

Computer operation is essential. The computer could be a dedicated system or used on a time-sharing basis. The basic equipment remains the same as in Scenario 12, although fewer storage cabinets are needed since all data will not be in-house.

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (3) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (20)
White gloves (2 gross)
File cabinets (2) 5 drawer type
Desks (3)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (2)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier

C.13 -- Continued.

Film splicing equipment and supplies
Film filing cabinets/shelves (4)
Computer system (dedicated or time-sharing)

Personnel:

One full-time computer operator/maintenance person, one full-time data handling specialist, one full-time resource analyst with remote sensing experience.

Space:

Storage area 20' x 20' (second room needed within few years), work area 20' x 20', library room 10' x 10', and office space for three people.

Utility:

Considerably higher immediate utility than Scenario 11 because of in-house expertise in analysis, although this is a somewhat artificial condition (see comments).

Intergovernmental Coordination:

Statewide cooperation in areas of funding, data gathering, and usage is needed. In this scenario the data facility would not control statewide data collection, but it would monitor all such activities to maintain an up-to-date data base.

C.13 -- Continued.

Comments:

This scenario is little different than Scenario 11, except that some analysis capability is now part of the data facility (rather than existing elsewhere within DPED). As structured, this option could serve as a statewide remote sensing and resource information center with DPED analysis capability as part of the facility, rather than separate.

C.14 Scenario 14.

Facility Function \ Data Type	A	B		C	
		a	b	a	b
I					
II					
III				14	

<u>Data</u>: The data pertinent to this scenario would include all the remote sensing data previously discussed under Levels A and B plus sources for the necessary ancillary information such as maps, special charts, reports, published research, interpretation results from earlier investigation, field notes, environmental impact reports.

<u>Cataloging Procedures:</u>

With the inclusion of all types of data and extensive analysis, the cataloging task would be only one aspect of the data facility operations. The primary effort would consist of a centralized resource information center. Computer system operation would be required and could be an outgrowth of the CZM geographical information system presently under development.

C.14 -- Continued.

Equipment:

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (40)
White gloves (3 gross)
File cabinets (3) 5 drawer type
Desks (8)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (5)
Computer system (dedicated)

In addition to the analysis and film handling equipment listed above, a dedicated stand-alone computer serving as a comprehensive information system would be needed. User-oriented peripherals to the main frame computer would include:

C.14 -- Continued.

Large flatbed plotter
Digitizing station
Interactive graphics terminal
High-resolution color CRT display for image processing (optional)

Some of these peripherals would also be useful in earlier scenarios where data handling was the primary task of the computer; here they would be more essential.

Personnel:

One data facility manager, one computer programmer, two data handling specialists, one full-time secretary.

Space:

Office space for eight people, a computer room, 20' x 20', a work area 20' x 20', a library room 10' x 20', a storage area (one or two rooms, each 20' x 20').

Utility:

This major information center would have very high usefulness, supporting numerous statewide planning and resource evaluation programs.

C.14 -- Continued.

Intergovernmental Coordination:

In this scenario, coordination actually decreases as the data facility (resource information center is perhaps a better name) could take on many of the functions now scattered among several agencies.

Comments:

This scenario describes a statewide information center rather than a single agency data facility. Although utility is very high, problems of governmental organization and politics may outweigh its usefulness.

C.15 Scenario 15.

Facility Function \ Data Type	A	B a	B b	C a	C b
I					
II					
III					15

Data: The data pertinent to this scenario would include all the remote sensing data previously discussed under Levels A and B plus the references for ancillary information such as maps, special charts, reports, published research, interpretation results from earlier investigation, field notes, environmental impact reports.

Cataloging Procedures:

Because of all types of data and extensive analysis has been added, the cataloging task is only one part of operation. The primary effort would consist of a centralized resource information center. Computer system operation would be required and could be an outgrowth of the CZM geographical information system presently under development. Although this scenario provides for the cataloging of all data types, they will not necessarily be stored in-house (as in Scenario 14).

C.15 -- Continued.

Equipment:

Light tables (2) Richards 30 x 40 or equivalent
Large work tables (2) - 4' x 6'
Portable stereo viewers (2)
7X loop magnifiers (minimum of 2)
Film cannisters (20)
White gloves (2 gross)
File cabinets (3) 5 drawer type
Desks (7)
3 x 5 card file (1)
Complete set of island maps (U.S.G.S. - 7.5 minute quadrangles)
Map file cabinet (1)
Rewind table (1)
Microfilm viewer (1) for satellite data
Light table (1) - Richards MIM3 (or equivalent) equipped with a Zoom 95 stereo magnifier
Film Splicing equipment and supplies
Film filing cabinets/shelves (5)
Computer system (dedicated)

In addition to the analysis and film handling equipment listed above, a dedicated stand-alone computer serving as a comprehensive information system would be needed. User-oriented peripherals to the main frame computer would include:

C.15 -- Continued.

Large flatbed plotter
Digitizing station
Interactive graphics terminal
High-resolution color CRT display for image processing (optional)

Some of these peripherals would also be useful in earlier scenarios where data handling was the primary task of the computer, but they become more essential here.

Personnel:

One data facility manager, one computer programmer, one data handling specialist, one full-time secretary.

Space:

Office space for seven people, a computer room, 20' x 20', a work area 20' x 20', a library room 10' x 20', and a storage area (one or two rooms, each 20' x 20').

Utility:

As a major information center, data utility is very high and would be expected to support numerous statewide planning and resource evaluation programs.

C.15 -- Continued.

Interagency Coordination:

In this scenario, the data facility would provide extensive interagency coordination. Not all of the data would be physically stored in the facility, which implies other agencies involved in some data collection and analysis programs. To reduce cost and obtain economies of scale, coordination would be required.

Comments:

The statewide facility would be heavily involved with coordination between agencies and would conduct joint programs of analysis with other agencies.

APPENDIX D

AVAILABLE LANDSAT DATA

This appendix provides the LANDSAT coverage over Hawaii through 22 July 1976.

1234567890123456789012345678901234567890123456 7 89012345678901234567890123456789012345678901234567890123456789012345

TYPE COVERAGE	TYPE / FILM SOURCE	SIZE / FILM SOURCE	PHOTO/SCENE IDENTIFICATION	A/C / QUALITY	4567 ERTS / QUALITY	CLOUD COVER	DATE ACQUIRED	LATITUDE / CENTER/ FIRST FRAME COORDINATES	LONGITUDE / CENTER/ FIRST FRAME COORDINATES	SCALE OF IMAGERY	ALTIT.	OVER-LAP	FIRST FRAME	LAST FRAME	NO. OF FRAMES	CASSETTE / MICROFILM	FRAME / MICROFILM
IDENTIFICATION				DATA CHARACTERISTICS									PHOTO STRIP INFO.				

FIRST LINE OF ACCESSION INFORMATION

COMPUTER PRINTOUT DECODING SHEET

SHEET 1

FOR INTERPRETATION OF IMAGERY FROM EROS DATA CENTER

INSTRUCTIONS:

This decoding sheet is used in conjunction with the enclosed computer listing to interpret characteristics of imagery available from the EROS Data Center.

From interpretation of choices listed, individual photographic accessions can be evaluated and appropriate order forms selected for ordering.

The computer listing may list several possible images available over your area of interest. Each will be described by two printed lines indicating in detail parameters of the individual image or photograph accession.

Detailed data can be read by aligning the scale on the top and bottom of this sheet with the upper and lower lines of each accession on the computer listing, noting characteristics for each data item.

TYPE COVERAGE for each accession indicates the correct ORDER FORM to be used. FILM TYPE SIZE *dictates products available from the table* at the bottom of the respective order forms.

Descriptions and code breakdown for data fields are shown on the right. A further breakdown of selected data fields is itemized on supplemental sheet 2.

Note that special procedures are required for imagery accessed by photo index or photo strip.

CODE EXPLANATIONS (REFER TO SHEET 2 FOR FURTHER BREAKDOWN)

TYPE COVERAGE
- DESIGNATES TYPE AND SOURCE OF PHOTOGRAPHIC COVERAGE LISTED
- *INDICATES ORDER FORM TO BE USED*

FILM SOURCE
- INDICATES TYPE AND SIZE OF MASTER REPRODUCIBLE FILM. REFER TO STANDARD PRODUCT TABLE ON ORDER FORM TO DETERMINE PRODUCTS AVAILABLE

B&W - BLACK AND WHITE
COL = COLOR
CIR = COLOR INFRARED
FCC = ERTS FALSE COLOR COMPOSITE
SIZE = SIZE OF FILM SOURCE
SIZE A = 10" × 12"
SIZE B = LARGER THAN 10" × 12"

PHOTO/ SCENE IDENTIFICATION
- COLUMN 1 - SOURCE AGENCY

CODE	AGENCY	AIRCRAFT	SPACE
1	USGS	×	
2	BUREAU OF RECLAMATION	×	
4	US BLM	×	
5	NASA-AMES	×	
6	NASA-JSC	×	
7	APOLLO/ GEMINI		×
8	ERTS/ LANDSAT		×
A	AMS	×	
B	AIRFORCE	×	
C	NAVY	×	
G	SKYLAB		×
H	ALASKA MISC.	×	

- *SEE SHEET 2 FOR DETAILED* BREAKDOWN

QUALITY
- ALL QUALITY CODES (0 = INFERIOR TO 9 = EXCELLENT)
- AERIAL/ AIRCRAFT/ SKYLAB/ APOLLO/ GEMINI

QUALITY APPEARS IN A/C COLUMN
- ERTS/ LANDSAT

MSS-(B&W)
4567 = INDIVIDUAL AVAILABILITY AND QUALITY FOR MSS BANDS 4, 5, 6, 7.
RBV-(B&W)
456 INDIVIDUAL AVAILABILITY AND QUALITY FOR RBV BANDS 1, 2, 3

- ERTS COLOR COMPOSITES

QUALITY APPEARS IN A/C COLUMN
4567 = ENTRY IN RESPECTIVE BANDS INDICATES THOSE USED FOR THE COMPOSITE

CLOUD COVER
- CLOUD COVER IN PERCENTAGE

00% = NO CLOUD COVER
TO
90% = 90% OR LESS CLOUD COVER

DATE ACQUIRED
- DATE OF EXPOSURE FOR THIS IMAGE

CENTER/ FIRST FRAME COORDINATE
- *SCENE/ PHOTO-CENTER OF SCENE OR PHOTO*
- PHOTO STRIP-CENTER OF FIRST FRAME

SCALE OF IMAGERY
- *SCALE OF IMAGERY FOR THIS ACCESSION*

ALTITUDE
- HEIGHT FROM WHICH EXPOSURE WAS MADE (IN HUNDREDS OF METERS)

OVERLAP
- FORWARD OVERLAP IN PERCENTAGE

PHOTO STRIP INFORMATION
- FIRST-LAST FRAME NUMBER OF THIS PHOTO STRIP ON FILM (USE FOR ORDERING)
- *NUMBER OF FRAMES IN THIS PHOTO STRIP*
- INTERPOLATED FRAME

MICROFILM
- *LOCATION OF THIS IMAGE IN MICROFILM LIBRARY*

CCT
- COMPUTER COMPATIBLE TAPE

ERTS/ LANDSAT ONLY
Y = CCT AVAILABLE AT EROS DATA CENTER
BLANK - CCT MUST BE REQUESTED BY EROS DATA CENTER FROM GODDARD SPACEFLIGHT CENTER
N = CCT CANNOT BE REPRODUCED

TYPE ACCESSION
- INDICATES WHETHER COVERAGE DESCRIBED I OR PHOTO (SINGLE IMAGE), PHOTO STRIP (2 ADJOINING FRAMES), OR PHOTO INDEX (MOSA MANY INDIVIDUAL PHOTOS)

CORNER POINT COORDINATES
- SCENE/ PHOTO-COORDINATES OF SCENE OR I
- PHOTO STRIP-COORDINATES OF ENTIRE STRI (SEVERAL SCENES)
- PHOTO INDEX-COORDINATES OF ENTIRE PHO INDEX (MANY SCENES)

SENSOR CODES
- (SEE SHEET 2)

SENSOR CLASS
- (SEE SHEET 2)

IMAGE CLASS
- (SEE SHEET 2)

FILTER CODE
- (SEE SHEET 2)

FILTER CODE & COLOR
- 100-199 = B & W
- 200-299 = COLOR
- 300-399 = B & W IR (INFRARED)
- 400-499 = COLOR IR (INFRARED)
- *SEE SHEET 2 FOR DETAILED CODES*

FORMAT SIZE
- LENGTH AND WIDTH OF IMAGE ON FILM MASTE *IN MILLIMETERS*

TOTALS
- ALL ACCESSIONS FOR EACH SPECIFIED AREA ARE TOTALED IN FOUR CATEGORIES

4/9/

SECOND LINE OF ACCESSION INFORMATION

TYPE ACCESSION	CORNER POINT COORDINATES								SENSOR	SNS / CLASS	IMG / CLASS	FILTER	FILM CODE	FORMAT SIZE (MM) / LENGTH	WID-
	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE							

1234567890123456789012345678901234567890 67890123456789012345678901234567890123456789012345678901234567890123456789012345678901234

DETAILED CODE INTERPRETATION
SHEET 2
SUPPLEMENT FOR DETAILED INTERPRETATION OF SHEET 1

PHOTO ID CODING

COLUMN 1 = 1

USGS GEOLOGICAL SURVEY
ID 1PPPPPCCCFFFFOO
1 USGS
PPPPP PROJECT
CCC ROLL OR MICROFILM CASSETTE
FFFF = FRAME
OO UNUSED

COLUMN 1 = 2

BUREAU OF RECLAMATION
ID 2PPPPPCCCFFFFOO
2 = USBR
PPPPP = PROJECT
CCC MICROFILM CASSETTE
FFFF = FRAME
OO UNUSED

COLUMN 1 = 4

USBLM : BUREAU OF LAND MGT
ID = 4PPPPPCCCFFFFOO
4 = USBLM
PPPPP = PROJECT
CCC = MICROFILM CASSETTE
FFFF = FRAME
OO = UNUSED

COLUMN 1 = 5

NASA-AMES RESEARCH CENTER
ID = 5YYORRRRFFFFOO
5 = NASA-AMES
YY YEAR
O UNUSED
RRRRR ROLL
FFFF FRAME
OO UNUSED

COLUMN 1 = 6

NASA-JSC JOHNSON SPACECRAFT CENTER
ID = 6MMMMRRRSFFFFOO
6 = NASA-JSC
MMMM = MISSION
RRR ROLL
S = SENSOR, OR 'O' = UNUSED
FFFF FIRST FRAME
OO = UNUSED

COLUMN 1 = 7

NASA-APOLLO/GEMINI MANNED SPACECRAFT
ID = 7SMMRRRRFFFFFOO
7 = APOLLO OR GEMINI
S = 'A' = APOLLO OR
'G' = GEMINI
MM = MISSION NUMBER
RRRR = ROLL NUMBER OR MAGAZINE LETTER
FFFFF = FRAME
OO = UNUSED

COLUMN 1 = 8

ERTS EARTH RESOURCE TECHNOLOGY SATELLITE OR LANDSAT
ID 8IDDDHHMM52A00O
8 ERTS/LANDSAT
1 ERTS-1 2 ERTS-2/LANDSAT
* ERTS-1, PAST DAY 999
DDD DAYS SINCE LAUNCH
WHEN 5 ERTS-1 ABOVE
ADD 1,000 TO DDD
HHMM HOURS/MIN SINCE LAUNCH
5 TENS OF SECONDS
2 RBV, 5 MSS
A ALASKA N GODDARD,
G GOLDSTONE, B BRAZIL
0 BULK, 1 PRECISION, 2 COLOR COMP, 3 COLOR COMP PRECS
OO UNUSED

COLUMN 1 = A

AMS ARMY MAP SERVICE
ID APPPPPCCCFFFFOO
A AMS
PPPPP PROJECT
CCC MICROFILM CASSETTE
FFFF = FRAME
OO = UNUSED

COLUMN 1 = B

AIRFORCE
ID = BPPPPPCCCFFFFOO
B AIRFORCE
PPPPP PROJECT
CCC ROLL OR MICROFILM CASSETTE
FFFF FRAME
OO UNUSED

COLUMN 1 = C

NAVY
ID CPPPPPRRRFFFFOO
NAVY
PPPPP PROJECT
RRR ROLL
FFFF FRAME
OO UNUSED

COLUMN 1 = G

SKYLAB (MANNED SPACECRAFT)
ID G2OAMMMFFFOOOOO
G SKYLAB
2 SKYLAB 2, 3 SKYLAB 3,
4 SKYLAB 4
O UNUSED
A = S190-A, B = S190-B
MMM = MAGAZINE OR ROLL
FFF = FRAME
OOOOO = UNUSED

COLUMN 1 = H

ALASKA-MISC
ID HPPPPRRRFFFFFOO
H ALASKA-MISC
PPPP PROJECT
RRR ROLL
FFFFF FRAME
OO UNUSED

SENSOR CODES

CAMERAS MM

C01 HR-732
C02 HR-732R
C03 RC-10
C04 PAN-30
C05 KA5C
C06 KA20
C07 KR-73B 913
C08 B-SYSTEM 914
C09 ITEK OPTICAL BAR (608)
C10 IZS-150
C11 KA96
C12 OPTICAL BAR PAN (608)
C13 HASS 38
C14 HASS 60
C15 HASS 100
C16 HASS 105
C17 MAUER 50
C18 MAUER 80
C19 KA-76 152
C31 WILD RC-8 152
C32 T-11
C33 AP6
C34 K-17CHI AER (457)
C35 K-17NIKON DATA (70)
C36 ZEISS (305)
C37 ZEISS RMK 30/23 (305)
C38 ZEISS RMK 15/23 (152)
C39 HASS 40
C40 ITEK M-BAND (100)
C41 ITEK M-BAND (150)
C42 HASS 4 50
C43 HASS B 80
C44 HASS 120
C45 HASS D 150
C46 HASS E 250
C47 HASS F 500
C48 KA62 A 76
C49 KA62 B 76
[illegible] KA62 76
[illegible] KA62 76
C52 KA62 E 76
C53 KA62 F 76
C54 VINTEN 44
C55 SMITH (152)
C56 FAIRCHILD 152
C57 HURD 152
C58 PARK 152
C59 WILD RC-5 152
C60 K17 (152)
C61 AERO 83 (152)
C62 AEROGON ENG-152
C63 KARGL (152)
C64 AEROGON (152)
C65 WILD (152)
C66 AERO VIEW (152)
C67 KARGL K-17 (152)
C68 KARGL T-12 (152)
C69 WILD RC-9 (88)
C70 AERO (304)
C71 S (100)
C72 RC8/4L (152)
C73 RC8/4R (152)
C74 RC8/4L (305)
C75 RC8/4R
C76 TEK 9
C77 MFMR 35
C78 M S
C79 P-22

C80 RFR
C81 KB8
C82 RC8 #1
C83 RC8 #2
C84 RC-10
C85 S190-A
C86 S190-B
C87 DA50 A
C88 K-12
C89 AAD-2
C90 KA-2
C91 AMP
C92 C24
C93 K224
C94 NIKON
C95 HC-730V
C96 HC-730W
C97 HC-730R
C98 HR-732
C99 HR-732F

SCANNERS

S01 AAS-SUV
S02 BENDIX 24 CH (80)
S03 UM
S04 RECON 4 (60)
S05 RS-(100)
S06 RS-4 (80)
S07 RS-(310)
S08 RS 314
S09 (97)
S10 HBV
S11 MSE
S12 APO 97
S13 UPD-2 SLAR
S14 HP-307C 130
S15 DP #6
S16 MSS GODDARD
S17 SAS
S18 OCS
S19 HRB454
S20 TI-D4

FILTER CODES

A [illegible]
AA [illegible]
BB C6 0
BL BLUE USGS 5
CA CLEAR AV
[illegible] C7 0 8
[illegible] CLEAR
[illegible] W12
DL 0 8 0 9
EE 0 5 0.88
FF 0 4 - 0 7
F0 1 000 - 000
F1 0 000 925
F2 0.000 324
F3 0 000 227
F4 0 000 [illegible]
F5 0 515 350
F6 0 350 - 40
G6 = 0 4 0 5
HH 0 425 - 0 41
HF HF 2
H3 HF 3
H4 HF4
H5 HF5
II 0.525 - 0 575
IS = I2S MULT BAND
JJ = 0 625 - 0 675
KK = 0 725 - 0 775
LL = 0 825 - 0.875
MM = 0 35 - 0 60
M4 = MSS - 4
M5 MSS - 5
M6 MSS - 6
M7 MSS - 7
M8 MSS - 8
NN 0 475 - 0 525
OO 0 575 - 625
PP 0 675 725
P1 400
P2 [illegible]
P3 [illegible]
P4 420
P5 10 625
P6 22 235
P7 22 355
P8 3 4
P9 10 69
PA 16 5
QQ 0 775 0.825
RR 0 875 - 0 925
R1 = RBV - 1
R2 RBV - 2
R3 RBV - 3
R4 24
SA = 1.20 - 1.30
SB 1 55 - 1 75
SC 2 10 - 2.35
SD = 10 2 12 5
SE SE
S1 0 41 - 0 46
S2 0 45 - 0 51
S3 0 52 - 0 56
S4 0 56 - 0 61
S5 0.62 - 0.67
S6 0 68 - 0 76
S7 = 0 78 - 0 88
S8 0 98 - 1 08
S9 1 09 - 1 19
T1 3.0 - 5.50
T2 = 0 3 - 0.[illegible]
T3 = 1 0 - 1 3[illegible]
T4 = 1.5 - 1.8

[illegible] 2 2.5
[illegible] [illegible] 2 5
[illegible] 0 7 0 9
T8 8 - 14
T9 8 - 0 5
UV UV 17
U1 10 0 12 0
U2 10.2 - 12 5
U3 10M - 515
U4 10M - 52
V1 475 - 575
V2 580 - 680
V3 690 - 760
V4 510 - 900
W1 W - 1
W5 W 15
WR W58A
[illegible] 21
[illegible] 22
ZA ZEISS A
ZB ZEISS B
ZC ZEISS C
ZD ZEISS D
0B 80B
07 0.7 MICRONS
1B 18B
1M 10M
2A = 2A
2C CC
2E = 2E
2H = HF3 & HF4
3 = 3
3A 29A
3B 30B
3R 30R
5A 25A
5B 50B
5G 56
6A 65A
7A 47A
7B 47B
7C 87C
8 8
8A 82A
8B 58B
9B 89B
12 W12
15 15
18 1.8
20 2.0 AV
22 2.2 AV
24 W24
25 W25
29 = 29
32 = 32
34 = 34
35 = 35
38 38
44 44
47 47
48 48
50 W500
53 W530
56 W156
57 57
58 58
61 = 61
70 W700
78 W78A
87 87
88 IR WR88A
89 W89

FILM CODES

B & W FILM

100 8401
101 8403
102 2405
103 2402
104 2403
105 2485
106 2498
107 = 3400
108 = 5425
109 3401
110 5401
111 xx
112 2404
113 SO467
114 5498
115 SO-206
116 SO-243
117 SO-349
118 SO-357
119 SO-380
120 = 2401
121 = 3404
122 SO-022
123 = 2479
124 = SO-287
125 = SO-355
126 = 3414
127 = RAR 2490
128 = 5366
129 = 2914
130 = 5474
131 = 2491

COLOR INFRARED

450 = 8443
452 = SO-117
453 = SO-180
454 = 2443
457 = 3443
458 = SO-131
459 = SO-127

FALSE COLOR COMP

500 = FCC

COLOR

220 = 8442
221 = 2448
222 = 2450
223 = SO-121
224 SO-118
225 = SO-368
226 = SO-397
227 D-500
228 = D-1000
229 = SO-271
230 = SO-360
231 = SO-278
232 = 267
233 = -C
234 = SO-168
235 = SO-242
236 = SO-356
238 = 2445
239 = 5389
240 = SO-224
241 = 4109
242 = FE-3492
243 = SO-217

B & W INFRARED

340 = SO-246
341 = 2424
342 = 5424
343 = -1
344 = FE-3215
346 = SO-289

SENSOR CLASS

01 = VERT CARTO
02 = VERT RECON
03 = SLAR
04 = THERMAL
05 = PANORAMIC
09 = PPI
10 = MICROWAVE
11 = PANCHROMATIC
16 = L. OBLIQUE
17 = H. OBLIQUE
37 = RBV
38 = MSS

IMAGE CLASS

06 = BULK
07 = PRECISION
08 = COLOR COMP
11 = PANCHROMATIC
12 = IR (B & W)
13 = IR (COLOR)
14 = COLOR
15 = MULTISPECTRAL
18 = RECTILINEARIZED
19 = NON-REC
20 = SLANT RANGE
21 = GROUND RANGE
22 = NON-IMAGE
23 = OTHER IMAGING
24 = BLACK & WHITE

U.S. GEOLOGICAL SURVEY
EROS DATA CENTER STANDARD PRODUCTS
AIRCRAFT PRODUCTS

Aug. 1, 1975

AERIAL MAPPING PHOTOGRAPHY

Image Size	Format	Black & White Unit Price
9 inch.	Film Positive	$ 5.00
9 inch.	Film Negative	6.00
9 inch.	Paper	3.00
18 inch.	Paper	8.00
27 inch.	Paper	9.00
36 inch.	Paper	15.00

Black & White Paper Print Photo Index

Film Source	Format	Unit Price
B & W - Size A	10" x 12"	$ 5.00
B & W - Size B	Other	5.00

NASA RESEARCH AIRCRAFT PHOTOGRAPHY

Image Size	Format	Black & White Unit Price	Color Unit Price
2.2 inch.	Film Positive	$ 3.00	$ 6.00
2.2 inch.	Film Negative	4.00	N.A.
4.5 inch.	Film Positive	4.00	7.00
4.5 inch.	Film Negative	5.00	N.A.
4.5 inch.	Paper	3.00	7.00
9.0 inch.	Film Positive	5.00	12.00
9.0 inch.	Film Negative	6.00	N.A.
9.0 inch.	Paper	3.00	7.00
9 X18 inch.	Film Positive	10.00	24.00
9 X18 inch.	Film Negative	12.00	N.A.
9 X18 inch.	Paper	6.00	14.00
18.0 inch.	Paper	8.00	20.00
27.0 inch.	Paper	9.00	25.00
36.0 inch.	Paper	15.00	40.00

MISCELLANEOUS

MICROFILM	Black & White Roll Price	Color Roll Price
16mm (100 foot roll)	$15.00	$40.00
35mm (100 foot roll)	20.00	45.00

KELSH PLATES

	Black & White
Contact Prints on Glass Specify thickness (0.25 or 0.06 inch) and method of printing (emulsion to emulsion or through film base).	$12.00

TRANSFORMED PRINTS

	Black & White
From convergent or transverse low oblique photographs.	$8.00

35 mm MOUNTED SLIDE	Black & White	Color
35 mm mounted duplicate slide where available	$1.00	$1.00

Complete roll reproduction delivered in roll format carries a 50% reduction in frame price.

Custom processing of non-standard products is available at three times the standard product price. If a non-standard size is desired, price is three times the next larger standard product price.

Priority service with guaranteed five working days shipment is offered for standard products only, at three times the standard product price.

See Reverse

U.S. GEOLOGICAL SURVEY
EROS DATA CENTER STANDARD PRODUCTS

SATELLITE PRODUCTS

Aug. 1, 1975

LANDSAT DATA

Image Size	Scale	Format	Black & White Unit Price	Color Composite Unit Price
2.2 inch.	1:3369000	Film Positive	$ 3.00	N.A.
2.2 inch.	1:3369000	Film Negative	4.00	N.A.
7.3 inch.	1:1000000	Film Positive	5.00	12.00
7.3 inch.	1:1000000	Film Negative	6.00	N.A.
7.3 inch.	1:1000000	Paper	3.00	7.00
14.6 inch.	1:500000	Paper	8.00	20.00
29.2 inch.	1:250000	Paper	15.00	40.00

COLOR COMPOSITE GENERATION *(When not already available)

Image Size	Scale	Format	Unit Price
7.3 inch.	1:1000000	Printing Master **	$50.00

* Color composites are portrayed in false color (infrared) and not true color.
** Cost of product from this composite must be added to total cost.

COMPUTER COMPATIBLE TAPES

Tracks	b.p.i.	Format	Set Price
7	800	tape set	$200.00
9	800	tape set	200.00
9	1600	tape set	200.00

NASA LANDSAT CATALOGS

Title	Cost Per Volume
U.S. Standard Catalog - Monthly	$ 1.25 each
Non - U.S. Standard Catalog - Monthly	1.25 each
Cumulative U.S. Standard Catalog — 1972/1973 also 1973/1974	
Volume 1 Observation ID Listing	
Volume 2 Coordinate Listing	1.25 each
Cumulative Non - U.S. Standard Catalog — 1972/1973 also 1973/1974	
Volume 1 Observation ID Listing	
Volume 2 Observation ID Listing	
Volume 3 Coordinate Listing	
Volume 4 Coordinate Listing	1.25 each

MANNED SPACECRAFT PRODUCTS

SKYLAB S190A PHOTOGRAPHY

Image Size	Scale	Format	Black & White Unit Price	Color Unit Price
2.2 inch.	1:2850000	Film Positive	$ 3.00	$ 6.00
2.2 inch.	1:2850000	Film Negative	4.00	N.A.
6.4 inch.	1:1000000	Paper	3.00	7.00
12.8 inch.	1:500000	Paper	8.00	20.00
25.6 inch.	1:250000	Paper	15.00	40.00

SKYLAB S190B PHOTOGRAPHY

Image Size	Scale	Format	Black & White Unit Price	Color Unit Price
4.5 inch.	1:950000	Film Positive	$ 4.00	$ 7.00
4.5 inch.	1:950000	Film Negative	5.00	N.A.
4.5 inch.	1:950000	Paper	3.00	7.00
8.6 inch.	1:500000	Paper	3.00	7.00
17.2 inch.	1:250000	Paper	8.00	20.00
34.4 inch.	1:125000	Paper	15.00	40.00

APOLLO/GEMINI PHOTOGRAPHY

Image Size	Format	Black & White Unit Price	Color Unit Price
2.2 inch	Film Positive	$3.00	$6.00
2.2 inch	Film Negative	4.00	N.A.
8.9 inch	Paper	3.00	7.00
17.9 inch	Paper	8.00	20.00

See Reverse

```
BOX  8 19/ N18D30M N22D30M W154D30M W160D45M
  82 ACCESSIONS
LIST FOR BLR -- 60700922

 TYPE COVERAGE       FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)           B&W-02.2" 81171204055A000  8888 20% 730110 N18 34 21 W161 29 01 3369000 9054 10%                  1200120622
 SCENE       (N19 12 11,W160 25 56)(N19 26 52,W162 06 47)(N17 41 41,W160 51 40)(N17 56 11,W162 31 40) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81189204115A000  8888 50% 730128 N18 52 17 W161 24 42 3369000 9080 10%                  1200140072
 SCENE       (N19 29 40,W160 20 58)(N19 45 18,W162 02 09)(N17 59 07,W160 47 42)(N18 14 33,W162 28 00) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81170203515A000  8888 40% 730109 N18 33 46 W160 01 53 3369000 9054 10%                  1200120486
 SCENE       (N19 11 24,W158 58 41)(N19 26 24,W160 39 28)(N17 40 59,W159 24 43)(N17 55 47,W161 04 39) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81188203525A000  8888 60% 730127 N18 52 03 W160 00 26 3369000 9077 10%                  1200131825
 SCENE       (N19 29 40,W158 56 53)(N19 44 54,W160 38 06)(N17 59 03,W159 23 12)(N18 14 05,W161 03 32) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81169202935A000  2888 60% 730108 N18 38 05 W158 35 27 3369000 9054 10%                  1100061060
 SCENE       (N19 15 46,W157 32 14)(N19 30 43,W159 13 05)(N17 45 20,W157 58 14)(N18 00 05,W159 38 13) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81205202955A000  8888 20% 730213 N18 49 51 W158 39 20 3369000 9130 10%                  1100070905
 SCENE       (N19 27 42,W157 35 27)(N19 43 00,W159 17 15)(N17 56 33,W158 01 52)(N18 11 39,W159 42 46) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81114202405A000  8888 50% 721114 N18 43 57 W157 11 36 3369000 9186 10%                  1100041621
 SCENE       (N19 21 49,W156 07 13)(N19 37 35,W157 49 30)(N17 50 11,W156 34 08)(N18 05 45,W158 15 31) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81168202345A000  8888 60% 730107 N18 38 44 W157 08 33 3369000 9054 10%                  1100061019
 SCENE       (N19 16 16,W156 05 15)(N19 31 26,W157 46 05)(N17 45 53,W156 31 27)(N18 00 51,W158 11 24) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81186202355A000  8888 60% 730125 N18 52 36 W157 07 52 3369000 9072 10%                  1100070288
 SCENE       (N19 30 14,W156 04 23)(N19 45 24,W157 45 33)(N17 59 40,W156 30 37)(N18 14 38,W158 10 54) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81204202415A000  2888 10% 730212 N18 45 30 W157 14 03 3369000 9127 10%                  1100080021
 SCENE       (N19 23 20,W156 10 13)(N19 38 39,W157 51 55)(N17 52 13,W156 36 37)(N18 07 20,W158 17 26) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81167201805A000  8822 50% 730106 N18 37 36 W155 42 50 3369000 9054 10%                  1100060977
 SCENE       (N19 15 07,W154 39 31)(N19 30 20,W156 20 19)(N17 44 44,W155 05 46)(N17 59 45,W156 45 42) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81203201825A000  8888 10% 730211 N18 46 39 W155 47 14 3369000 9123 10%                  1100070863
 SCENE       (N19 24 26,W154 43 24)(N19 39 48,W156 25 04)(N17 53 22,W155 09 51)(N18 08 31,W156 50 38) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81221201835A000  8882 20% 730301 N18 50 27 W155 50 48 3369000 9177 10%                  1100080539
 SCENE       (N19 28 34,W154 46 39)(N19 43 49,W156 28 59)(N17 56 56,W155 13 03)(N18 11 59,W156 54 30) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81293201835N000  8888 50% 730512 N18 51 55 W155 56 45 3369000 9058 10%                  1100101611
 SCENE       (N19 29 47,W154 53 34)(N19 44 28,W156 34 38)(N17 59 14,W155 19 18)(N18 13 44,W156 59 30) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82181200615000C  5555 20% 750722 N18 52 59 W155 40 59 3369000 9026 10%                  2100070824
 SCENE       (N19 29 51,W154 37 25)(N19 45 54,W156 17 54)(N17 59 56,W155 04 30)(N18 15 48,W156 44 08) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82217200515000O  5555 40% 750827 N18 45 00 W155 34 59 3369000 9111 10%                  2100110002
 SCENE       (N19 22 20,W154 30 58)(N19 38 19,W156 12 22)(N17 51 32,W154 58 03)(N18 07 19,W156 38 34) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81184201225A000  8888 20% 730123 N18 51 14 W154 10 17 3369000 9068 10%                  1100070210
 SCENE       (N19 28 55,W153 06 52)(N19 43 57,W154 48 00)(N17 58 21,W153 33 00)(N18 13 12,W155 13 14) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81202201245A000  8888 30% 730210 N18 46 20 W154 22 49 3369000 9120 10%                  1100070822
 SCENE       (N19 24 21,W153 19 09)(N19 39 19,W155 00 51)(N17 53 13,W153 45 13)(N18 08 00,W155 26 01) S11 3806 M5 113   55  53
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BOX 8 19/ N18D30M N22D30M W154D30M W160D45M
82 ACCESSIONS
LIST FOR BLR -- 60700922

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TYPE COVERAGE     FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)      B&W-02.2" 81171204035A000  8888 10% 730110 N20 00 43 W161 07 34 3369000 9055 10%          1100061137
 SCENE     (N20 38 29,W160 03 55)(N20 53 17,W161 45 41)(N19 08 00,W160 29 54)(N19 22 35,W162 10 44) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81189204045A000  8888 10% 730128 N20 18 57 W161 03 05 3369000 9080 10%          1100070402
 SCENE     (N20 56 16,W159 58 46)(N21 12 02,W161 40 53)(N19 25 44,W160 25 46)(N19 41 17,W162 06 55) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81170203455A000  8888 20% 730109 N20 01 14 W159 40 47 3369000 9054 10%          1100061100
 SCENE     (N20 38 53,W158 37 03)(N20 53 53,W160 18 48)(N19 08 26,W159 03 14)(N19 23 14,W160 44 02) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81188203505A000  8888 60% 730127 N20 18 53 W159 38 44 3369000 9077 10%          1100070366
 SCENE     (N20 56 25,W158 34 37)(N21 11 47,W160 16 45)(N19 25 50,W159 01 12)(N19 40 59,W160 42 22) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81115202925A000  8888 40% 721115 N20 08 56 W158 17 30 3369000 9186 10%          1100050142
 SCENE     (N20 46 51,W157 12 39)(N21 02 30,W158 55 53)(N19 15 12,W157 39 36)(N19 30 38,W159 21 52) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81169202905A000  8828 60% 730108 N20 04 56 W158 13 36 3369000 9055 10%          1100061059
 SCENE     (N20 42 31,W157 09 49)(N20 57 38,W158 51 35)(N19 12 06,W157 36 06)(N19 27 00,W159 16 55) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81205202935A000  8888 30% 730213 N20 16 26 W158 17 53 3369000 9129 10%          1100070904
 SCENE     (N20 54 14,W157 13 27)(N21 09 37,W158 56 10)(N19 23 06,W157 40 05)(N19 38 16,W159 21 50) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81223202945A000  8888 20% 730303 N20 13 07 W158 20 58 3369000 9181 10%          1100080574
 SCENE     (N20 51 00,W157 15 06)(N21 06 40,W158 59 19)(N19 19 24,W157 43 05)(N19 34 52,W159 25 20) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81457202645A000  8888 10% 731023 N20 14 40 W158 11 35 3369000 9091 10%          1100161178
 SCENE     (N20 52 26,W157 07 30)(N21 07 33,W158 49 48)(N19 21 39,W157 33 50)(N19 36 32,W159 15 10) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81114202335A000  8888 70% 721114 N20 09 28 W156 49 58 3369000 9188 10%          1100041620
 SCENE     (N20 47 14,W155 45 00)(N21 03 10,W157 28 13)(N19 15 37,W156 12 13)(N19 31 20,W157 54 27) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81168202325A000  8888 80% 730107 N20 05 29 W156 46 47 3369000 9055 10%          1100061018
 SCENE     (N20 42 56,W155 42 54)(N20 58 16,W157 24 38)(N19 12 34,W156 09 24)(N19 27 41,W157 50 11) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81186202335A000  8888 50% 730125 N20 18 19 W156 46 13 3369000 9072 10%          1100070287
 SCENE     (N20 55 52,W155 42 09)(N21 11 11,W157 24 13)(N19 25 19,W156 08 40)(N19 40 25,W157 49 47) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81204202345A000  2888 30% 730212 N20 12 07 W156 51 50 3369000 9126 10%          1100080020
 SCENE     (N20 49 47,W155 47 22)(N21 05 21,W157 29 58)(N19 18 44,W156 14 10)(N19 34 04,W157 55 47) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81222202355A000  8882 20% 730302 N20 14 07 W156 56 29 3369000 9179 10%          1100080559
 SCENE     (N20 52 14,W155 51 48)(N21 07 30,W157 35 05)(N19 20 34,W156 18 22)(N19 35 38,W158 00 40) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81077201715A000  88 8 40% 721008 N20 18 01 W155 19 45 3369000 9142 10%          1100040354
 SCENE     (N20 55 59,W154 15 18)(N21 11 13,W155 58 12)(N19 24 41,W154 41 47)(N19 39 42,W156 23 43) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81167201745A000  8822 50% 730106 N20 04 09 W155 20 58 3369000 9055 10%          1100060976
 SCENE     (N20 41 33,W154 17 04)(N20 56 57,W155 58 47)(N19 11 11,W154 43 38)(N19 26 23,W156 24 24) S11 3806 M5 113   55  53

ERTS-1 (MSS)      B&W-02.2" 81203201805A000  8888 30% 730211 N20 13 05 W155 25 42 3369000 9123 10%          1100070862 Y
 SCENE     (N20 50 46,W154 21 10)(N21 06 14,W156 03 45)(N19 19 46,W154 48 07)(N19 35 02,W156 29 44) S11 3806 M5 113   55  53

ERTS-1 (MSS)      FCC-07.3" 81203201805A200 7BG R 30% 730211 N20 13 05 W155 25 42 1000000 9123 00%        1100070862
 SCENE     (N20 50 47,W154 21 17)(N21 06 16,W156 03 53)(N19 19 45,W154 48 00)(N19 35 00,W156 29 37) S11 3808 M5 500  185 178
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                                  EROS DATA CENTER DATA INQUIRY SYSTEM                      DATE 07/22/76   REPORT DI002
                                      GENERAL LIST (TERMINAL)                               TIME    08:31   PAGE       3
BOX  8 19/ N18D30M N22D30M W154D30M W160045M
 82 ACCESSIONS
LIST FOR BLR -- 60700922

 TYPE COVERAGE      FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)              B&W-02.2" 81221201815A000  8888 20% 730301 N20 16 39 W155 29 56 3369000 9177 10%                 1100080538
 SCENE       (N20 54 47,W154 25 15)(N21 10 01,W156 08 33)(N19 23 07,W154 51 48)(N19 38 09,W156 34 06) S11 3806 M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81221201815A200 7BG R 20% 730301 N20 16 39 W155 29 56 1000000 9177 00%                 1100080538
 SCENE       (N20 54 47,W154 25 15)(N21 10 01,W156 08 33)(N19 23 07,W154 51 48)(N19 38 09,W156 34 06) S11 3808 M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81293201805A000  8888 70% 730512 N20 18 36 W155 35 25 3369000 9060 10%                 1100101610
 SCENE       (N20 56 25,W154 31 39)(N21 11 11,W156 13 42)(N19 25 52,W154 57 36)(N19 40 26,W156 38 41) S11 3806 M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 82217200455C000  5555 50% 750827 N20 11 59 W155 12 59 3369000 9111 10%                 2100110001
 SCENE       (N20 49 15,W154 08 24)(N21 05 23,W155 50 43)(N19 18 28,W154 35 44)(N19 34 22,W156 17 06) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81202201215A000  8888 50% 730210 N20 12 56 W154 01 05 3369000 9119 10%                 1100070821
 SCENE       (N20 50 50,W152 56 50)(N21 05 58,W154 39 26)(N19 19 45,W153 23 12)(N19 34 40,W155 04 50) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81184201155A000  8888 20% 730123 N20 17 45 W153 48 30 3369000 9068 10%                 1100070209
 SCENE       (N20 55 26,W152 44 33)(N21 10 30,W154 26 38)(N19 24 52,W153 10 50)(N19 39 43,W154 51 56) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81171204005A000  8828 30% 730110 N21 26 03 W160 45 24 3369000 9056 10%                 1100061136
 SCENE       (N22 03 40,W159 41 06)(N22 18 43,W161 23 51)(N20 33 13,W160 07 28)(N20 48 03,W161 49 10) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81189204025A000  8888 20% 730128 N21 45 31 W160 41 23 3369000 9079 10%                 1100070401
 SCENE       (N22 22 46,W159 38 28)(N22 38 37,W161 19 35)(N20 52 15,W160 03 43)(N21 07 52,W161 45 46) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81062203355A000  8888 40% 720923 N21 36 41 W159 13 15 3369000 9094 10%                 1100030594
 SCENE       (N22 14 02,W158 08 20)(N22 29 50,W159 51 31)(N20 43 22,W158 35 30)(N20 58 56,W160 17 38) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81170203425A000  8888 20% 730109 N21 27 34 W159 19 23 3369000 9056 10%                 1100061099
 SCENE       (N22 05 12,W158 15 04)(N22 20 15,W159 57 50)(N20 34 45,W158 41 27)(N20 49 34,W160 23 11) S11 3806 M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81170203425A200 7BG R 20% 730109 N21 27 34 W159 19 23 1000000 9056 00%                 1100061099
 SCENE       (N22 05 12,W158 15 04)(N22 20 15,W159 57 50)(N20 34 45,W158 41 27)(N20 49 34,W160 23 11) S11 3808 M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81188203435A000  8888 60% 730127 N21 45 02 W159 16 09 3369000 9077 10%                 1100070365
 SCENE       (N22 22 24,W158 11 21)(N22 38 03,W159 54 28)(N20 51 51,W158 38 22)(N21 07 16,W160 20 26) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81223202915A000  8888 30% 730303 N21 39 56 W158 00 21 3369000 9181 10%                 1100080573
 SCENE       (N22 17 53,W156 54 57)(N22 33 26,W158 39 14)(N20 46 16,W157 21 58)(N21 01 35,W159 05 12) S11 3806 M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81223202915A200 8BG R 30% 730303 N21 39 56 W158 00 20 1000000 9181 00%                 1100080573
 SCENE       (N22 17 53,W156 54 57)(N22 33 26,W158 39 14)(N20 46 16,W157 21 58)(N21 01 35,W159 05 12) S11 3808 M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81115202855A000  8882 40% 721115 N21 34 36 W157 55 32 3369000 9188 10%                 1100050141
 SCENE       (N22 12 24,W156 50 02)(N22 28 15,W158 34 17)(N20 40 46,W157 17 19)(N20 56 23,W159 00 31) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81169202845A000  8888 80% 730108 N21 31 47 W157 51 11 3369000 9056 10%                 1100061058
 SCENE       (N22 09 13,W156 46 43)(N22 24 34,W158 29 29)(N20 38 50,W157 13 24)(N20 53 58,W158 55 08) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81205202905A000  8888 30% 730213 N21 42 59 W157 56 09 3369000 9129 10%                 1100070903
 SCENE       (N22 20 43,W156 51 06)(N22 36 13,W158 34 50)(N20 49 36,W157 18 00)(N21 04 52,W159 00 40) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81457202625A000  2888 20% 731023 N21 41 25 W157 49 24 3369000 9091 10%                 1100161177
 SCENE       (N22 19 04,W156 44 41)(N22 34 23,W158 27 58)(N20 48 18,W157 11 21)(N21 03 23,W158 53 36) S11 3806 M5 113   55  53
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BOX  8 19/ N18D30M N22D30M W154D30M W160D45M
  82 ACCESSIONS
LIST FOR BLR -- 60700922

 TYPE COVERAGE       FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE   CENTER/1ST FRAME CTR   SCALE   ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-2 (MSS)              B&W-02.2" 8221920155500000  5858 40% 750829 N21 40 59 W157 42 59 3369000 9118 10%                     2100100778
 SCENE        (N22 18 09,W156 37 40)(N22 34 30,W158 21 06)(N20 47 20,W157 05 24)(N21 03 26,W158 47 47) S11  3806  M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 8223720155500000  6885 70% 750916 N21 37 59 W157 46 59 3369000 9193 10%                     2100101533
 SCENE        (N22 15 35,W156 47 16)(N22 31 51,W158 25 33)(N20 43 59,W157 08 57)(N21 00 00,W158 52 11) S11  3806  M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 8225520154500000  5555 40% 751004 N21 35 59 W157 45 59 3369000 9218 10%                     2100110662
 SCENE        (N22 13 30,W156 39 58)(N22 30 07,W158 24 28)(N20 41 42,W157 08 03)(N20 58 05,W158 51 28) S11  3806  M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 8227320153500000  5550 30% 751022 N21 36 59 W157 48 59 3369000 9178 10%                     2100111097
 SCENE        (N22 14 32,W156 47 23)(N22 30 44,W158 27 29)(N20 43 05,W157 11 02)(N20 59 03,W158 54 04) S11  3806  M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 8230920150500000  5855 70% 751127 N21 45 00 W157 47 59 3369000 9037 10%                     2100130476
 SCENE        (N22 21 55,W156 47 16)(N22 37 57,W158 25 51)(N20 51 52,W157 10 39)(N21 07 41,W158 52 12) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81114202315A000  8888 50% 721114 N21 34 28 W156 27 49 3369000 9189 10%                     1100041619
 SCENE        (N22 12 05,W155 27 11)(N22 28 16,W157 06 23)(N20 40 30,W155 49 47)(N20 56 26,W157 32 56) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81168202255A000  8988 70% 730107 N21 31 54 W156 24 21 3369000 9056 10%                     1100061017
 SCENE        (N22 09 11,W155 19 47)(N22 24 46,W157 02 30)(N20 38 51,W155 46 41)(N20 54 13,W157 28 23) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81186202305A000  8888 40% 730125 N21 44 52 W156 24 07 3369000 9072 10%                     1100070286
 SCENE        (N22 22 18,W155 19 25)(N22 37 48,W157 02 30)(N20 51 47,W155 46 16)(N21 07 03,W157 28 18) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81204202325A000  2888 90% 730212 N21 37 47 W156 29 57 3369000 9125 10%                     1100080019
 SCENE        (N22 15 21,W155 24 52)(N22 31 05,W157 08 26)(N20 44 20,W155 51 58)(N20 59 50,W157 34 30) S11  3866  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81222202335A000  8888 30% 730302 N21 40 08 W156 34 52 3369000 9179 10%                     1100080558
 SCENE        (N22 18 12,W155 29 34)(N22 33 34,W157 13 52)(N20 46 33,W155 56 23)(N21 01 41,W157 39 37) S11  3806  M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81222202335A200 4BG R 30% 730302 N21 40 08 W156 34 52 1000000 9179 00%                   1100080558
 SCENE        (N22 18 12,W155 29 34)(N22 33 34,W157 13 52)(N20 46 33,W155 56 23)(N21 01 41,W157 39 37) S11  3808  M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81203201735A000  8888 40% 730211 N21 39 29 W155 04 04 3369000 9122 10%                     1100070861
 SCENE        (N22 17 08,W153 59 03)(N22 32 42,W155 42 39)(N20 46 07,W154 26 01)(N21 01 27,W156 08 33) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81221201745A000  8888 20% 730301 N21 43 20 W155 08 15 3369000 9177 10%                     1100080537
 SCENE        (N22 21 24,W154 02 58)(N22 36 44,W155 47 17)(N20 49 45,W154 29 45)(N21 04 52,W156 12 59) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81293201745A000  8888 60% 730512 N21 44 00 W155 14 07 3369000 9062 10%                     1100101609
 SCENE        (N22 21 47,W154 09 45)(N22 36 37,W155 52 49)(N20 51 14,W154 35 55)(N21 05 50,W156 17 56) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81167201715A000  8822 90% 730106 N21 30 33 W154 58 42 3369000 9057 10%                     1100060975
 SCENE        (N22 07 49,W153 54 08)(N22 23 27,W155 36 50)(N20 37 29,W154 21 04)(N20 52 53,W156 02 45) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81184201135A000  8888 30% 730123 N21 44 15 W153 26 25 3369000 9068 10%                     1200131341
 SCENE        (N22 21 51,W152 21 52)(N22 37 02,W154 04 57)(N20 51 18,W152 48 23)(N21 06 15,W154 30 26) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81202201155A000  8888 50% 730210 N21 39 14 W153 39 04 3369000 9118 10%                     1100070820
 SCENE        (N22 17 01,W152 34 11)(N22 32 20,W154 17 47)(N20 45 58,W153 00 52)(N21 01 03,W154 43 25) S11  3806  M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81171203945A000  8828 40% 730110 N22 52 07 W160 22 33 3369000 9057 10%                     1100061135
 SCENE        (N23 29 33,W159 17 31)(N23 44 55,W161 01 19)(N21 59 09,W159 44 21)(N22 14 17,W161 27 01) S11  3806  M5 113   55  53
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                                         EROS DATA CENTER DATA INQUIRY SYSTEM                     DATE 07/22/76   REPORT DI002
                                              GENERAL LIST (TERMINAL)                             TIME    08:31   PAGE        5
BOX  8 19/ N18D30M N22D30M W154D30M W160D45M
  82 ACCESSIONS
LIST FOR BLR -- 60700922

 TYPE COVERAGE       FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)           B&W-02.2" 81170203405A000  8888 70% 730109 N22 54 08 W158 57 27 3369000 9057 10%                  1100061098
 SCENE       (N23 31 41,W157 59 29)(N23 46 51,W159 36 21)(N22 01 15,W158 19 07)(N22 16 10,W160 01 52) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81169202815A000  8888 60% 730108 N22 57 32 W157 28 32 3369000 9057 10%                  1100061057
 SCENE       (N23 34 58,W156 23 03)(N23 50 41,W158 07 21)(N22 04 13,W156 50 17)(N22 19 41,W158 33 27) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81168202235A000  8888 10% 730107 N22 58 01 W156 01 40 3369000 9058 10%                  1200120261
 SCENE       (N23 35 09,W154 56 22)(N23 51 01,W156 40 10)(N22 04 51,W155 23 43)(N22 20 28,W157 06 24) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81167201655A000  8822 90% 730106 N22 56 18 W154 36 20 3369000 9058 10%                  1200120138
 SCENE       (N23 33 27,W153 31 04)(N23 49 18,W155 14 50)(N22 03 09,W153 58 23)(N22 18 45,W155 41 02) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81531203635A000  2222 90% 740105 N23 02 17 W160 27 28 3369000 9137 10%                  1100200025
 SCENE       (N23 40 06,W159 21 50)(N23 55 30,W161 06 42)(N22 08 53,W159 48 49)(N22 24 03,W161 32 32) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81549203555A000  2222 80% 740123 N23 10 46 W160 21 00 3369000 9079 10%                  1100200559
 SCENE       (N23 48 12,W159 15 36)(N24 03 44,W160 59 52)(N22 17 37,W159 42 42)(N22 32 54,W161 25 49) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81188203415A000  8888 70% 730127 N23 11 46 W158 53 11 3369000 9077 10%                  1100070364
 SCENE       (N23 48 56,W157 47 38)(N24 04 53,W159 31 49)(N22 18 28,W158 15 07)(N22 34 09,W159 58 10) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81205202845A000  8888 10% 730213 N23 09 28 W157 34 12 3369000 9128 10%                  1100070902
 SCENE       (N23 47 07,W156 28 28)(N24 02 43,W158 13 18)(N22 16 02,W156 55 39)(N22 31 23,W158 39 20) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81204202255A000  2888 90% 730212 N23 03 49 W156 08 22 3369000 9125 10%                  1200150709
 SCENE       (N23 41 21,W155 02 38)(N23 57 07,W156 47 19)(N22 10 20,W155 29 58)(N22 25 52,W157 13 31) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81203201715A000  8888 50% 730211 N23 05 40 W154 42 11 3369000 9121 10%                  1200141887
 SCENE       (N23 43 15,W153 36 30)(N23 58 55,W155 21 12)(N22 12 15,W154 03 43)(N22 27 40,W155 47 16) S11 3806 M5 113   55  53

TOTALS  ERTS-  82, MANNED SPACECRAFT-    , NASA-AIRCRAFT-    , AERIAL MAPPING-
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