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DEVELOPMENT AND APPLICATION OF OPERATIONAL TECHNIQUES FOR THE INVENTORY AND MONITORING OF RESOURCES AND USES FOR THE TEXAS COASTAL ZONE

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16 Abstract

The most significant information contained in this report is 1) the determination that a cost-savings analysis is the cost-benefit approach most suitable for this investigation, and 2) the development of the cost-accounting system that will be integrated with project tasks

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1 0 INTRODUCTION

1 1 Scope and Purpose of Report

This progress report covers activities during the first 4 months, April 25, through August 25, 1975 for LANDSAT Investigation #23790. This investigation is funded for 19 months to develop techniques in Texas state agencies for using LANDSAT data to inventory and monitor coastal resources and uses The General Land Office (GLO) is the Texas agency coordinating this investigation

1.2 Summary of Work Performed

During the first reporting period most of the accomplishments were organizational The General Land Office (GLO) has been negotiating contracts with State agencies and individual consultants, and also has been defining and delegating areas of responsibility according to each entity expertise Texas natural resource agencies contracting with the GLO to develop techniques for using LANDSAT data are the Texas Water Development Board (TWDB), the Bureau of Economic Geology (BEG), and the Texas Parks and Wildlife Department (TPWD) TWDB staff are responsible for ordering and indexing data and for processing computer compatible tapes (CCT) of LANDSAT data BEG staff will perform the image interpretation and guide the computer classification by TWDB data processing staff TPWD staff will work closely with BEG and TWDB staff to guide the biological interpretations and perform the field verification of imagery interpretation and computer classification.

Three specific accomplishments for this first quarter have been (1) to further define the tasks necessary to accomplish the anticipated results in the contract with NASA for the purpose of scheduling the investigation and for the accounting of costs, (2) to perform a preliminary examination of computer software on test site 3 (San Antonio Bay area), and (3) to determine that a cost-savings analysis is the cost-benefit approach most suitable for this investigation

2 0 PROBLEMS

2 1 Staffing Changes

Bureau of Economic Geology (BEG). At the time the contract was signed (April 25, 1975) the BEG staff was fully committed to other projects This staff problem resulted from the uncertain start date during the long contract negotiations with NASA Dr Wermund spent most of the first quarter recruiting personnel and initiating the inventory of available LANDSAT imagery Because of their other commitments, BEG staff were not able to attempt any interpretation of satellite imagery It is expected that BEG staff also will have a major role in guiding the computer classification work and in assisting the evaluation of the computer classification schemes implemented at the Texas Water Development Board (Section 3 2 2)

Dr Robert Finley will be the research scientist on the contract beginning August 25, 1975. He has a Ph D. from the

University of South Carolina, where he specialized in coastal geologic studies Dr. Finley's dissertation is entitled *Morphologic Development and Hydrodynamic Processes at a Barrier Island Inlet, North Inlet, South Carolina* He will be assisted in this investigation part-time by Mr Samuel Shannon, who has an M S in geology from the University of Alabama Mr Shannon worked several years with the Alabama Geological Survey and is, therefore, well acquainted with project work

Texas Parks & Wildlife Department (TPWD) During the summer quarter, the TPWD staff assigned to this investigation were Steve James, who is the Austin coordinator for the TPWD tasks, and Ray Childress, a field biologist located at Seadrift, Texas, on San Antonio Bay, who was responsible for the field effort Paul Shank, a TPWD cartographer who is directing an update of coastal habitats onto USGS 7 5 minute topographic maps for the TPWD Commission with the guidance of Ray Childress, was supporting two assistants on LANDSAT contract funds This expense was justified on the basis that Ray Childress would use some of these coastal habitat quads (at least one per test site) as a base on which to annotate specific observations when field-checking the interpretations from satellite data These quads also will be examined as a source of supportive data to aid the computer classification A status report on this coastal habitat updating project is included in Appendix A

Ray Childress resigned from TPWD unexpectedly on August 14, 1975, and Steve James has assumed the primary role for designing and coordinating the field effort Much of the field work will actually be conducted by field biologists stationed on the coast near the four smaller test sites Unfortunately, the work Mr Childress conducted this summer to familiarize himself with test sites 3 (San Antonio Bay) and 4 (Harbor Island), to give a brief check to the Texas Water Development Board classification attempts, and to prepare procedures for field-checking were not documented before he left Steve James will begin designing the field effort this September

Mr James has a M S from the University of Texas at Austin where he specialized in coastal biology He worked at the University of Texas Marine Science Institute and participated in the University of Texas NSF-RANN project, "Establishment of Operational Guidelines for Texas Coastal Zone Management," before going to work for the Texas Parks & Wildlife Department

Texas Water Development Board (TWDB) Michael Ellis, who was supervising the investigation at the TWDB, resigned in August to become a private consultant Mr Ellis's supervisory duties were reassigned to his superior T R Evans, at TWDB The technical effort at TWDB for implementing and operating the classification algorithms, will continue to be directed by David Murphy.

2.2 Technıcal Problems

None of the problems encountered durıng the examınatıon of classıfıcatıon software by the Texas Water Development Board ımpeded the ınvestıgatıon serıously These problems ınclude the followıng (1) The LANDSAT scene avaılable ın the Texas Natural Resources Informatıon Systems (TNRIS) lıbrary for the Austwell sıte was found to be poor ın qualıty, partly because of numerous bad data lınes Although probably suffıcıent, the poor qualıty of the data tapes ıntroduced an element of uncertaınty ınto the ınıtıal testıng of the classıfıcatıon algorıthms However, good qualıty LANDSAT tapes of the area that were ınventorıed by the Bureau of Economıc Geology are beıng ordered (2) Numerous programmıng "bugs" occurred, as was expected They were corrected durıng ımplementatıon of the classıfıcatıon schemes dıscussed ın Sectıon 3 2 2

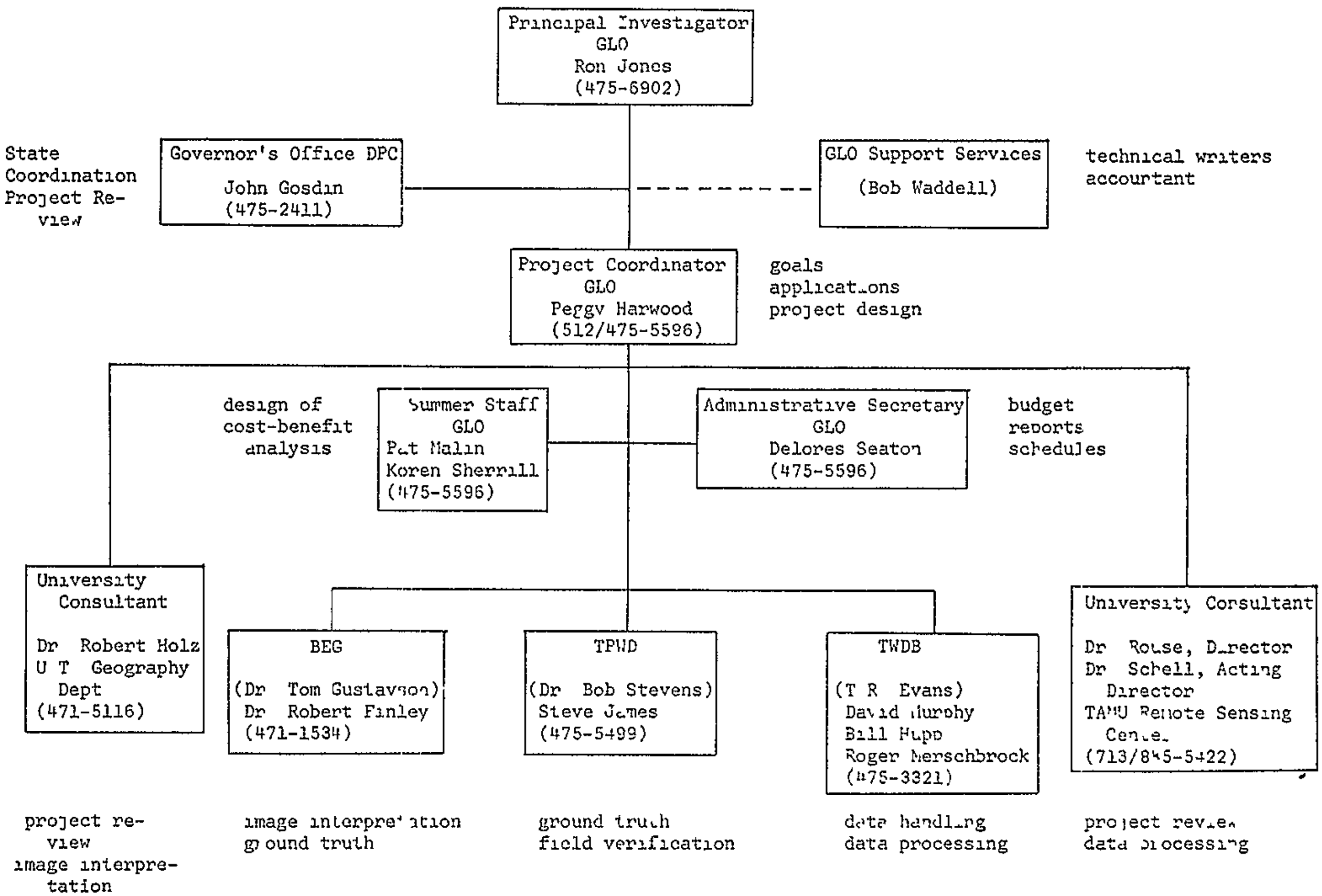
3 0 ACCOMPLISHMENTS

3.1 Overall Program

3 1 1 Organızatıon

The functıonal organızatıon for thıs ınvestıgatıon ıs shown ın Fıgure 1 along wıth general areas of responsıbılıty assıgned to each agency and consultant Texas natural resource agencıes contractıng wıth the GLO to develop technıques for usıng LANDSAT data are the Texas Water Development Board (TWDB), the Bureau of Economıc Geology (BEG), and the Texas Parks & Wıldlıfe Department (TPWD) TWDB staff are responsıble for orderıng and ındexıng data, and for processıng computer comigure 1 LANDSAT ORGANIZATION CHART

Persons named in parentheses are agency supervisors for staff assigned to this investigation



patible tapes (CCT) of LANDSAT data. BEG staff will perform the image interpretation and guide the computer classification by TWDB data processing staff. TPWD staff will work closely with BEG and TWDB staff to guide the biological interpretation, and perform the field verification of imagery interpretation and computer classification.

During the first reporting period, interagency contracts were negotiated between the General Land Office and the principal participating agencies Texas Parks and Wildlife Department (TPWD), Texas Water Development Board (TWDB), and the Bureau of Economic Geology (BEG) Contracts or other arrangements also are being negotiated with the technical consultants and advisors, Dr Robert K Holz and the Texas A&M University (TAMU) Remote Sensing Center (Dr John Schell, acting director) and the Governor's office, Division of Planning Coordination Because Texas operates on biennial appropriations, all but one of these arrangements involve two contracts, one for the biennium ending August 31, 1975 and one for the next biennium The TAMU Remote Sensing Center will have one contract effective September 1, 1975

In the original proposal to NASA funds were budgeted for the Governor's Office of Information Services (OIS), which has since been disbanded by the Governor One of the tasks of OIS in the first work program was to assist in performing the cost-benefit analysis on the monitoring system developed during the investigation. Because we no longer had the services of an economist in either the GLO or the Governor's Office, money budgeted for OIS was used instead to plan the cost-benefit approach and to develop the cost accounting procedures for this investigation

Pat Malin and Koren Sherrill were economic consultants on the cost-benefit design this summer Both are in the graduate school of Economics at the University of Texas at Austin, and both are working on Ph d degrees Dr Edward B Deakin III, an Assistant Professor of Accounting at the University of Texas at Austin, prepared the accounting system for this investigation

3 1 2 Task Definition and Integration with Cost Accounting

Tasks in Phase I of the work program have been further defined, or outlined, into the steps necessary to complete each task Some of the draft Program Evaluation Review Schedules (PERS) for displaying and scheduling these tasks, are shown in Appendix B All but one of the PERS included in Appendix B are incomplete, that is, the steps outlined and the persons designated (as having responsibility for performing that step, as control to insure that the work is on schedule, or as important for coordination) are still tentative The PERS will be completed in the next reporting period by the investigation staff responsible for performing each task

Task definition and scheduling (PERS) is necessary for two purposes (1) to assist coordination of investigation activities in participating state agencies, and (2) to to provide a way to account for experimental and training costs, and to estimate operational costs The PERS also reflect the investigation strategy laid out in the work program

Two important results of this investigation are anticipated to be (1) a "quasi-operational" monitoring system for coastal resources using satellite and supportive data, and (2) a documented cost-benefit analysis on the system In order to gather experience with a "quasi-operational" monitoring system and also collect cost data on that system, a simplified systems approach has been adopted in the definition of certain tasks For example, the PERS outlining the task, "Examining ADP Software for test site 3," is broken down into data acquisition, information extraction and information display components (Appendix B) Development of the various procedures and techniques required to accomplish important steps in each component is part of the design of the monitoring system Likewise, accounting for costs of performing important steps will be the basis of the cost-benefit analysis of the system

Appendix C is an outline of the cost accounting system for this investigation that has been integrated with the PERS concept

When reviewing the PERS for "Examining ADP Software" and for "Building a Regional Base" (Appendix B), keep in mind the following points

1 Examination of test sites will progress in sequence from site 3 to 4, 5 and then 2 Test site 3 was chosen last spring as the beginning site because several of the participating agencies had been collecting geologic, biologic, hydrologic and meteorologic data in San Antonio Bay for the previous 2 or 3 years The next most familiar site to the participants was site 4, Harbor Island at Corpus Christi Bay West Galveston Bay (site 2) was the least familiar

2 Each of the small test sites (Figure 2) was selected for a different climatic zone of the Texas coast for documenting representative classes and developing change detection and "signature extension" techniques

3 The system components for each test site are repetitive Some steps, such as those for ordering and indexing data, may be completed simultaneously for different sites However, within a task the steps are sequential.

3 1 3 <u>Program for Next Reporting Interval</u>

The following activities are planned for the next quarter

1) Complete part of the monitoring system design dealing with perfecting data handling procedures, selecting useful information product formats and implementing a data library and archives

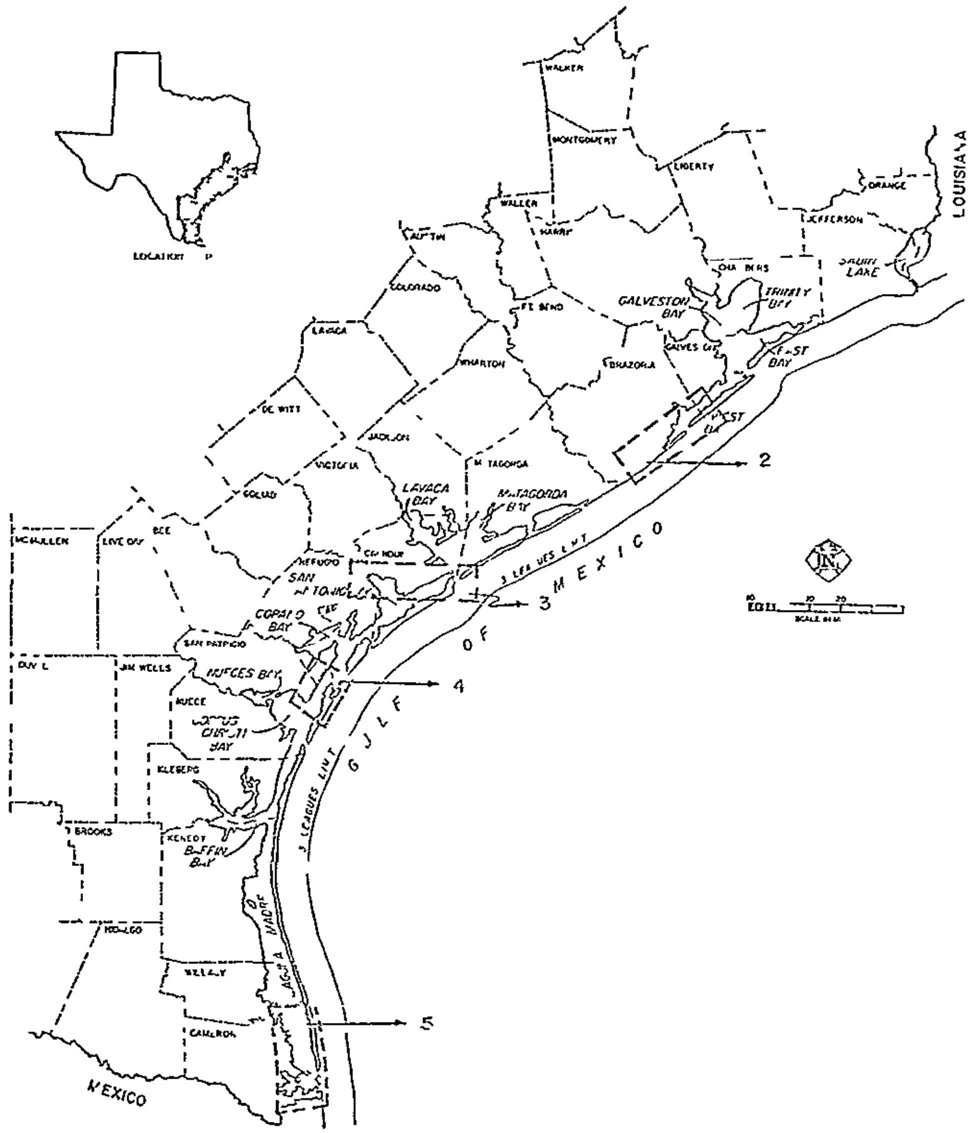


Figure 2 Approximate location of small test sites for LANDSAT Investigation #23790 Test site 1 is the entire coastal strip about 27 miles wide

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2) Complete the task definition and scheduling process for the investigation

3) Complete the image interpretation and automatic data processing (ADP) tasks for test sites 3, 4, 5, and 2 (Appendix B)

4) Present a report on this investigation to the Texas Natural Resources Information System Task Force tentatively scheduled to meet November 14, 1975

3 2 Preliminary Examination of Test Site 3 (San Antonio Bay Area)

3 2 1 Criteria for Selecting LANDSAT Imagery

The availability of quality LANDSAT data for imagery interpretation of coastal Texas was determined initially by Dr Wermund from catalogs at the Texas Water Development Board in Austin Then, the browse file located at the Remote Sensing Center of Texas A&M University (TAMU) was used to complete the search for quality imagery LANDSAT imagery rated Good in all four bands was found to be essentail for interpreting sufficient information for coastal management Rarely, Fair (quality) might be used Also, most of the data required for this investigation should have less than 20% and generally 0% cloud cover These conclusions were based on examination of both microfilm in the TAMU browse file and 1 250,000 single band, black-and-white imagery of part of Texas at the Bureau of Economic Geology (BEG) Examination of a 1 250,000 color composite print for which band 5 was rated Fair and there was 10% cloud cover also supported these preliminary data selection criteria Tables 1 and 2 list LANDSAT coverage already at the Texas Water Development Board and the best quality scenes available for the Texas coast

Using data from only one satellite, LANDSAT-1, it does not appear that the Texas coastal zone could be monitored on a seasonal basis After two years of collecting data each eighteen days from LANDSAT-1, imagery of Good resolution and 0% cloud cover has been collected only between December and May For the primary test site 3, there have been only three Good quality images It is quite disappointing that no late summer-early fall imagery is available, because this is the period for the optimal growth and greatest areal extent of submerged grassflats and wetland vegetation It is hoped that the more frequent imagery collection with two satellites, LANDSAT-1 and LANDSAT-2, and that the shortening of interval coverage to nine days, will increase the likelihood of collecting Good cloud-free imagery between June and November

A preliminary look at the imagery at BEG indicated that certain unvegetated land-water boundaries can be defined fairly easily in Band 7 With one date of imagery it was not immediately possible to define those land-water boundaries located in highly vegetated areas

TABLE 1

LANDSAT COVERAGE AT TEXAS WATER DEVELOPMENT BOARD

JUNE 1975

SITE 2	Index No	Scene No	Date	Tape No	Comment
Digital	2	1037-16244	8/29/72	ER014	Top
	9	1073-16244	10/4/72	ER001	Top
	23	1127-16260	11/27/72	ER025	All
	57	1180-16194	1/19/73	ER013	Half
Imagery	9	1073-16244	10/4/72	ER001	Top
	21	1126-16201	11/26/72		Almost All
	22	1127-16253	11/27/72		Top
	85	1289-16254	5/8/73		Top
	86	1289-16261	5/8/73		All
SITE 3					
Digital	23	1127-16260	11/27/72	ER025	Part
	45	1146-16314	12/16/72	ER028	All
Imagery	45	1146-16314	12/16/72	ER028	All
	86	1289-16261	5/8/73		Almost All
SITE 4					
Digital	45	1146-16314	12/16/72	ER028	Top
	46	1146-16320	12/16/72	ER048	All
Imagery	45	1146-16314	12/16/72	ER028	Top
	58	1182-16315	1/21/73		Bottom
SITE 5					
Digital	46	1146-16320	12/16/72	ER048	Top
	47	1146-16323	12/16/72	ER029	All
Imagery	58	1182-16315	1/21/73		Top
	59	1182-16322	1/21/73		Bottom
	Other Imagery On Coast				
	20	1126-16195	11/26/72		SE

TABLE 2

SCENES OF COASTAL ZONE, 20% OR LESS CLOUDS

	OID	Micro No	Date	Cloud Cover	Lat	Long	QUAL
Site 2	1703-16175	10026/1037	6/26/74	10	28 57N	95 50W	GGPG
	2034-16200	2-10002/0231	2/25/75	0	28 50N	97 30W	GGGG
Site 3	1614-16761		3/24/74				
	2034-16200		2/25/75				
	1209-16261		6/ 8/73				
	1703-16175		6/26/74				
	1578-16264		2/21/74				
	1505-16230		2/10/73				
	2051-16140		3/14/75				
Site 4	1486-16173	10018-0265	11/21/73	0	28 42N	94 22W	-GGG
	1504-16171	10018/0872	12/ 9/73	20	28 42N	94 25W	GPGG
	1522-16165	10019/0608	12/27/73	10	28 49N	94 21W	-GGG
	1703-16175	10026/1037	6/26/74	10	28 57N	95 50W	GGPG
	1936-16034	1-10034/0216	2/14/75	20	28 56N	94 24W	GGGG
	2051-16140	2-10002/0442	3/14/75	0	28 53N	95 36W	FGFF
Site 5	2070-16203	2-10003/0365	4/ 2/75	20	26 04N	97 44W	GFGG
	2034-16205	2-10002/0233	2/25/75	0	25 58N	97 50W	FFGG
Area North of 2	1504-16165	10018/0871	12/ 9/73	10	30 08N	94 00W	PGGG
	1576-16152	10002/1434	2/19/74	0	28 55N	94 16W	GGGG
	1882-16033	10033/0017	12/22/74	0	30 16N	94 00W	GFFG
	1882-16060	10033/0018	12/22/74	10	28.50N	94 24W	GFFF
	1936-16034	1-10034/0216	2/14/75	20	28 56N	94 24W	GGCG
N 1/2 between 2 and 3	1703-16175	10026/1037	6/26/74	10	28 57N	95 50W	GGPG
	2051-16140	2-10002/0442	3/14/75	0	28 53N	95 36W	FGFF
S 1/2 between 2 and 3	1505-16230	10018/0856	12/10/73	0	28 45N	95 48W	PGPP
	1901-16110	10033/0842	1/10/74	10	28 46N	95 51W	PF-F
	1703-16175	10026/1037	6/26/74	10	28 57N	95 50W	GGPG
Between 3 and 4	1614-16261	10022/1602	3/29/74	10	28 50N	97 13W	GGGG
	1452-16293	10016/0669	10/18/73	10	27 28N	97 31W	GGPG
	1974-16133	1-10036/0292	3/24/75	0	28 53N	97 20W	FGGG
Between 4 and 5	1452-16293	10016/0669	10/18/75	10	27 28N	97 31W	GGPG
	1758-16221	10028/0122	8/20/74	10	27 24N	97 37W	PGPG
	1740-16225	10027/1116	8/ 2/74	20	27 22N	97 39W	GGGG
	2034-16202	2-10002/0232	2/25/75	0	27 24N	97 27W	FFGG
	1974-16135	1-10036/0293	3/24/75	10	27 26N	97 44W	FGFG
	2070-16203	2-10003/0365	4/ 2/75	20	26 04N	97 44W	GFGG

3.2.2 Examination of Automatic Data Processing (ADP) Software

In order to accomplish the task "Preliminary examination of ADP software in test site 3" (Appendix B) undertaken by the Texas Water Development Board (TWDB) in LANDSAT investigation #23790, it was first necessary to implement several computer systems on the UNIVAC 1106 EXEC 8 configuration in use at TWDB Three such systems were used, each was acquired by the TWDB from NASA/JSC during the last two years for the Texas Natural Resources Information System (TNRIS) The principal system employed was LARSYS-ISOCLS, an amalgamation of LARSYS version 2 0 and of ISOCLS, an iterative clustering procedure developed at NASA/JSC LARSYS was one of the earliest operational computer systems to employ pattern recognition techniques in the analysis of multispectral scanner data This system was developed at Purdue University's Laboratory for Applications of Remote Sensing (LARS) and was converted for UNIVAC by the Earth Observation Division of NASA/JSC The other two computer systems used in the study were the Detection and Mapping (DAM) package, designed by the Earth Observations Division of NASA/JSC to detect and map surface water, and ASTEP, the Algorithm Simulation Test and Evaluation Program developed by the Mission Planning and Analysis Division of NASA/JSC.

Implementation of the above systems at TWDB required the addition of new subroutines and the modification of others (Appendix D) A section was added to LARSYS-ISOCLS to enable it to process LANDSAT bulk data tapes Missing subroutines (i e., system subroutines at NASA/JSC but not at TWDB) were added and other subroutines modified to conform to operations at TWDB. FORTRAN problems involving NTRAN I/O handling of bulk data tapes were encountered and corrected Due to the very large size of the systems (LARSYS-ISOCLS contains over 125 separate subroutines), several minor programming bugs have developed since the initial implementation period Such occurrences were expected in the implementation of the systems and are being corrected as they are encountered

The initial testing and evaluation of the various classification packages is being conducted in the Austwell Quadrangle (USGS 7 5 minute topographic series) within test site 3 (Figure 3) Both digital tapes and imagery for the Austwell Quad were available in the TNRIS remote sensing library for one LANDSAT scene, 1146-16314, dated 16 December 1972 The TNRIS also maintains complete meteorological data files for Texas These were examined to establish that no unusual rainfall had occurred in the area within 15 days prior to the time of the LANDSAT overpass The NOAA Weather Station in the area is located at Victoria, approximately 25 miles from the site, and some weather data is also available from Port O'Connor, Point Comfort, Refugio, and Rockport

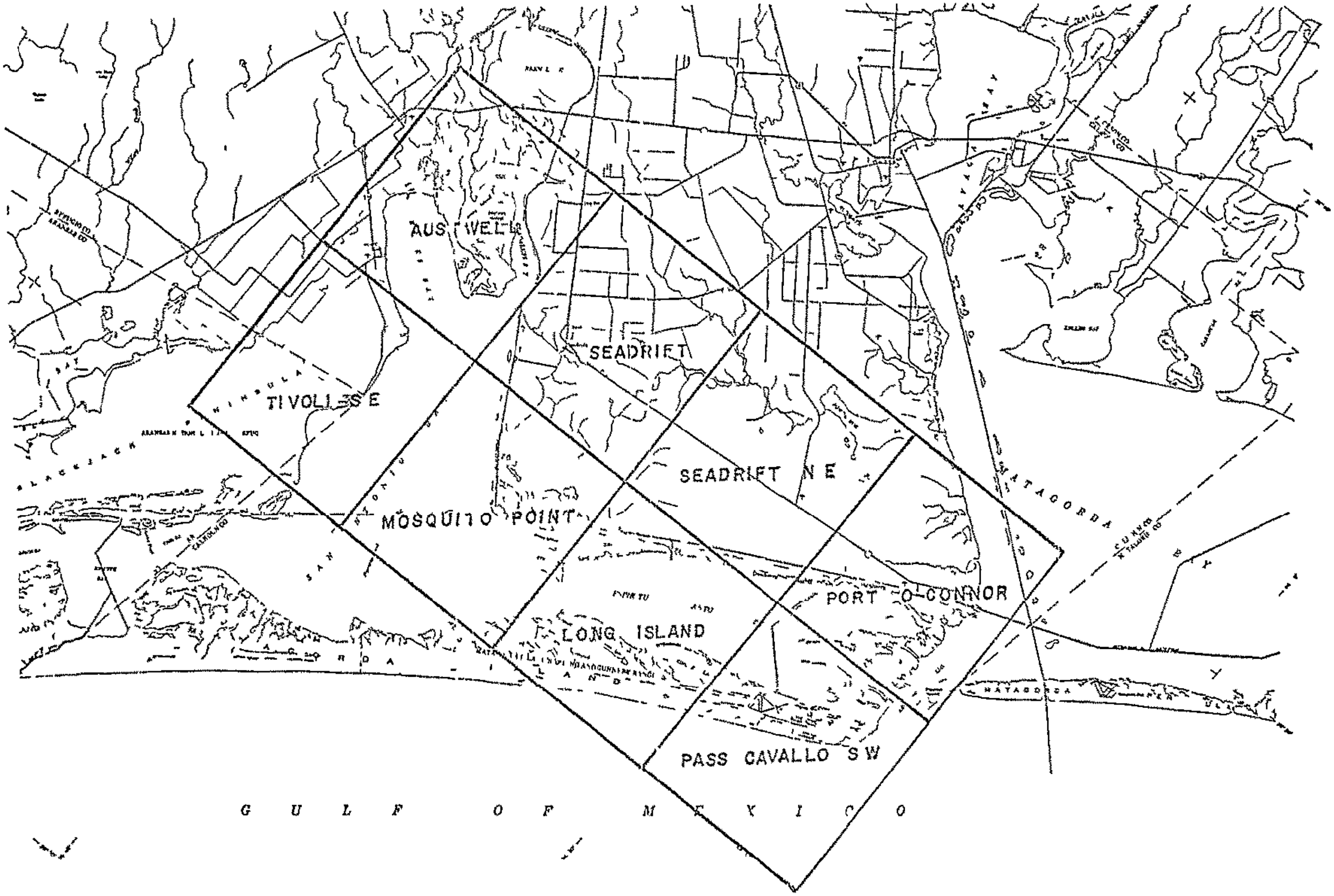


Figure 3 USGS 7 5 minute topographic maps overlapping test site 3, San Antonio Bay area

(Appendix E)

A gray scale map of the test site was generated for each of the four channels using the LARSYS, DAM, and ASTLP programs (Figure 4) These gray scale maps were then compared with each other and with the following supportive data (1) a USGS 7 5 minute topographic map (Austwell Quad, dated 1952), (2) a land use map of the Port Lavaca Area available from the Bureau of Economic Geology (McGowen et al , in press), and (3) aerial photography of the Austwell Area flown by NASA for this investigation Due to the complexity of the water features in test site 3 (bay, reservoirs, lakes, etc), it was decided to use the DAM package to classify water in the area and to display the results at the scale of 1/24,000 (Figure 5) Information from this map was then overlaid on a light table and transferred to one of the gray scale maps generated by LARSYS

At this time a certain inconvenience was noted The Austwell test site was contained partially on tape 3 of the scene and partially on tape 4 To alleviate this situation, a program was written to merge sections across two LANDSAT data tapes (Appendix F) Thus data for any site, overlapping on two tapes and less than 810 pixels wide, could be merged and then processed from a single tape

After noting the complexity of the spectral response in the study area and the irregularity and variability of its features, it was decided to experiment with classifying

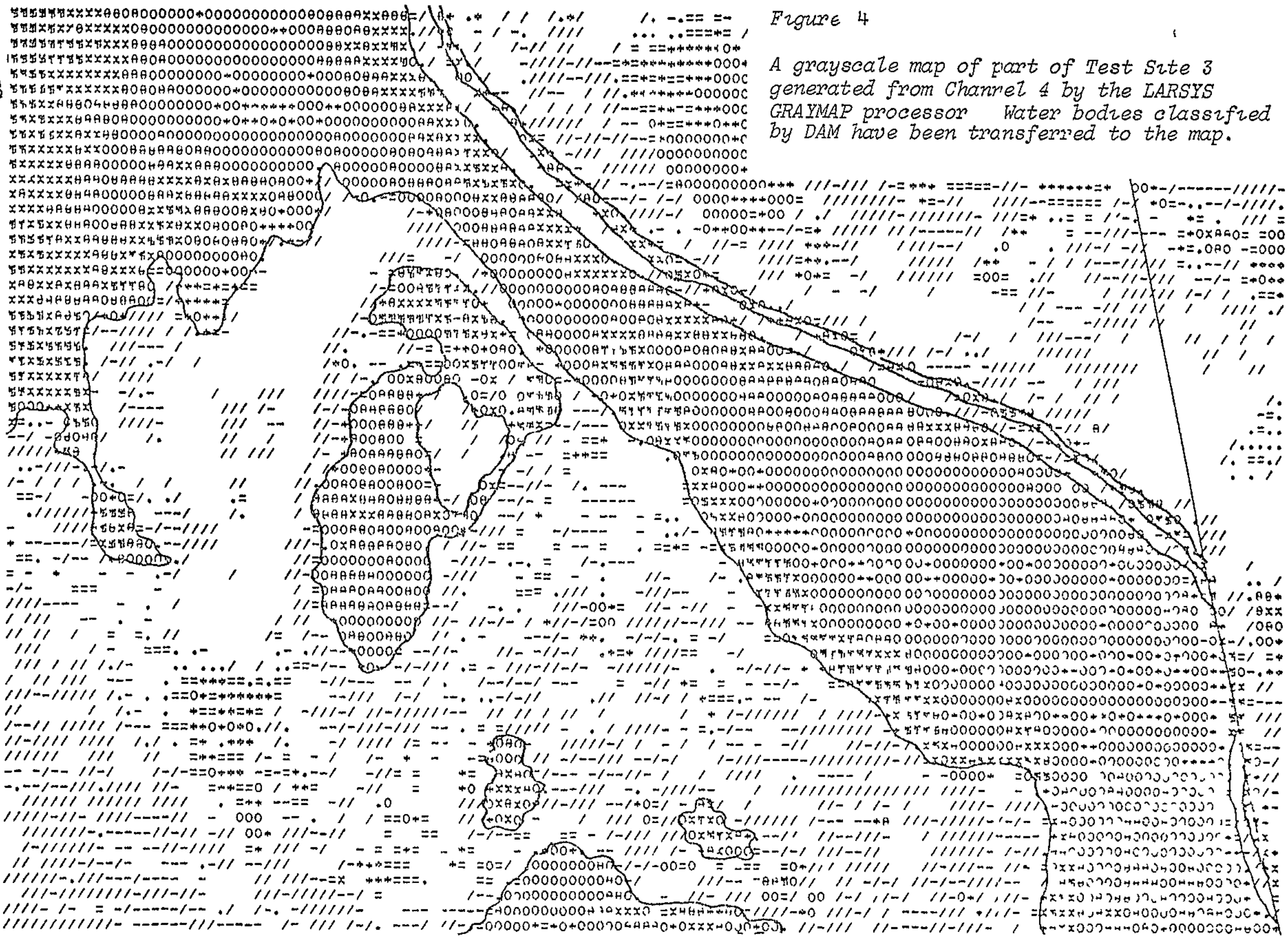


Figure 4

A grayscale map of part of Test Site 3 generated from Channel 4 by the LARSYS GRAYMAP processor. Water bodies classified by DAM have been transferred to the map.

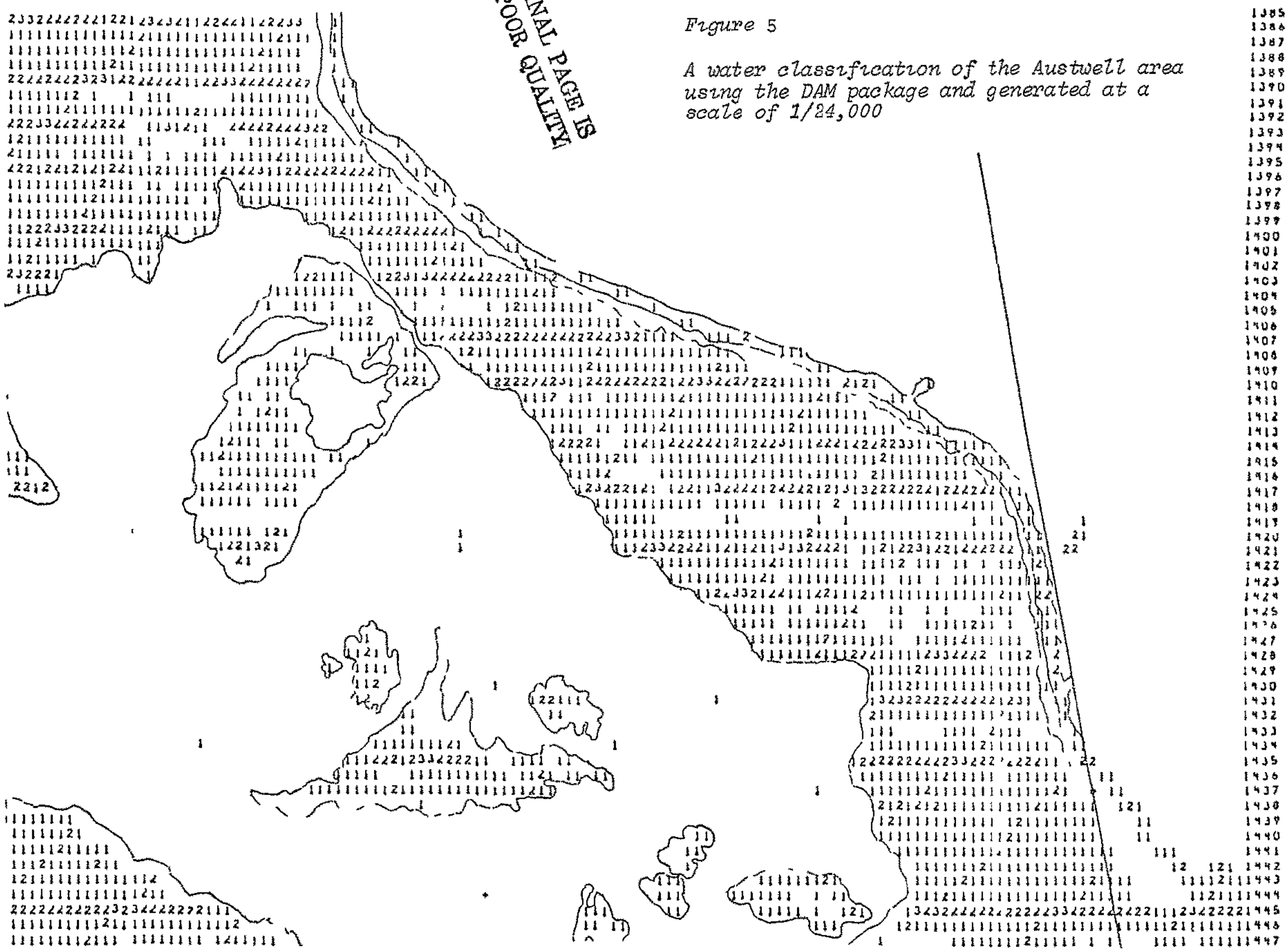
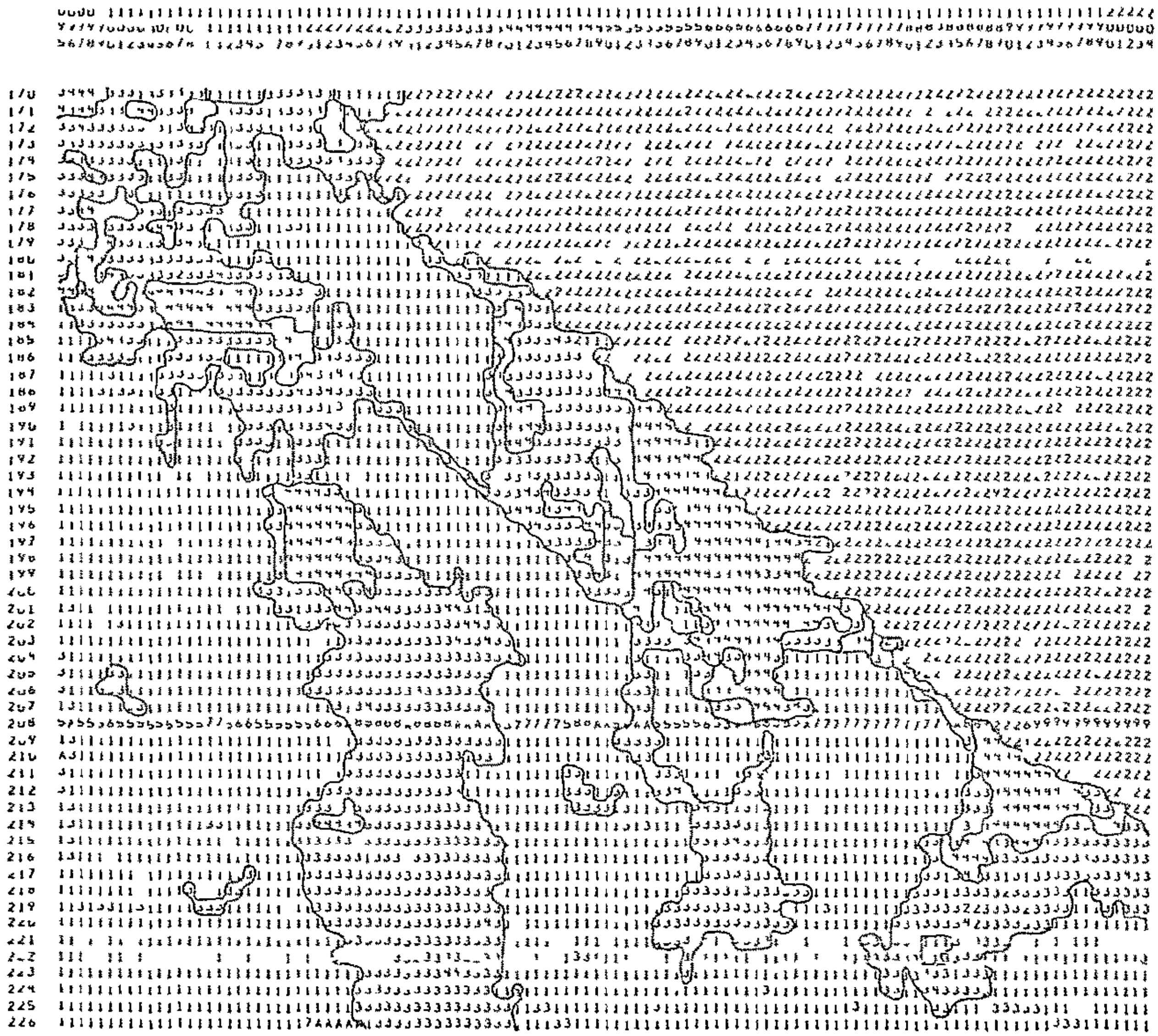


Figure 5

A water classification of the Austwell area using the DAM package and generated at a scale of 1/24,000 a small section from the lower left-hand corner of the Austwell Quad (Figure 3) LARSYS-ISOCLS was used as the main programming tool, with help from the other two systems as appropriate Cluster maps of a small section (60 x 110 pixels) of the test site generated by ISOCLS are shown in Figure 6 Maps produced by ISOCLS and ASTEP were found to be quite similar For both systems, the map combining all four channels seemed to produce the most detail and thus was selected for use in the following analysis

Training fields and test fields were selected from the cluster map generated by ISOCLS in order to produce a blind classification of the area (i.e , data is not correlated with ground truth until after classification) Statistics for the training fields were then generated with the LARSYS STAT processor In using the LARSYS SELECT processor to choose the best combination of channels for classification, a programming bug was encountered due to an error in the map overlay structure All four channels were used together prior to correcting this problem Using the LARSYS CLASSIFY and DISPLAY processors, a classification map of the small section was produced, and the performance of the training and test fields were evaluated by the DISPLAY processor (Figure 7) Accuracy of both training and test field classification has so far exceeded 90 percent



POINTS PER CLUSTER IN THIS FIELD

CLUSTER	SYMBOL	POINTS
1	1	2327
2	2	2006
3	3	1346
4	4	474
5	5	33
6	6	11
7	7	22
8	8	17
9	9	14
10	A	18

Figure 6

An ISOCLS map of the Southwest corner of the Austwell quadrangle All four channels were used Note that line 208 is a bad scan line and accounts for clusters 5 through 10 (symbols 5 through 9 and A)

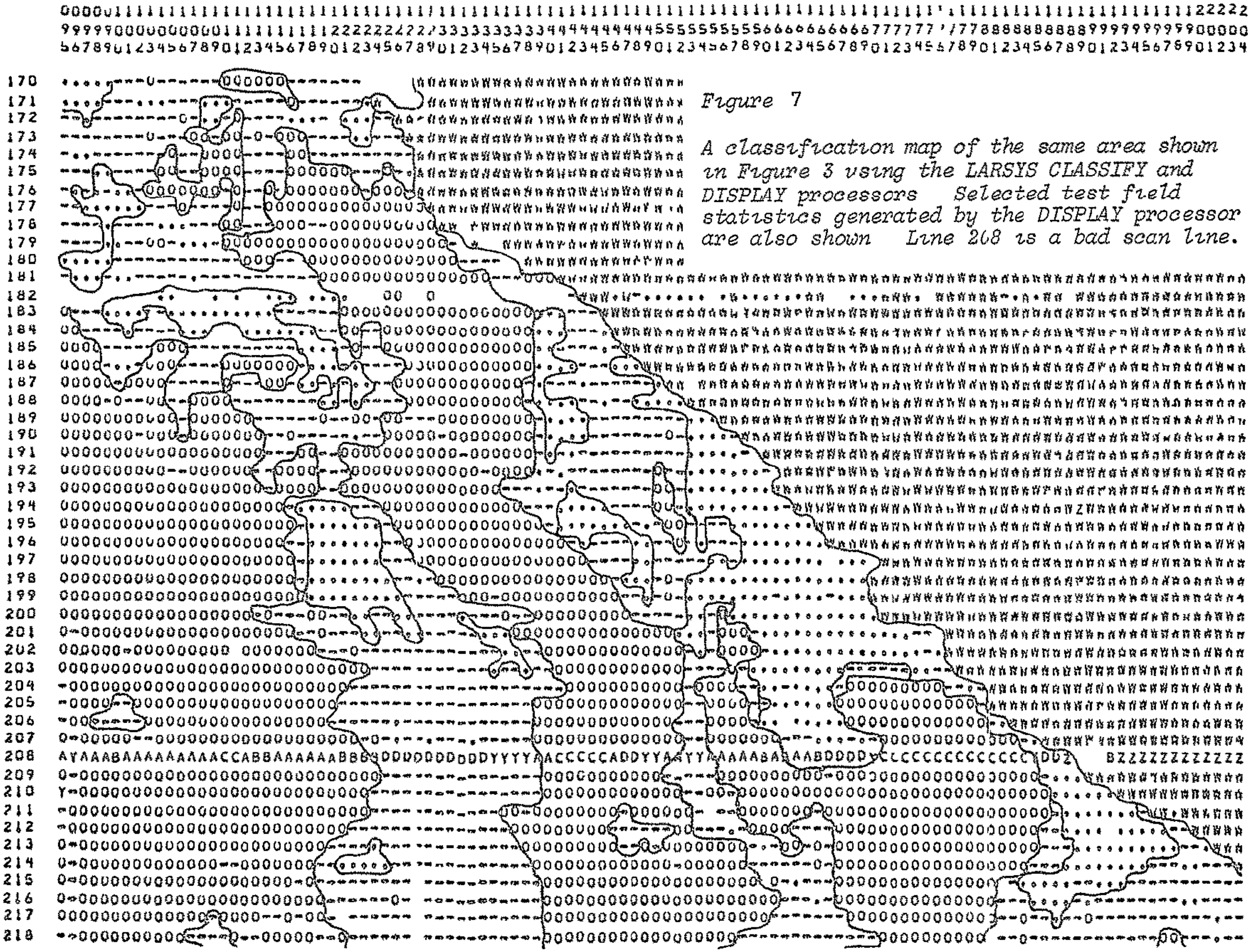


Figure 7

A classification map of the same area shown in Figure 3 using the LARSYS CLASSIFY and DISPLAY processors. Selected test field statistics generated by the DISPLAY processor are also shown. Line 208 is a bad scan line.

TOTAL NUMBER OF SAMPLED POINTS = 6270

TOTAL POINTS IN EACH CLASS

CLASS NAME	TOTAL POINTS	PERCENTAGE
CLASS 1	2278	36.33
CLASS 2	1968	31.39
CLASS 3	1304	20.80
CLASS 4	537	8.56
CLASS 5	34	.54
CLASS 6	10	.16
CLASS 7	22	.35
CLASS 8	18	.29
CLASS 9	14	.22
CLASS 10	17	.27
THRESHOLDED	68	1.08

CLASSIFICATION SUMMARY BY TEST CLASSES

	CLASS	NO OF SAMPS	PCT. CORCT	NO OF SAMPLES CLASSIFIED INTO: BROW	RED	PURP	GREE	CLAS	CLAS	CLAS	CLAS	CLAS	CLAS	THRS
1	BROW	190	99.5	189	0	0	0	0	0	0	0	0	0	1
2	RED	332	100.0	0	332	0	0	0	0	0	0	0	0	0
3	PURP	72	97.2	2	0	70	0	0	0	0	0	0	0	0
4	GREE	56	80.4	0	5	0	45	0	0	0	0	0	0	6
	TOTAL	650		191	337	70	45	0	0	0	0	0	0	7

OVERALL PERFORMANCE = 97.8

AVERAGE PERFORMANCE BY CLASS = 94.3

*** SDISPLAY - COMPLETED ***

A comparison of the blind classified section and the original ISOCLS map of the same area showed them to be nearly identical in the basic clusters Also, feeding the ISOCLS statistics directly into the CLASSIFY and DISPLAY processors without using training fields produced equally high test field classification accuracy It should be noted, however, that these high test field classification accuracies were obtained without comparing the results with traditional image interpretation and field verification Thus, these results may only indicate the internal consistency of the various classification algorithms used (e g , clustering vs maximum liklihood classification training on clustered fields) Comparison of the classification results with traditional image interpretation and field verification of the classification has not yet been done because of staffing changes in the Texas Parks and Wildlife Department (TPWD) and Bureau of Economic Geology (BEG) Correlation with image interpretation and field checking is planned for September

Thus far the following results have been achieved (1) three multispectral scanner classification packages have been implemented on the TWDB computer facilities and each has been modified, tested, and debugged, (2) several classification schemes (LARSYS-ISOCLS, DAM, ASTEP) have been explored in part of test site 3 based upon clustering and training field techniques And, (3) good preliminary classification results using these schemes have been achieved with above 90 percent accuracy without correlation with ground truth

3.3 Recommendation for a Cost-Benefit Strategy to Evaluate a LANDSAT-Based Inventory and Monitoring System

3.3.1 Role of Cost-Benefit in this Investigation

This LANDSAT investigation potentially is one step in the development of an operational system for delivering LANDSAT-derived information products on land and water features to decision-makers in the state government, and eventually, to the private sector of Texas. Two important objectives of this investigation are 1) to develop the capability within state government to produce LANDSAT-derived products and 2) to evaluate a few of these information products used as tools for solving management problems. Because the scope of the investigation is limited to the coastal region, the evaluation of satellite data is restricted to those agency programs with concerns in the coastal zone.

One method of evaluating information products from satellite data is the cost-benefit analysis. The purpose of this section is to propose some design alternatives which would ensure the appraisal of not only the technical feasibility but also the costs and value of supplying such satellite data to state agencies. Within the context of this LANDSAT investigation, the evaluation of the costs of producing information and also the value of satellite information to coastal zone decision-makers in the state is the particular task of cost-benefit. As cost- benefit analyses can be lengthy investigations of data specification and choice of analytical methods, and as the project contract allocates no funds explicity for performing such an analysis, it is important to assess the possible depth of a cost-benefit in this project The following is a discussion of the types of benefits which could accrue to various state agencies if satellite data are used and a notion of the time and costs that different kinds of evaluation would entail

At the outset, it is important to emphasize that the development costs of the project will not be evaluated <u>per se</u> as part of the costs (or benefits) of supplying satellite data to the state These costs are already sunk in the sense that they are already committed to the project On the other hand, it is possible that a similar project might need to be undertaken for land and water features outside the coastal area, and perhaps the development costs of the LANDSAT project could be used to evaluate whether or not such an investigation should be undertaken

In the following discussion, though, it should become obvious why system costs need to be documented This is a crucial aspect of the design of the project

For purposes of discussion, the benefits of the LANDSAT project can be broken into two categories These can be usefully dubbed the "cost-savings" benefits and the "new information" benefits Notice that the benefits have to do with the value of the information to decision-makers Information on physical features has no meaning in a cost-benefit analysis unless some use is made of it by decision-makers.

The first category of benefits assumes that the value of information now used by agencies is worth at least the costs they incur in collecting it The important distinction in this case is the assumption that the information obtained from satellite data is the same in quality and quantity as that currently obtained by conventional methods In this context, the only distinction between information products generated from competing sources is the costs of production The cost-benefit analysis then amounts to a comparison of costs. The benefits or disbenefits of satellite data over conventional collection methods are the cost-savings or extra costs, respectively, of choosing to use satellite data

Benefits (or disbenefits) from the cost-saving method of evaluation normally imply that there is a need for the specific type of information required (e g , types of features, accuracy of identification, frequency of coverage, and timeliness of processing the data), by potential users in the state

It is possible, however, to evaluate the costs of acquiring certain physical information without reference to an application Investigation of the costs of alternatives, such as aerial photography or ground surveys, could be undertaken Such cost comparisons would simulate actual data needs in certain state agencies and could perhaps be used later on to evaluate the cost-savings associated with different information "packages" to various agencies At this point, it is important to emphasize that a basic requirement of this type of analysis is the cost of generating information from satellite data Methodologies for estimating the costs of generating information from satellite data are discussed in Appendix G

"New information" benefits could arise from the fact that satellite data will differ in kind from present data The synoptic character of the data or frequency of availability could prove invaluable to a decision-maker Thus, satellite data may have the potential to alter the decision-making process itself In this case, the benefits would derive from the fact that new demands for satellite data might spring up in some quarters as new uses are perceived These new demands for satellite data might exceed the demands for previous information, and satellite data might replace those data Finally, there is the possibility that satellite data will be so inexpensive and/or revolutionary in its impact that it will induce a decision-maker to use it in areas where no information existed before. Ultimately, in this case, the demand for new kinds of information is a derived demand, for the value of information is only the benefit (or disbenefit) as it contributes to better (worse) decisions which impact on society or the state

"New Information" benefits are extremely difficult to anticipate One can imagine having tried, twenty-five years ago, to anticipate the impact of the computer on society today

For the above reasons, i e , 1) the difficulty of anticipating impacts of new information on the decision-making process, 2) the impact on society of the changed decision, and 3) the limited funds of the LANDSAT project, it is recommended that the cost-benefit evaluation concentrate on a cost-savings evaluation of LANDSAT-derived information

It is appropriate to consider what a cost-savings analysis would miss in the way of benefits of using satellite data In truth, most satellite data will probably be somewhat different in kind from that now collected in every agency Thus, benefits can be artifically divided into four categories 1) those in which information supplied by satellite is the same, so that cost-savings are the only benefit, 2) those in which some cost-savings accrue from the use of satellite data, but the agency also foresees new information benefits, 3) those in which there are little or no cost-savings, but new or added information benefits from satellite data are perceived and replacement of current collection systems seems warranted, and 4) those in which there are no cost-savings, and information from satellites is used where no information source existed before

A cost-savings evaluation of an operational LANDSAT system will capture all of the benefits in (1), some of the benefits in (2), and none of the benefits in (3) and (4).

A few points should be stressed A cost assessment of the value of LANDSAT implies matching similar kinds of information products with those currently used by agencies As stated earlier, such products might perhaps be completely simulated Another approach might be to conduct a survey of all data use in state agencies that deal with the coastal zone to select the most widely useful satellite information products to test in this investigation However, the approach chosen in this investigation was to select information products currently used and available in the General Land Office (biologic assemblage information on USGS 7 5 minute quads, and land use maps at 1 125,000 published by the Bureau of Economic Geology) as the initial products for testing. What the above discussion on choosing appropriate products implies is that current data use may be difficult and time-consuming to assess, and that "new information" needs might be even more difficult and time-consuming to survey

Even if new information needs could be assessed, an evaluation of the benefits of using satellite data still might not be a simple task

Assume that satellite-derived information products along the coast were used in the oil and gas leasing process of the Land Office These products might have the effect of making leasing requirements more strenuous thus, increasing businesses' uncertainty about whether or not to lease, which could discourage leasing along the coast A decline in leasing might mean a decline in revenues to the state, but how much would revenue have declined anyway if such information had not been used by decision-makers? Again, suppose changes in the leasing process affect the coastal environment by increasing leasing in some areas and decreasing it in others? Is the fishing industry, for example, worse off or better off because of decreased or increased disturbance of habitat? Such a question might call for a full scale evaluation of fish habitats in the state and the natural and man-caused changes which have been occurring in them

This example illustrates the difficulty of anticipating the impact of the altered decision-making process on society resulting from "new" information Such an analysis is beyond the scope and purpose of this investigation Therefore, an analysis of new information benefits will not be undertaken

3.3 2 The Evaluation Strategy

The design strategy for evaluating the feasibility of implementing an operational LANDSAT system will focus on a cost-savings evaluation of the system The objective of this type of approach is to determine whether, and to what extent information obtained from an operational LANDSAT system is cheaper to produce than comparable information produced from non-satellite sources The assumption is made that satellites and their technology will be available to potential users during the lifetime of a proposed operational system, thus, no allowance is made in the evaluation for the possibilities that satellite data may cease to be available because of administrative decisions by either NASA or the U S Congress, the ultimate funding authority for an operational LANDSAT system Availability of satellite data is an exogenously determined variable within the context of this LANDSAT project, and as such, availability of data is not a subject for the evaluation

The cost-savings approach will document the difference in costs between information products derived from satellite vs non-satellite data as the benefit, in dollars saved, to an agency or user Since information products derived from satellite data will usually be somewhat different in kind from the data presently used, we propose to evaluate information products derived from satellite data that the decision-maker finds just as usable as and roughly "equivalent" to the information that he presently uses LANDSAT-derived information products that are similar to non-LANDSAT information products will be analyzed, rather than totally new types of information products, partly because information on the cost of producing existing products, such as the Bureau of Economic Geology land use maps, should be available

The cost-savings evaluation will therefore focus on the unit costs of producing information products that are derived from technologically competing data sources This approach will entail a careful documentation of the costs associated with the experimental phase of the LANDSAT project, an estimation of the costs of producing satellite derived information products under operational conditions, collection of data on the costs of producing non-satellite derived information products, cost comparisons, estimates of demand functions for information (Appendix H), and estimates of the present values of the annual streams of costs and benefits that will be associated with the implementation of an operational LANDSAT system

The methodologies and assumptions that are employed in the evaluation, as well as estimation procedures, are discussed in greater detail in Appendix G The cost-savings evaluation will not only show how much implementation of an operational LANDSAT system will lower the unit costs of generating an information product, such as a land use map, but will also provide an estimate of benefits realized, given certain assumptions about the demand for information The conclusions emerging from a cost-savings evaluation should indicate whether there are pecuniary advantages to be gained by using LANDSAT data to generate certain types of information products

Finally, because a cost-savings evaluation might prove inapplicable to this project, and because additional types of evaluations might prove useful, a section on the cost-effectiveness approach to evaluating LANDSAT information is included in Appendix G

4 0 SIGNIFICANT RESULTS

None

5 0 PUBLICATIONS

None

6 0 RECOMMENDATIONS

None

7 0 FUNDS EXPENDED

GENERAL LAND OFFICE (GLO)

- Labor $8,084 00
- Overhead $ 454 93
- Travel $ 293 85

TOTAL EXPENDITURES FOR THE 1ST QUARTER $ 8,832 78

BUREAU OF ECONOMIC GEOLOGY (BEG)

- Labor $1,540 00
- Material & Supplies $ 285 00
- Equipment $6,475 00
- Travel $ 0

TOTAL EXPENDITURES FOR THE 1ST QUARTER $ 8,300 00

Due to some accounting peculiarities resulting from the appropriation biennium the Bureau of Economic Geology transferred equipment funds into a local funds account, from which they have arranged to purchase the following equipment in September

Accessories for B & L Zoom Transfer Scope
(already belonging to the Bureau of Economic Geology)

1 #53-05-12 2x map lens $163 00

2 #53-05-31 0 75 x map lens $163 00

3 #53-05-72 positioning stage $150 00

A Bausch and Lomb scope will also be selected in September

The Richards Corporation, Model MIM-231100 Light Table, self-supporting, Elevating with 11 x 40 inch illuminated surface, 28 to 44 inch stage elevation, manual dual film reel brackets, and overhead carriage with coarse and fine focus mechanisms to accomodate Bausch & Loomb's Zoom 95 Stereoscope System . $4,950 00

TEXAS PARKS & WILDLIFE DEPARTMENT (TPWD)

- Labor $1,457 81
- Materials & Supplies $ 62 79
- Travel $ 141 25

TOTAL EXPENDITURES FOR THE MONTH OF JUNE $ 1,661 85

(we have not been billed for the months of July and August)

TEXAS WATER DEVELOPMENT BOARD (TWDB)

- Labor $3,932 00
- Computer Cost $ 750 00

TOTAL EXPENDITURES FOR THE 1ST QUARTER $ 4,682 00

CONSULTING SERVICES

- Office of Information Services (OIS)

  $3,250 was allocated in the proposal to the Governor's Office of Information Services which has since been disbanded by the Governor One of the tasks of OIS in first work program was to assist in performing the cost-benefit analysis on the monitoring system developed during the investigation Because we no longer had the services of an economist in either the GLO or the Governor's Office, the decision was made to use money budgeted for OIS to plan our cost-benefit approach and to develop our cost accounting procedures

  Pat Malin and Koren Sherrill worked as economic consultants on the cost-benefit design this summer Edward B Deakin III, the accounting consultant prepared the Cost Accounting System

  TOTAL EXPENDITURES FOR THE 1ST QUARTER $2,843 20

- Consulting Services Contract with Dr Robert K Holz

  TOTAL EXPENDITURES FOR THE 1ST QUARTER $2,000 00

TOTAL EXPENDITURES FOR THE 1ST QUARTER ON THE LANDSAT INVESTIGATION . $28,319 83

8 0 DATA USE AS OF AUGUST 31, 1975

	IMAGERY Account #G23790 Amount	CCT Account #G B3790 Amount	AIRCRAFT Account #G W3790 Amount
Value of Data Allowed	$900 00	$6,400 00	$9,216 00
Value Ordered	$368 00	N/A	N/A
Value Received	$ 45 00	N/A	N/A
BALANCE	$505 00	$6,400 00	$9,216 00

9 0 AIRCRAFT DATA

None ordered during this reporting interval

REFERENCES

Earth Satellite Corporation and the Booz-Allen applied Research Corporation, 1974, Earth Resources Survey Benefit-Cost Study prepared for U S Department of Interior, Geological Survey, Contract No 135-19, volumes III, IV, V and Appendices 5, 6

ECON , Incorporated, 1974, The Economic Value of Remote Sensing of Earth Resources from Space-An ERTS Overview and the Value of Continuity of Service prepared for the Office of the Administrator, National Aeronautics and Space Administration, Contract No NASW-2580, volume V, Inland Water Resources

Lauer, Donald T , and Paul F Krumper, 1973, Testing the Usefulness of ERTS-1 imagery for inventorying wildland resources in northern California, in <u>Symposium on Significant Results Obtained from Earth Resources Technology Satellite-1</u>, The proceedings of a symposium held on March 5-9, 1973, by Goddard Space Flight Center volume 1, Technical Presentations, Section A, paper A-12, pp 97-104

McGowen, J H , C V Proctor, Jr , L F Brown, Jr , W L Fisher, C G Groat, and T J Evans, in press, Environmental Geologic Atlas of the Texas Coastal Zone - Port Lavaca Area University Texas, Bur Econ Geology, text in press, maps available on request

Mishan, E J , 1971, <u>Cost-Benefit Analysis</u> <u>An Introduction</u> Praeger Publishers, New York

APPENDIX A

STATUS REPORT OF GLO/TP&WD HABITAT MAPPING
1 June 1975 to 31 August 1975

prepared by Paul Shank

Map Production

Prior to the contract period, considerable effort was expended in Zoom Transfer Scope familiarization, training, symbology design and product format. During this phase the Austwell sheet was produced. There is a continuing effort to upgrade subject presentation.

Austwell sheet. Base map (vegetation anomalies not identified) was completed before the contract period. Published (photo copies prepared).

Port O'Connor sheet. Base map completed July 10. Published.

Pass Cavallo sheet. Base map completed July 28. Not published.

Port Aransas. In compilation. Aborted July 10.

Compilation Procedure - Base Map

Map base (geodetic) control is maintained by direct transfer of selected photo imagery to USGS 7½' Quadrangle. Color infrared prints, furnished by the General Land Office, are mounted in the Bausch and Lomb Zoom Transfer Scope and projected onto the USGS map at map scale. Discounting the need for the higher powered map lenses of the ZTS to facilitate identification and delineation of complex areas, the 1X map lens is relied upon to maintain spatial relationship. The 1X lense offers a larger field of view and expedites the compilation process. NASA photography, film positives in color or color IR, generally of small scale, are used as additional reference or as primary source when additional coverage is necessary.

The photo imagery is analyzed and significant data selected to compile an updated manuscript copy on the USGS Quadrangle.

A review is made of pertinent reference material for its application to the manuscript. The review includes Bureau of Economic Geology (biologic assemblage data), General Land Office (oil wells and pipelines), Texas Parks and Wildlife (prime nurseries, biologic sampling stations, commercially important reefs, dredge altered areas, public ramps, parks), Department of Interior (Wildlife refuges), and National Ocean Survey (channels and GIWW markers).

A final compilation copy is then prepared in the form of a mylar tracing of the manuscript copy. Additional data such as land tracts (traced from GLO/BEG mylar copies) are added at this point. Symbols and text annotation are then applied to complete the compilation copy. This copy, prepared in mylar format, is reproduced in either photo mylar or blue line paper copy.

Habitat Annotation Procedure

Vegetation anomalies are identified on the photo imagery and outlined on a mylar overlay registered to the photo image. The image is field checked to determine dominant plant species. Following the field check, the information completed on the mylar overlay is drafted and identified on a photo mylar copy of the base map. As of this date, the following have been determined germane to the identification effort. Amaryllis, Baccharis, Batis, Borrichia, Carex, Cymodocea, Distichlis, grasses, Halodule, Halophila, Juncus, Monanthochle, Phragmites, Ruppia, Sagittaria, Salicornia, salt cedar, Scirpus, Spartina, Suaeda, Thalassia, Typha.

Problem Areas

Location of our facilities in an area of extreme humidity has had two major affects on our cartographic effort.

1. Map positioning error. The USGS Quadrangle, in paper format, was subjected to differential expansion...primarily east and west. The expansion is as much as one quarter of an inch (.6 cm). At scale, this represents a ground position error of 500' (150 m) when the photo mylar copy of land tracts, prepared in Austin, is registered to the paper copy held at Seadrift.

2. Zoom Transfer Scope. In early July, difficulty was experienced in determining features and color of the photo image. The scope was inoperative as of July 10. The problem was discussed with Mr. Rex McHail of Bausch and Lomb. Following his instructions, the lenses inside the control module were examined. One lens was covered with what appeared to be a fungus growth. The module was then delivered to Mr. Chard, Bausch and Lomb representative at Austin.

APPENDIX B

EXAMPLES OF PROGRAM EVALUATION AND REVIEW SCHEDULES (PERS) USED TO DEFINE PROJECT TASKS AND SCHEDULING

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE FOR DESIGNING APPROACH FOR COST-BENEFIT ANALYSIS

DRAFT 7/75

	Control Date	Date Expected Complete	Date Completed
1 Review project objectives stated in the proposal and work statement and determine role of cost/benefit in this investigation a) Pat Malin b) Peggy Harwood c) Wermund, Ellis, Koren Sherrill		6/13/75	6/13/75 PH
2 Investigate "what NASA wants in a cost/benefit analysis" a) Pat Malin b) Peggy Harwood c) NASA contacts at Goddard & JSC, Koren		6/27/75	6/30/75 PH
3 Document steps 1 and 2 a) Pat Malin b) Peggy Harwood		7/11/75	7/11/75 PH
4 Begin design of approach for cost/benefit analysis a) Pat Malin b) Peggy Harwood c) Koren Sherrill		7/16/75	7/17/75 PH
5 Review design a) Ron Jones b) Peggy Harwood c) Pat Malin, Koren Sherrill		7/18/75	7/18/75 PH
6 Coordinate design with technical monitor a) Peggy b) Koren Sherrill		7/25/75	7/25/75 PH phone call from Gordon
7 Design cost-accounting procedures and sheets a) Accountant b) Koren Sherrill		8/15/75	8/7/75 PH
8 Complete design and document for quarterly report a) Koren Sherrill b) Peggy Harwood c) Pat Malin		8/29/75	8/29/75 PH

Page___of___

CMP Form 5 Revised (7/22/75)

Phase I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING REGIONAL BASE
FOR TEST SITE 3 SAN ANTONIO BAY

Draft 7/75

	Control Date	Date Expected Complete	Date Completed
1 Transfer to TWDB records of investigation account numbers for ordering air craft and satellite data from EROS Data Center a Peggy Harwood b Delores Seaton c Mike Ellis			
2 Decide criteria for selecting imagery (same date as TWDB tapes? scale, bands, prints, colors, PR?) and supporting aircraft data (test sites 3,4) a Wermund (BEG) b Peggy Harwood (GLO) c Holz, Childress			
3 Inventory satellite imagery available from EROS at TAMU browse file a Wermund b Mike Ellis c Peggy, Roger			
4 Order imagery from EROS Data Center, Copy to GLO a Roger (TWDB) b Mike Ellis (TWDB) c Wermund and Delores (copies of transactions, records)			
5 Index imagery and aircraft data (Mission 300) a Roger b Mike Ellis c BEG, DPC Wermund, Goessling, Rouse			
6 Prepare "reports" documenting data selections criteria and data handling procedures a Wermund, Ellis b Peggy Harwood			
7 Identify features and imagery a Robert Finlay (BEG) b Peggy Harwood			
8 "Ground Truth" interpretation with aerial photography, coastal atlas, TPWD maps, meteorological and tide data a Finlay b Peggy Harwood			
9 Review interpretation and select field stations for field verification and change detection in each important feature a Childress b Peggy Harwood c Finlay, David Murphy (TWDB), Holz			
10 Prepare reports documenting steps 7 through 9 including time/cost a Finlay, Childress b Peggy Harwood			

Phase I a

LEGEND

/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING REGIONAL BASE FOR
TEST SITE 3 SAN ANTONIO BAY

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Obtain negatives and clean positives Copies of USGS topo maps (1 24,000 scale) with State tracts from Highway Department (maybe) a Peggy Harwood b Finlay c Watson, Waddell, Delores (requires new contract?/new $)			
12 Obtain blue-line copies of topos with State tracts from GLO a Peggy Harwood b Finlay			
13 Obtain base maps at 1 250,000 scale from Coastal Atlas series, Port Lavaca Sheet a BEG b Finlay			
14 Transfer features identified onto USGS topo base (1 24,000) with State tracts and onto base at 1 250,000 scale, with legend a BEG b Finlay			
15 Compute areas of features identified a BEG b Finlay			
16 Develop criteria for selecting image product formats and evaluating map products a Peggy b Ron Jones c Finlay, purpose, use, info needs, accuracy, cost/time, Holz, Gosdin, Childress, Woodruff			
17 Prepare reports evaluation 1 250,000 scale map as an inventory tool to update Coastal Atlas series land use map, including time/cost of preparation a Finlay b Peggy Harwood c Holz			
18 Prepare report evaluating 1 24,000 scale maps as inventory tools to assist coastal leasing decisions in GLO, other selected problems, including time/cost of preparation a Peggy Harwood b Finlay c Childress Holz, Bob Clark, Woodruff			
19 Transfer completed information products (maps, charts, legends) to system archives a Roger? b Mike c Finlay, Peggy			

Phase Ia

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST SITE 4 HARBOR ISLAND

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Review and modify, if necessary, criteria used to select imagery and supporting aircraft data for test site 3 a Finlay b Peggy Harwood c Holz, Childress			
2 Inventory Satellite data available from EROS a Roger b Mike c Finlay, Childress			
3 Order imagery and supporting aircraft data, copy to GLO a Roger b Mike c Finlay, Delores			
4 Index imagery and aircraft data for test site 4 a Roger b Mike			
5 Prepare reports documenting modifications (if any) in data selection criteria or data handling procedures a Finlay, Ellis b Peggy Harwood			
6 Identify features on imagery, using test site 3 as guide (signature extension) a Finlay b Peggy			
7 "Ground Truth" interpretation with supportive data with attention to confidence in Step 6 a Finlay b Peggy			
8 Review interpretation and select field stations a Childress b Peggy c Finlay, David Murphy (TWDB), Holz			
9 Prepare "reports" documenting steps 6 through 8 including time/cost a Finlay, Childress b Peggy			
10 Obtain negatives and clean positive copies of topos with State tracts (1 24,000) from Highway Department a. Peggy b Finlay c Watson, Waddell, Delores			

I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR
TEST SITE 4 HARBOR ISLAND

Draft 7/75

	Control Date	Date Expected Complete	Date Completed
11 Obtain blue-line copies of tops with State tracts from GLO a Peggy b Finlay			
12 Obtain base map(s) at 1 250,000 scale from coastal atlas Corpus Christi Sheet and Port Lavaca Sheet? a BEG b Finlay			
13 Transfer features identified to topo base (1 24,000) and to 1 250,000 scale base with legend a BEG b Finlay			
14 Compute areas of features identified a BEG b Finlay			
15 Review criteria for selecting product formats and for evaluating map products a Peggy b Ron Jones c Holz, Finlay, Gosdin, Childress			
16 Prepare report evaluating 1 250,000 scale map format as inventory tool to update coastal atlas land use map, including time/cost of preparation a Finlay b Peggy c Holz, Woodruff			
17 Prepare report evaluating 1 24,000 map format as inventory tool to assist GLO coastal leasing decisions, including time/cost of preparation a Peggy b Finlay c Childress, Holz, Bob Clark			
18 Transfer completed information products to archives a Roger b Mike c Finlay, Peggy			

Phase I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST SITE 5 SOUTHERN LAGUNA MADRE

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Review and modify, if necessary, criteria used to select imagery and supporting aircraft data for test sites 3 and 4, dates for test site 5 a Finlay b Peggy Harwood c Holz, Childress			
2 Inventory satellite data available from EROS a Roger b Mike c Finlay, Childress			
3 Order imagery and supporting aircraft data a Roger b Mike c Finlay, Delores			
4 Index imagery and aircraft data for test site a Roger b Mike			
5 Prepare reports documenting modification (if any) in data selection criteria or data handling procedures a Finlay, Ellis b Peggy Harwood			
6 Identify features on imagery, using test sites 3 and 4 as guide (signature extension) a Finlay b Peggy			
7 "Ground Truth" interpretation with supportive data, and with attention to confidence in Step 6 a Finlay b Peggy			
8 Review interpretation and select field stations a Childress b Peggy c Finlay, David Murphy (TWDB), Holz			
9 Prepare "reports" documenting steps 6 through 8 including time/cost a Finlay, Childress b Peggy			
10 Obtain negatives and clean positive copies of topos with State tracts (1 24,000) from Highway Department a Peggy b Finlay c Watson, Waddell, Delores			

LEGEND Phase I a

/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST SITE SITE 5 SOUTHERN LAGUNA MADRE

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Obtain blue-line copies of topos with State tracts from GLO a Peggy b Finlay			
12 Obtain base map(s) at 1 250,000 scale from Coastal Atlas Corpus Christi Sheet and Port Lavaca Sheet? a BEG b Finlay			
13 Transfer features identified to topo base (1 24,000) and to 1 250,000 scale base with legend a BEG b Finlay			
14 Compute areas of features identified a BEG b Finlay			
15 Review criteria for selecting product formats and for evaluating map products a Peggy b Ron Jones c Holz, Finlay, Gosdin, Childress			
16 Prepare report evaluating 1 250,000 scale map format as inventory tool to update coastal atlas land use map, including time/cost of preparation a Peggy b Finlay c Childress, Holz, Bob Clark			
17 Prepare report evaluating 1 24,000 map format as inventory tool to assist GLO coastal leasing decisions, including time/cost of preparation a Peggy b Finlay c Childress, Holz, Bob Clark			
18 Transfer completed information products to archives a Roger b Mike c Finlay, Peggy			

39-B-7

Phase I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST
SITE 2 WEST GALVESTON BAY

Draft: 7/75

	Task	Control Date	Date Expected Complete	Date Completed
1	Review and modify, if necessary, criteria used to select imagery and supporting aircraft data for Test site 5, dates for test site 2 a Finlay b Peggy Harwood c Holz, Childress			
2	Inventory satellite data available from EROS a Roger b Mike c Finlay , Childress			
3	Order imagery and supporting aircraft data, copy to GLO a Roger b Mike c Finlay, Delores			
4	Index imagery and aircraft data for test site 2 a Roger b Mike			
5	Prepare reports documenting modifications (if any) in data selection criteria or data handling procedures a Finlay, Ellis b Peggy Harwood			
6	Identify features on imagery, using test sites 3-5 as guide (signature extension) a Finlay b Peggy			
7	"Ground Truth" interpretation with supportive data with attention to confidence in Step 6 a Finlay b Peggy			
8	Review interpretation and select field stations a Childress b Peggy c Finlay, David Murphy (TWDB), Holz			
9	Prepare "reports" documenting steps 6 through 8 including time/cost a Finlay, Childress b Peggy			
10	Obtain negatives and clean positive copies of topos with State tracts (1 24,000) from Highway Department a Peggy b Finlay c Watson, Waddell, Delores			

ORIGINAL PAGE IS
OF POOR QUALITY

LEGEND I a

/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST
SITE 2 WEST GALVESTON BAY

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Obtain blue-line copies of topos with State tracts from GLO a Peggy b Finlay			
12 Obtain base map(s) at 1 250,000 scale from coastal atlas Corpus Christi Shut and Port Lavaca Shut? a BEG b Finlay			
13 Transfer features identified to topo base (1 24,000) and to 1 250,000 scale base with legend a BEG b Finlay			
14 Compute areas of features identified a BEG b Finlay			
15 Review criteria for selecting product formats and for evaluating map products a Peggy b Ron Jones c Holz, Finlay, Gosdin, Childress			
16 Prepare report evaluating 1 250,000 scale map format as inventory tool to update Coastal Atlas land use map, including time/cost of preparation a Finlay b Peggy c Holz, Woodruff			
17 Prepare report evaluating 1 24,000 map format as inventory tool to assist GLO coastal leasing decisions, including time/cost of preparation a Peggy b Finlay c Childress, Holz, Bob Clark			
18 Transfer completed information products to archives a Roger b Mike c Finlay, Peggy			

39-B-9

LEGEND Phase I a

/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST
SITE 1 ENTIRE TEXAS COASTAL STRIP

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Review and modify, if necessary, criteria used to select imagery and supporting aircraft data for test sites 3, 4, 5, 2 a Finlay b Peggy c Holz, Childress			
2 Inventory satellite data available from EROS a Roger b Mike c Finlay, Childress			
3 Order imagery and supporting aircraft data a Roger b Mike c Finlay, Delores			
4 Index imagery and aircraft data for test site 1 a Roger b Mike			
5 Prepare reports documenting modifications (if any) in data selection criteria or data handling procedures a Finlay, Ellis b Peggy			
6 Identify features on imagery, using test sites 3, 4, 5, 2 as guide (signature extension) a Finlay b Peggy			
7 "Ground Truth" interpretation a Childress b Peggy			
8 Review interpretation a Childress b Peggy c Finlay, David Murphy (TWDB)			
9 Prepare "reports" documenting steps 6 through 8 a Finlay, Childress b Peggy			
10 Review map product evaluation, including time/cost data for 1 250,000 and 1 24,000 scale maps to determine if some or all of steps 11-17 can/or should be attempted a Peggy b John Gosdin c Ron Jones, Finlay			

ORIGINAL PAGE IS OF POOR QUALITY

Phase I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR BUILDING A REGIONAL BASE FOR TEST
SITE 1 ENTIRE TEXAS COASTAL STRIP

Draft 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Obtain negatives and clean positive copies of topos with State tracts (1 24,000) from Highway Department a Peggy b Finlay c Watson, Waddell, Delores			
12 Obtain blue-line copies of topos with State tracts from GLO a Peggy b Finlay			
13 Obtain base map(s) at 1 250,000 scale from remaining Coastal Atlas a BEG b Finlay			
14 Transfer features identified to topo base (1 24,000) and to 1 250,000 scale base with legend a BEG b Finlay			
15 Compute areas of features identified a BEG b Finlay			
16 Prepare report evaluating 1 250,000 scale map format as inventory tool to update coastal atlas land use map a Finlay b Peggy c Holz, Woodruff			
17 Prepare report evaluating 1 24,000 map format as inventory tool to assist GLO coastal leasing decisions a Peggy b Finlay c Childress, Holz, Bob Clark			
18 Transfer completed information products to archives a Roger b Mike c Finlay, Peggy			

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR PRELIMINARY EXAMINATION OF ADP SOFTWARE IN TEXT SITE 3 - SAN ANTONIO BAY

DRAFT 7/15

Task	Control Date	Date Expected Complete	Date Completed
1 Inventory existing LANDSAT tapes in TWDP Library a David Murphy b Mike			
2 Inventory existing conventional algorithms in TWDB Library for classifying LANDSAT data a David b Mike			
3 Provide interpretation references (supportive data) to computer operators for site 3 a Peggy b Mike c Wermund, Holz			
4 Acquire meterological and tide data for dates, times of LANDSAT tapes (from TWDB?) a David or Bill Hupp b Peggy c Roger, Wermund, Childress, Rouse			
5 Provide field trip and interpretive guide to orient participants to test site 3 a Holz b Peggy c Wermund, Childress			
6 Perform preliminary classification on existing data with conventional algorithms a David Murphy b Mike			
7 "Ground Truth" and refine classification with supportive data a David, Bill Hupp b Mike c Wermund, Childress, Peggy			
8 Prepare reports evaluating and documenting quality of tapes, algorithm performance and any new procedures implemented a Mike, David b Peggy			

39-8-12

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE
FOR TEST SITE 3

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Decide criteria for selecting LANDSAT tapes a David Murphy (TWDB) b Peggy c Mike Ellis, Rouse/Schell, Wermund (Phase Ia)			
2 Inventory satellite data available from EROS a Roger b Mike c Wermund			
3 Order tapes from EROS a Roger b Mike c Delores			
4 Index tapes a Roger b Mike c Rouse/Schell (review procedures)			
5 Prepare "reports" documenting data selection criteria and data handling procedures a Mike Ellis, Roger, David b Peggy			
6 Acquire supportive data to assist classification (imagery, aerial photos, BEG and TPWD maps, tide & meteorlogical data) a Bill Hupp b David c Finlay, Peggy, Childress			
7 Perform feature classification a David b Mike c Rouse & Schell			
8 "Ground Truth," and refine classification with supportive data a David, Bill Hupp b Mike c Finlay, Childress, Peggy			
9 Review classification and perform field observations at field stations a Childress b Peggy c Finlay			
10 Prepare reports documenting steps 7, 8 and 9 a David, Childress b Peggy			

39-B-13

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE FOR EXAMINING ADP SOFTWARE FOR TEST SITE 3

DRAFT 7/75

	Control Date	Date Expected Complete	Date Completed
11 Register LANDSAT scenes to 1 250,000 and 1 24,000 scale map bases a David b Mike c Rouse/Schell			
12 "Overlay" Test site boundaries and State tracts on classified portions of scenes a David b Mike c Rouse/Schell			
13 Compute areas of features classified in each test site, map area or state tract a David b Mike c Rouse/Schell			
14 Display classified features at 1 250,000 and 1 24,000 scales with display boundaries same as map bases, legend a David b Mike			
15 Develop criteria for selecting computer product formats, and for evaluating products a Peggy b Ron Jones c Mike Ellis, Rouse, Gosdin, Longley, Childress			
16 Prepare reports evaluating computer products as users a Finlay, Peggy b Mike			
17 Transfer completed products to archives a Roger? b Mike c David, Peggy			

39-B-14

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR
TEST SITE 4 - HARBOR ISLAND

DRAFT 7/75

	Control Date	Date Expected Complete	Date Completed
1 Review criteria for selecting LANDSAT Tapes a David b Mike c Rouse/Schell, Finlay			
2 Inventory satellite data available from EROS a Roger b Mike c Finlay			
3 Order tapes from EROS a Roger b Mike c Delores			
4 Index tapes a Roger b Mike c Rouse/Schell (review procedures)			
5 Prepare "reports" documenting data selection criteria and data handling procedures a David, Mike Ellis, Roger b Peggy			
6 Acquire supportive data to assist classification (imagery, aerial photos, BEG and TPWD maps, tide & meteorlogical data) a Bill Hupp b David c Finlay, Peggy, Childress			
7 Perform feature classification with attention to extending signatures from test site 3 a David b Mike c Rouse & Schell			
8 "Ground Truth," and refine classification with supportive data a David b Mike c Finlay, Childress, Peggy			
9 Review classification and perform field operations at field stations a Childress b Peggy c Finlay, David			
10 Prepare reports documenting steps 7, 8, and 9 a David, Childress b Peggy			

39-B-15

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR
TEST SITE 4 - HARBOR ISLAND

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Register LANDSAT scenes to 1 250,000 and 1 24,000 scale map bases a David b Mike c Rouse/Schell			
12 "Overlay" Test site boundaries and State tracts on classified portions of scenes a David b Mike c Rouse/Schell			
13 Compute areas of features classified in each test site, map area or state tract a David b Mike c Rouse/Schell			
14 Display classified features at 1 250,000 and 1 24,000 scales with display boundaries same as map bases, legend a David b Mike			
15 Review criteria for selecting computer product formats, and for evaluating products a Peggy b Ron Jones c Mike Ellis, Rouse, Gosdin, Longley, Childress			
16 Prepare reports evaluating computer products as users a Finlay, Peggy b Mike			
17 Transfer completed products to archives a Roger? b Mike c David Peggy			

39-B-16

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR TEST
SITE 5 - SOUTHERN LAGUNA MADRE

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Review criteria for selecting LANDSAT Tapes a David b Mike c Rouse/Schell, Finlay			
2 Inventory satellite data available from EROS a Roger			
3 Order tapes from EROS a Roger b Mike c Delores			
4 Index tapes a Roger b Mike c Rouse/Schell (review procedures)			
5 Prepare "reports" documenting data selection criteria and data handling procedures a Mike Ellis, Roger, David b Peggy			
6 Acquire supportive data to assist classification (imagery, aerial photos, BEG and TPWD maps, tide & meteorlogical data) a Bill Hupp b David c Finlay, Peggy, Childress			
7 Perform feature classification with attention to extending signatures from test site 3 and 4 a David b Mike c Rouse & Schell			
8 "Ground Truth," and refine classification with supportive data a David b Mike c finlay, Childress, Peggy			
9 Review classifications and perform field observations at field stations a Childress b Peggy c Finlay, David			
10 Prepare reports documenting steps 7, 8 and 9 a David, Childress b Peggy			

39-8-17

Phase I a

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR
TEST SITE 5 - SOUTHERN LAGUNA MADRE

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Register LANDSAT scenes to 1 250,000 and 1,24,000 scale map bases a David b Mike c Rouse/Schell			
12 "Overlay" Test site boundaries and State tracts on classified portions of scenes a David b Mike c Rouse/Schell			
13 Compute areas of features classified in each test site, map area or state tract a David b Mike c Rouse/Schell			
14 Display classified features at 1 250,000 and 1 24,000 scales with display boundaries same as map bases, legend a David b Mike			
15 Review criteria for selecting computer product formats, and for evaluating products a Peggy b Ron Jones c Mike Ellis, Rouse, Gosdin, Longley, Childress			
16 Prepare reports evaluating computer products as users a Finlay, Peggy b Mike			
17 Transfer completed products to archives a Roger? b Mike c David, Peggy			

39-B-18

Phase I b

LEGEND

/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR
TEST SITE 2 - WEST GALVESTON BAY

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
1 Review criteria for selecting LANDSAT Tapes a David b Mike c Rouse/Schell, Finlay			
2 Inventory satellite data available from EROS a Roger			
3 Order tapes from EROS a Roger b Mike c Delores			
4 Index tapes a Roger b Mike c Rouse/Schell (review procedures)			
5 Prepare "reports" documenting data selection criteria and data handling procedures a Mike Ellis, Roger, David b Peggy			
6 Acquire supportive data to assist classification (imagery, aerial photos, BEG and TPWD maps, tide & meteorlogical data) a Bill Hupp b David c Finlay, Peggy, Childress			
7 Perform feature classification with attention to extending signatures from test sites 3, 4, and 5 a David b Mike c Rouse & Schell			
8 "Ground Truth," and refine classification with supportive data a David b Mike c Finlay, Childress, Peggy			
9 Review classification and perform field observations at field stations a Childress b Peggy c Finlay, David			
10 Prepare reports documenting steps 7, 8 and 9 a David, Childress b Peggy			

Phase I b

LEGEND
/Task /Time Period
a /Responsibility
b /Control
c /Coordination

EVALUATION REVIEW SCHEDULE
FOR EXAMINING ADP SOFTWARE FOR TEST
SITE 2 - WEST GALVESTON BAY

DRAFT 7/75

Task	Control Date	Date Expected Complete	Date Completed
11 Register LANDSAT scenes to 1 250,000 and 1 24,000 scale map bases a David b Mike c Rouse/Schell			
12 "Overlay" Test site boundaries and State tracts on classified portions of scenes a David b Mike c Rouse/Schell			
13 Compute areas of features classified in each test site, map area or state tract a David b Mike c Rouse/Schell			
14 Display classified features at 1 250,000 and 1 24,000 scales with display boundaries same as map bases, legend a David b Mike			
15 Review criteria for selecting computer product formats, and for evaluating products a Peggy b Ron Jones c Mike Ellis, Rouse, Gosdin, Longley, Childress			
16 Prepare reports evaluating computer products as users a Finlay, Peggy b Mike			
17 Transfer completed products to archives a Roger? b Mike c David, Peggy			

Page___of___

PP Form 2 Revised (7/22/75)

APPENDIX C

COST RECORDING FOR THE LANDSAT PROJECT

Prepared By

Ed Deakin III

August 7, 1975

I Objectives

Cost records are to be maintained for product development at each of the test sites The purpose of maintaining these records will be to assist in the evaluation of cost effectiveness of satellite data-gathering methods

II. Types of Records

There are two types of records that are to be kept by individual project participants These are

1 Time allocation records, and
2 Equipment usage records

Data from these records will be accumulated by a project accountant The records which the project accountant will use are

1 Staff cost accumulation sheets, and
2 Equipment cost accumulation sheets

Each of these types of records and their use is described below

III Time Allocation Records

Staff members are to maintain an account of the time spent on each task at each site, and for time spent on each step according to the Project Evaluation Review Schedule (PERS) The Time Allocation Record (Exhibit I) is designed to facilitate this record-keeping

The staff member should fill in a new Time Allocation Record each day as work is performed, a notation is made on the record There are two task codes

E for Examining ADP Software, and
B for Building a Regional Base.

AGENCY ______________________

LANDSAT PROJECT
TIME ALLOCATION RECORD

EXHIBIT I

NAME ______________________

STAFF LEVEL ______________________

Week Ending ______________________

PLRS Draft Date ______________________

MONDAY				TUESDAY				WEDNESDAY				THURSDAY				FRIDAY			
Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours
Other ______				Other ______				Other ______				Other ______				Other ______			
TOTAL HOURS				TOTAL HOURS				TOTAL HOURS				TOTAL HOURS				TOTAL HOURS			

AGENCY ______________________

LANDSAT PROJECT
TIME ALLOCATION RECORD

EXHIBIT 1a

NAME *John Doe*

STAFF LEVEL *Geologist I*

Week Ending *September 5, 1975*

PFRS Draft Date *July 7, 1975*

MONDAY				TUESDAY				WEDNESDAY				THURSDAY				FRIDAY			
Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours	Task	Site Code	Step	Hours
				E	3	4	7	E	3	4	2	E	3	8	2	E	4	6	2
				E	3	5	1	E	3	6	1 3/4	E	3	10	1	B	4	7	2
								E	3	7	4 1/4	E	3	11	4	E	3	17	1/2
																E	4	1	3 1/2
Other *Holiday*			8	Other				Other				Other *IDLE: Equipment breakdown*			1	Other			
TOTAL HOURS			8	TOTAL HOURS			8	TOTAL HOURS			8	TOTAL HOURS			8	TOTAL HOURS			8

If a staff member is working on Examining ADP Software for Test Site 3, and is Indexing Tapes from EROS (Step 4), the person would enter an E in the Task column, a 3 in the Site Code column, and a 4 in the Step column. The hours spent on the task would be entered in the hours column Exhibit Ia shows a time allocation record that has been filled in for John Doe, who performed that task on Tuesday of the week ending September 5, 1975

Exhibit Ia also shows sample entries for Monday, a holiday, and for other days of the week Note that on Friday, this person performed several tasks The second task, which is labeled B 4 7 2 in the four columns of the form indicates that this person spent two hours on Friday building a regional base at Harbor Island, and during that time the person was involved in "Ground Truth" interpretation

Time should be kept to within 1/4 of an hour (Smaller divisions of time are generally more costly than the benefit of increased accuracy obtained)

IV Equipment Usage Records

Use of specialized equipment and use of the computer should be recorded on equipment usage records (Exhibit II) The recording of computer use will be handled by the computer accounting system, thus use of these records by the staff will concentrate on the use of specialized equipment An Equipment Usage Record form should be kept near each piece of equipment When the equipment is used, the user should record the Task, Site Code, Step and Time of use in the appropriate columns on the Equipment Usage Record In many cases, equipment use is limited to a few of the steps for each task The project accountant should be able to compare the times spent on tasks with the equipment usage record to help verify the data contained on the EUR

An example of an EUR for a Richards Light Table is shown in Exhibit IIa This type of equipment is used to perform Steps 7 and 8 in Task B only Thus, usage for the equipment should conform fairly closely to the time spent on those tasks From the example, one can see that the equipment was used on Tuesday and Friday only Tasks performed on those days were as noted

V Staff Cost Accumulation Sheets

Data from the time allocation records must be transferred to cost records which accumulate costs by task, site and step. The project accountant will use the cost accumulation forms in order

AGENCY ______________________

LANDSAT PROJECT

EQUIPMENT USAGE RECORD

EXHIBIT II

TYPE OF EQUIPMENT

____

____

Week Ending ______________________

PERS Draft Date ______________________

MONDAY				TUESDAY				WEDNESDAY				THURSDAY				FRIDAY			
Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs
TOTAL USAGE				TOTAL USAGE				TOTAL USAGE				TOTAL USAGE				TOTAL USAGE			

AGENCY ______________________

LANDSAT PROJECT
EQUIPMENT USAGE RECORD

EXHIBIT IIa

TYPE OF EQUIPMENT Richards Light Table

Week Ending ______________

PERS Draft Date ______________

MONDAY				TUESDAY				WEDNESDAY				THURSDAY				FRIDAY			
Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs	Task	Site Code	Step	Hrs
				B	3	7	1½									B	3	7	
				B	3	8	½									B	3	8	
				B	3	7	2												
Holiday																			
TOTAL USAGE			0	TOTAL USAGE			4	TOTAL USAGE			0	TOTAL USAGE			0	TOTAL USAGE			

to transfer data from the time allocation records An example of a Staff Cost Accumulation forms in order to transfer data from the time allocation records An example of a Staff Cost Accumulation Sheet is shown in Exhibit III

An example of a filled-in Staff Cost Accumulation Sheet is presented in Exhibit IIIa The first line shows that a Geologist I spent one hour during the week on Step 1 of Task E at Site 3 The standard rate for a Geologist I is $10 00. This rate is multiplied by the hours worked to obtain the total cost for that staff level during the week. The totals are added across the line, and a total cost for each step is entered in the last column

In Step 4, there are three staff levels which were engaged in performing this particular step this week The hours for each, and the standard rates for each are used to determine the totals The three total costs are added together to arrive at a total cost for Step 4 for this week (Notice that the Geologist II hours can be tied back to Exhibit Ia The arrow indicates the steps where this can be done)

Step 8 required more than three staff levels To indicate the continuation onto the next line, a diagonal line was placed in the "Total for This Step" column, and the additional data were entered in the next line

If a particular task requires more than one Staff Cost Accumulation Sheet, additional sheets can be added, with the notation "Continuation" made at the top

Weekly accumulations should be made in order to facilitate reporting At the time that reports are due, the weekly cost accumulation sheets can be used as a basis for preparing cumulative cost accumulative cost accumulation sheets The cumulative box would be checked, and the accumulated hours for each of the staff levels would be entered under the appropriate steps At the end of each task for each site, the cumulative cost accumulation sheet will have the total times spent on each of the steps in that task as well as the total standard costs for that step

The standard costs to be used for each staff level should be the costs that are expected to occur if the project is operational These costs would include the employee's hourly rate plus a provision for employee benefits, and other costs related to that employee's time.

The staff levels are abbreviated in the cost accumulation forms The project director should prepare a key to indicate the staff levels associated with each of the abbreviations, as well as the

EXHIBIT III

LANDSAT PROJECT
COST ACCUMULATION SHEET
STAFF

TASK ______________________ SITE ______________________

CUMULATIVE /__/ WEEKLY /__/ WEEK ENDING ______________________

Step	Staff Level	Hrs	Std Hrs	Total	Staff Level	Hrs	Std Hrs	Total	Staff Level	Hrs	Std Hrs	Total	Total For This Step

LANDSAT PROJECT
COST ACCUMULATION SHEET
STAFF

EXHIBIT IIIa

TASK E

SITE 3

CUMULATIVE [ ] WEEKLY [X]

WEEK ENDING September 5, 1975

Step	Staff Level	Hrs	Std Hrs	Total	Staff Level	Hrs	Std Hrs	Total	Staff Level	Hrs	Std Hrs	Total	Total For This Step
1	G 1	1	10.00	10 00									$10 00
2	G 1	3	10 00	30 00	G2	2	8 00	16 00					46 00
3													-00-
4	G 1	5	10 00	50 00	G2	9	8 00	72 00	S3	2	5 20	10 40	132 40
5	G2	1	8 00	8 00									8.00
6	G 1	2	10 00	20 00	G2	1 3/4	8 00	14.00					34 00
7	G2	4 1/4	8.00	34.00									34.00
8	G 1	4	10 00	40.00	G2	2	8.00	16 00	S2	2	6 50	13.00	
	S3	1	5 20	5 20									74.20
9													-00-
10	G2	1	8.00	8 00									8 00
11	G2	4	8 00	32 00									32 00

standard rate for each level.

VI Equipment Cost Accumulation Sheets

The costs associated with the use of each piece of specialized equipment and with the computer should be accumulated on Equipment Cost Accumulation Sheets (Exhibit IV) The process of transferring the data from individual Equipment Usage Records to these sheets is identical to the process for transferring staff time records

The standard rates for equipment use should be determined based on the expected life of equipment This can be approximated by taking the expected life of the equipment in years, and multiplying it by the expected annual usage in hours. This "productive hours" life of the equipment is then divided into the equipment cost to arrive at an hourly cost for use of the equipment For example, if a machine will last for two years, and is used an average of 520 hours per year (or 10 hours per week), it has a productive-hours life of 1040 hours (2 years x 520 hours per year) If the equipment costs $18,560 and can be sold for $4,000 at the end of the second year, then the net equipment cost is $14,560. ($18,560 - $,000) The hourly rate would be this $14,560 divided by 1,040 hours, or $14 00 per hour

Computer costs should be assigned to each step based on the records maintained by the computer center Each job sumbitted to the center should be coded to indicate the Task, Site, and Step to which the job applies Standard computer use costs should be based on the computer costs expected to occur under operational conditions

VII Other Cost Records

Certain other costs will be incurred under the project The most significant of these is likely to be travel costs The basic document for these costs will be the travel voucher These vouchers should be coded with the Task, Site and Step codes so that the travel costs can be associated with the final cost reports

Other costs such as supplies, should be estimated In general, these costs will be too small to require detailed record-keeping Estimates of supplies use should be reported by breaking down the total use for the project to individual steps on an appropriate basis

EXHIBIT IV

LANDSAT PROJECT
COST ACCUMULATION SHEET
EQUIPMENT

TASK: ______________________ SITE ______________________

CUMULATIVE / / WEEKLY / / WEEK ENDING ______________________

Step	Equip Type	Hrs	Std Rate	Total	Equip Type	Hrs	Std Rate	Total	Equip Type	Hrs	Std Rate	Total	Total For This Step

VIII Reporting Costs Incurred

A report of costs incurred for each step should be prepared to indicate the costs likely to occur in an operational setting Such a report should list costs for each of the three major step categories.

Data Acquisition
Information Extraction, and
Display

Under each of these steps, costs should be shown with the following categories

Cost	Source of Information
Staff	Staff Cost Accumulation Sheets--Cumulative
Equipment	Equipment Cost Accumulation Sheets-Cumulative
Travel	Travel Vouchers--according to codes
Other	As Estimated

The estimates for Other Costs should be documented to provide a means of tracing these costs

APPENDIX D

PROGRAM CHANGES AND ADDITIONS

The following list summarizes modifications made to the LARSYS-ISOCLS system for use at TWDB

1. NTRAN

NTRAN is a UNIVAC I/O processor for reading and writing binary information on tape or disc Due to the non-integral block structure of LANDSAT bulk data tapes, NTRAN reads always return an error status code In order to continue processing, the NTRAN operation 22 (wait and unstack then release unit) has to be performed after each NTRAN operation The LARSYS subroutines affected are as follows COVAR1, DAVDN3, DSPLY2, DSTAP, ISODAT, LEARNN, LNTRAN, PRINT, SETUP7, TAPERD, TAPWRT, and TWRITE

2 Map overlay (see listings at end of Appendix)

The map overlay structure received from NASA/JSC was written for EXEC 2 (LARSAA) It was necessary to translate it into EXEC 8 (MAP) for use at TWDB

3. SETMRG (see listing at end of Appendix)

SETMRG controls the number of blank lines at the top and bottom of a print page It was added to replace a NASA/JSC system subroutine New calling parameters for SETMRG were added to the following subroutines

CLSFY1, CLSFY2, CLSHIS, DSPLY2, HEADING, LEARNN, and PRINT

5. FSBSFL (see listing at end of Appendix)

Forward Space Back Space FiLe controls file positioning It was added to replace a NASA/JSC system subroutine

6. The following programs are system subroutines at NASA/JSC RESET, CRMERR, DRMAVL, and DRMASG Since they are not required for running LARSYS at TWDB, they were made into dummy subroutines

7 UNPKIT (see listing at end of Appendix)

Assembler subroutine added to unpack LANDSAT bulk data tapes

8 TDATE (see listing at end of Appendix)

Assembler subroutine for getting the current date Rewritten to conform to the TWDB system

9 TAPERD (see listing at end of Appendix)

TAPERD reads and unpacks multispectral scanner data tapes Changes were made to this subroutine to enable it to read and process LANDSAT bulk data tapes. Lines inserted or changed for this purpose are marked in the listing

10. Punch unit was changed from Unit-3 to Unit 1 to conform to the TWDB system

11 Variable SAVTAP was changed from Unit 1 to Unit 11, since Unit 1 is reserved for punch files at TWDB

12 Minor changes were made to the FORTRAN PROCs to conform to the TWDB system

13 Minor changes were made in format and write statements to accommodate larger fields

```
DB0200-02*LARSYS LARSAA
           BLK   B ITRX,SCRAC I
             SEG   MONTOR-*(A,B,G,I)
      A  SEG   MAKLOD-WRTMTX-GRPSCN-REDSAV-TAPSTA-CLSCHK-REDDAT-*(C,D,E,F)
      B  SEG   HIST-GRAYMP-*(SETUP5,SETUP6,HISTGM,PICT)
      C  SEG   STAT-*(SETUP1,C1)
      C1         SEG   LEARNN-*(CLSSPC,COVARR,PCHSTA)
      D  SEG   CLSFY-BATPX-SCRACH-*(CLSFY1,D1,SETUP2)
      D1   SEG   CLSFY2-CONTEX
      E  SEG   DSPLAY-*(DSPLY1,E1,SETUP3)
      E1 SEG DSPLY2-*(FLDBOR,PCTTTT,PRTPCT)
      F  SEG SELECT-DIVERG-TRACE-COLINV-F1-*(F2,PRELIM,EXSRCH,WHRPLC,F4,USERIN,;
            GENRPT,EVLFET,WRTBMT)
      F1 SEG GTSTAT-EVALSP-F3-*(AVEDIV,TRNDIV,BHTCHR,TRNCLS)
      F2  SEG   SETUP4-*(WGTSCN,WGTCHK,PRTFLD)
      F3 SEG *(MTMLS2,MTMLTR,MTMLS4,MTMLS1,MATDIF,MATSUM,MLTMV,MTRXOP)
      F4 SEG DAVIDN-*(DAVDN1,DAVDN2,DAVDN3)
      G  SEG   ISOCLS-PRINT-*(SETUP7,ISODAT,COVAP1,TWRITE,PCHST1,CHAIN,RDDATA,;
           DASWRT)
      I  SEG   DATATR-*(MAXMAT,TRHIST,LNTRAN,SETUP8)
```

EXEC 2 MAP OVERLAY

EXEC 8 MAP OVERLAY

```
DB0200-02*LARSYS MAP
      SEG MAIN
      IN  LARSYS MONTOR,.BLKCOM
      SEG A*,(MAIN)
      IN  LARSYS MAKLOD, WRTMTX,.GRPSCN,.REDSAV,.TAPSTA,.CLSCHK,.REDDAT
      SEG B*,(MAIN)
      IN  LARSYS HIST, GRAYMP
      SEG C*,(A)
      IN  LARSYS STAT
      SEG C1*,(C)
      IN  LARSYS LEARNN
      SEG D*,(A)
      IN  LARSYS CLSFY,BMTRX,SCRACH
      SEG D1*,(D)
      IN  LARSYS CLSFY2,.CONTEX
      SEG E*,(A)
      IN  LARSYS DSPLAY
      SEG E1*,(E)
      IN  LARSYS DSPLY2
      SEG F*,(A)
      IN LARSYS.SELECT, DIVERG,.TRACE,.COLINV
      SEG F1*,(F)
      IN LARSYS.CTSTAT,.EVALSP
      SEG F31*,(F1)
      IN  LARSYS MTMLS2
      SEG F32*,(F1)
      IN  LARSYS MTMLTR
      SEG F33*,(F1)
      IN  LARSYS MTMLS4
      SEG F34*,(F1)
      IN  LARSYS MTMLS1
      SEG F35*,(F1)
      IN  LARSYS MATDIF
      SEG F36*,(F1)
      IN  LARSYS MATSUM
      SEG F37*,(F1)
      IN  LARSYS MLTMV
      SEG F38*,(F1)
      IN  LARSYS MTPXOP
      SEG F11*,(F31,F32,F33,F34,F35,F36,F37,F38)
      IN LARSYS AVEDIV
      SEG F12*,(F31,F32,F33,F34,F35,F36,F37,F38)
      IN LARSYS TRNDIV
      SEG F13*,(F31,F32,F33,F34,F35,F36,F37,F38)
      IN LARSYS BHTCHP
      SEG F14*,(F31,F32,F33,F34,F35,F36,F37,F38)
      IN LARSYS.TRNCLS
      SEG F2*,(F11,F12,F13,F14)
      IN  LARSYS SETUP4
      SEG F4*,(F11,F12,F13,F14)
      IN  LARSYS DAVIDN
      SEG PRELIM*,(F11,F12,F13,F14)
      IN  LARSYS PRELIM
      SEG EXSRCH*,(F11,F12,F13,F14)
      IN  LARSYS EXSRCH
      SEG WHRPLC*,(F11,F12,F13,F14)
      IN  LARSYS.WHRPLC
      SEG USERIN*,(F11,F12,F13,F14)
      IN  LARSYS USERIN
      SEG GENRPT*,(F11,F12,F13,F14)
      IN  LARSYS.GENRPT
      SEG EVLFET*,(F11,F12,F13,F14)
      IN  LARSYS.EVLFET
      SEG WRTBMT*,(F11,F12,F13,F14)
      IN  LARSYS.WRTBMT
      SEG WGTSCN*,(F2)
      IN  LARSYS WGTSCN
      SEG WGTCHK*,(F2)
      IN  LARSYS.WGTCHK
      SEG PRTFLD*,(F2)
      IN  LARSYS PRTFLD
      SEG DAVDN1*,(F4)
      IN  LARSYS DAVDN1
```

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```
SEG DAVDM2*,(F4)
IN  LARSYS DAVDM2
SEG DAVDM3*,(F4)
IN  LARSYS DAVDM3
SEG G*,(MAIN)
IN  LARSYS ISOCLS, PRINT
SEG I*,(MAIN)
IN  LARSYS.DATATR
SEG SETUP5*,(B)
IN  LARSYS SETUP5
SEG SETUP6*,(B)
IN  LARSYS SETUP6
SEG HISTGM*,(B)
IN  LARSYS HISTGM
SEG PICT*,(B)
IN  LARSYS.PICT
SEG SETUP1*,(C)
IN  LARSYS.SETUP1
SEG CLSSPC*,(C1)
IN  LARSYS CLSSPC
SEG COVARR*,(C1)
IN  LARSYS COVARR
SEG PCHSTA*,(C1)
IN  LARSYS PCHSTA
SEG CLSFY1*,(D)
IN  LARSYS CLSFY1
SEG SETUP2*,(D)
IN  LARSYS SETUP2
SEG DSPLY1*,(E)
IN  LARSYS DSPLY1
SEG SETUP3*,(E)
IN  LARSYS SETUP3
SEG FLDBOR*,(E1)
IN  LARSYS FLDBOR
SEG PCTTTT*,(E1)
IN  LARSYS PCTTTT
SEG PRTPCT*,(E1)
IN  LARSYS PRTPCT
SEG SETUP7*,(G)
IN  LARSYS.SETUP7
SEG ISODAT*,(G)
IN  LARSYS ISODAT
SEG COVAR1*,(G)
IN  LARSYS COVAR1
SEG TWRITE*,(G)
IN  LARSYS TWRITE
SEG PCHST1*,(G)
IN  LARSYS PCHST1
SEG CHAIN*,(G)
IN  LARSYS CHAIN
SEG RDDATA*,(G)
IN  LARSYS.RDDATA
SEG DASWRT*,(G)
IN  LARSYS DASWRT
SEG MAXMAT*,(I)
IN  LARSYS MAXMAT
SEG TRHIST*,(I)
IN  LARSYS.TRHIST
SEG LNTRAN*,(I)
IN  LARSYS LNTRAN
SEG SETUP8*,(I)
IN  LARSYS.SETUP8
LIB LARSYS.
END
```

```
DB0200-02*LARSYS.SETMRG
                    AXR$
        SETMRG*     SA       A0,SAVE
                    LA       A0,*0,X11
                    LSSL     A0,18
                    A        A0,1,X11
                    ER       PRTCN$
                    L        A0,SAVE
                    J        3,X11
        SAVE        RES 1
                    END
```

```
DB0200-02*LARSYS.FSBSFL
        $(0)        AXR$
        FSBSFL*     LA       A3,*0,X11
                    SLJ      NBTOD$
                    SA       A3,IOPKT
                    LR       R1,*1,X11
                    LA,U     A0,IOPKT
                    JGD      R1,MOVE
        MOVE        ER       IOW$
                    JGD      R1,MOVE
                    LA,S1    A1,IOPKT+3
                    SA       A1,*2,X11
                    J        4,X11
        IOPKT       '        '
                    '        '
                    +0
                    +052,0,0
                    +0
                    END
```

D80200-02*LARSYS UNPKIT

```
         $(1)      AXR$                                .
         .  SUBROUTINE UNPKIT(IN,OUT)                  .
         POP*      PROC      1,3                       .
         ST        FORM      6,4,4,4,2,16              .
                   LDSC      A2,8                      .
                   AND,U     A3,0377                   . GET LAST 8 BITS
                   ST        01,00,04,;                . FJA STORF A4
                             POP(1,2),;                . X  INDEX REGISTER
                             2*POP(1,*2),              . H  INDEX INCREMENTATION
                             POP(1,1)                  . U  ADDRESS
                   END                                 .
         BLOCK*    PROC      0,28                      .
                   DL        A2,0,*A1                  .
                   DO J=1 ,  POP       0,A0            .
                   DO J<3 ,  POP       1,A0            .
                   DO J<4 ,  POP       810,A0          .
                   DO J<5 ,  POP       811,A0          .
                   DO J<6 ,  POP       1620,A0         .
                   DO J<7 ,  POP       1621,A0         .
                   DO J<8 ,  POP       2430,A0         .
                   POP       2431,*A0                  .
                   POP       0,A0                      .
                   DO J>1 ,  POP       1,A0            .
                   DO J>2 ,  POP       810,A0          .
                   DO J>3 ,  POP       811,A0          .
                   DO J>4 ,  POP       1620,A0
                   DO J>5 ,  POP       1621,A0         .
                   DO J>6 ,  POP       2430,A0
                   DO J=8 ,  POP       2431,*A0        .
                   END                                 .
         UNPKIT*   L,U       A0,*1,X11                 . STORAGE COUNTER
                   L,U       A1,*0,X11                 . LOADING COUNTER
                   L,U       R2,44                     . CYCLE COUNTER
                   SZ        A4                        . CLEAR RECEIVING REGISTER
                   LXI,U     A0,2                      .
                   LXI,U     A1,2                      .
         CYCLE                                         .
         J         DO 8 , BLOCK                        .
                   JGD       R2,CYCLE                  .
                   J         3,X11                     . RETURN TO CALLER
                   END                                 .
```

```
DB0200-02*LARSYS TDATE
        .    TITLE             TODAYS  DATE
        .  DESCRIPTION
             THIS ROUTINE IS DESIGNED TO BE CALLED BY FORTRAN V
             AND TO RETURN 8 CHARACTER S CONTAINING   MONTH DAY YEAR   XX/XX/XX
        .
        .
        $(1)      AXR$                  .
        TDATE*                          .
        ITDATE*                         .
                  ER     DATE$          .
                  LA     A1,SL          .
                  DSL    A0,12          .
                  SSC    A1,6           .
                  DSL    A0,12          .
                  SSC    A1,6           .
                  LDSL   A0,24          .
                  AA     A1,SP          .
                  DS     A0,*0,X11      .
                  J      2,X11          .
        $(0)                            .
        SL        '//////'              .
        SP        +05050505             .
                  END                   .

@BRKPT PRINT$
```

```
DB0200-02*LARSYS.TAPERD
      C*                                                                TAPE0000
            SUBROUTINE TAPERD                                           TAPE0000
      C*****************************************************************TAPE0010
      C*                                                                TAPE0020
      C*    TAPERD READS THE MULTISPECTRAL SCANNER DATA TAPE, UNPACKS THE   TAPE0030
      C*    REQUESTED DATA AND RETURNS IT UNPACKED TO THE CALLING ROUTINE.  TAPE0040
      C*    THERE ARE THREE ENTRY POINTS TO THE SUBROUTINE. TAPHDR, FLDINT  TAPE0050
      CC*    AND LINERD                                                 TAPE0060
      C*                                                                TAPE0070
      C*    TAPHDR MUST BE CALLED ONCE TO READ THE HEADER RECORD AND UNPACK TAPE0090
      C*     NECESSARY DATA FROM THE RECORD                             TAPE0100
      C*                                                                TAPE0110
      C*    CALL TAPHDR(IDR,DATAPE,FORMAT)                              TAPE0120
      C*        IDR-OUTPUT ARRAY CONTAINING HEADER INFORMATION          TAPE0130
      C*        DATAPE-INPUT UNIT NUMBER FOR DATA TAPE                  TAPE0140
      C*        FORMAT-(INPUT) FORMAT OF DATA TAPE                      TAPE0150
      C*             =1 UNIVERSAL FORMAT                                TAPE0160
      C*             =2 LARSYS II FORMAT                                TAPE0170
      C*      -->   [=3 GODDARD FORMAT ]
      C*                                                                TAPE0180
      C*    FLDINT MUST BE CALLED ONCE FOR EACH FIELD, THE TAPE IS POSITIONED TAPE0190
      C*    TO THE CORRECT RECORD AND PARAMETERS ARE INITIALIZED FOR THE FIELDTAPE0200
      C*                                                                TAPE0210
      C*    CALL FLDINT(BLOCK,FETVEC,NOFEAT)                            TAPE0220
      C*        BLOCK(1)=LINE START                                     TAPE0230
      C*        BLOCK(2)=LINE END                                       TAPE0240
      C*        BLOCK(3)=LINE INCREMENT                                 TAPE0250
      C*        BLOCK(4)=SAMPLE START                                   TAPE0260
      C*        BLOCK(5)=SAMPLE END                                     TAPE0270
      C*        BLOCK(6)=SAMPLE INCREMENT                               TAPE0280
      C*        FETVEC- (INPUT) VECTOR CONTAINING FEATURES REQUESTED    TAPE0290
      C*        NOFEAT (INPUT) NO  OF FEATURES IN FETVEC                TAPE0300
      C*                                                                TAPE0310
      C*    LINERD MUST BE CALLED ONCE FOR EACH SCAN LINE IN THE FIELD  TAPE0320
      C*                                                                TAPE0330
      C*    CALL LINERD(IDATA)                                          TAPE0340
      C*        IDATA-(OUTPUT) ARRAY CONTAINING UNPACKED DATA           TAPE0350
      C*                                                                TAPE0360
      C*                                                                TAPE0370
      C*****************************************************************TAPE0380
      --> [DIMENSION ISCAN(3240)]
            DIMENSION ID(20),IBUF(6800)                                 TAPE0390
            IMPLICIT INTEGER(A-Z)                                       TAPE0440
            LOGICAL READY                                               TAPE0400
      C*    READY IS A LOGICAL INDICATOR TO TEST WHETHER THE TAPE HAS BEEN  TAPE0410
      C*    POSITIONED AND PARAMETERS SET FOR A FIELD                   TAPE0420
            DATA READY/ FALSE /
            DIMENSION FRM(2,2)                                          TAPE0450
            DATA FRM/'UNIVERSAL   ','LARSYS 2'/                         TAPE0460
            DIMENSION IST(15),IBYTE(30),JREC(30)                        TAPE0470
      C*                                                                TAPE0480
      C*    THE ARRAYS BIT,NB,AND HWRD ARE PRECALCULATED WORD AND BIT   TAPE0490
      C*    POSITIONS OF INFORMATION IN THE HEADER RECORD OF THE UNIVERSAL  TAPE0500
      C*    FORMAT WHICH MUST BE EXTRACTED.                             TAPE0510
      C*                                                                TAPE0520
      C*      NRPDS - NO. OF RECORDS PER DATA SET                       TAPE0530
      C*      NCPR - NO  OF CHANNELS PER RECORD ON RECORDS PAST ANCILLARY RECOTAPE0540
      C*      NPRC - NO. OF PHYSICAL RECORDS PER CHANNEL                TAPE0550
      C*      ANCLNG - ANCILLARY LENGTH IN BYTES                        TAPE0560
      C*      NC - NO. OF CHANNELS                                      TAPE0570
      C*      NS - NO  OF SAMPLES PER CHANNEL PER SCAN                  TAPE0580
      C*      NBITS - NO  OF BITS PER PIXEL                             TAPE0590
      C*      DOI - DATA ORDER INDICATOR                                TAPE0600
      C*      NDSPR - NO. OF DATA SETS PER RECORD                       TAPE0610
      C*      NCAR - NO  OF CHANNELS OF VIDEO DATA ON SAME RECORD       TAPE0620
      C*             WITH ANCILLARY DATA)                               TAPE0630
      C*      SVD - START OF VIDEO DATA. (BYTE POSITION WITHIN DATA FOR TAPE0640
      C*            A GIVEN CHANNEL)                                    TAPE0650
      C*                                                                TAPE0660
            DIMENSION BIT(11),NB(11),HWRD(11)                           TAPE0670
            DATA HWRD/23,23,23,24,20,397,21,24,395,397,21/              TAPE0680
            DATA BIT/32,16,24,4,28,32,0,20,32,16,8/                     TAPE0690
```

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```
      DATA NB/8,8,8,16,8,16,8,8,8,16,16/                                TAPE0700
      EQUIVALENCE (ID(1),NRPDS ),(ID(2),NCPR  ),                        TAPE0710
     *            (ID(3),NPRC  ),(ID(4),ANCLNG),                        TAPE0720
     *            (ID(5),NC    ),(ID(6),NS    ),                        TAPE0730
     *            (ID(7),NBITS ),(ID(8),DOI),                           TAPE0740
     *            (ID(9),NDSPR),(ID(10),NCAR ),                         TAPE0750
     *            (ID(11),SVD)                                          TAPE0760
      DATA IUNIT/3/                                                     TAPE0770
C*                                                                      TAPE0780
C*                                                                      TAPE0790
C*    ENTRY FOR READING HEADER INFORMATION                              TAPE0800
C*                                                                      TAPE0810
      ENTRY TAPHDR(DATAPE)
C*                                                                      TAPE0840
C*    INFORMATION IN EBCDIC OR IBM FLOATING PIONT IS NOT UNPACKED       TAPE0850
C*    FROM THE HEADER RECORD AT THIS TIME.                              TAPE0860
C*                                                                      TAPE0870
      IUNIT=DATAPE                                                      TAPE0880
      KBUF=680                                                          TAPE0890
C*                                                                      TAPE0900
      CALL NTRAN(IUNIT,10,22)
      CALL NTRAN(IUNIT,2,KBUF,IBUF,ISTAT,22)                            TAPE0910
      IF (ISTAT EQ 178) FORMAT = 2
      IF (ISTAT EQ. 680)  FORMAT = 1
 --> |IF (ISTAT NE 178 AND ISTAT.NE.680) FORMAT=3|
     |IF (FORMAT.EQ 3) GO TO 95                  |
      IF (ISTAT GT 0) GO TO 20                                          TAPE0920
   10 WRITE (6,280)                                                     TAPE0930
      WRITE(6,340)
      CALL CMERR                                                        TAPE0950
   20 IF (FORMAT EQ.1) GO TO 40                                         TAPE0960
      IF (FORMAT .NE 2)  GO TO 265
      CALL UNPAK1(IBUF)                                                 TAPE0970
      DO 30 I=1,6                                                       TAPE0980
   30 CALL UNPACK(ID (I),32)                                            TAPE0990
      NCS=NC*NS                                                         TAPE1020
      MAXREC=(NCS*8 + 32)/36 + 2                                        TAPE1030
      NRPDS=1                                                           TAPE1040
      NCAR=NC                                                           TAPE1050
      ANCLNG=4                                                          TAPE1060
      SVD=1                                                             TAPE1070
      NBITS=8                                                           TAPE1080
      DOI=0                                                             TAPE1090
      NCPR=0                                                            TAPE1100
      NDSPR=1                                                           TAPE1110
      NPRC = 0
      GO TO 100                                                         TAPE1120
C*                                                                      TAPE1130
C*    UNPACK NECESSARY INFORMATION FROM HEADER RECORD-UNIVERSAL FORMAT  TAPE1140
C*                                                                      TAPE1150
   40 DO 60 I=1,11                                                      TAPE1160
      IWD=HWRD(I)                                                       TAPE1170
      IF ((BIT(I)+NB(I)).LE.36) GO TO 50                                TAPE1180
      INB=36-BIT(I)                                                     TAPE1190
      KNB=NB(I)-INB                                                     TAPE1200
      ITEMP=FLD(BIT(I),INB,IBUF(IWD))                                   TAPE1210
      ID(I)=ITEMP*2**KNB + FLD(0,KNB,IBUF(IWD+1))                       TAPE1220
      GO TO 60                                                          TAPE1230
   50 CONTINUE                                                          TAPE1240
      ID(I)=FLD(BIT(I),NB(I),IBUF(IWD))                                 TAPE1250
   60 CONTINUE                                                          TAPE1260
      MAXREC=680                                                        TAPE1270
      IF (NRPDS LE.15) GO TO 70                                         TAPE1280
      WRITE (6,370)NRPDS                                                TAPE1290
      CALL CMERR                                                        TAPE1300
   70 IF (NPRC.LE 1) GO TO 80                                           TAPE1310
      WRITE (6,380)                                                     TAPE1320
      CALL CMERR                                                        TAPE1330
   80 CONTINUE                                                          TAPE1340
      IF(NDSPR LE.0)NDSPR=1                                             TAPE1350
      IF (NBITS EQ.8) GO TO 90                                          TAPE1360
      WRITE (6,390)NBITS                                                TAPE1370
      NBITS=8
```

```
   90 IF (DOI EQ 0) GO TO 100                                        TAPE1390
      WRITE (6,400)DOI                                               TAPE1400
      CALL CMERR                                                     TAPE1410
C*********************************************************************
C***SET PARAMETERS FOR GODDARD DATA TAPES
95    NC=4
      NS=810
      MAXREC=733
      NRPDS=1
      NDSPR=1
      CALL NTRAN(IUNIT,10,22,7,2,22)
      IFRST=0
C*********************************************************************
  100 CONTINUE                                                       TAPE1420
      KPTS=0                                                         TAPE1430
      IRD=0                                                          TAPE1440
      IF (FORMAT EQ 3) GO TO 120
C*                                                                   TAPE1450
C*    DATA SET LENGTH IN BYTES                                       TAPE1460
      DSL=ANCLNG+NS*NC                                               TAPE1470
C*                                                                   TAPE1480
C*    READ FIRST DATA SET TO DETERMINE FIRST SCAN LINE NUMBER        TAPE1490
C*                                                                   TAPE1500
      CALL BUFILL                                                    TAPE1510
      CALL NTRAN(IUNIT,22)                                           TAPE1520
      IF (IST(1).GT.0) GO TO 110                                     TAPE1530
      WRITE (6,350)IST(1)                                            TAPE1540
      WRITE (6,340)FRM(1,FORMAT),FRM(2,FORMAT)                       TAPE1550
      CALL CMERR                                                     TAPE1560
  110 IF(FORMAT EQ 1)IFRST=FLD(20,16,IBUF(16))                       TAPE1570
      IF(FORMAT.EQ.2)IFRST=FLD(0,16,IBUF(1))                         TAPE1580
      IF (IFRST GT.0) GO TO 120                                      TAPE1590
      WRITE (6,380)                                                  TAPE1600
      WRITE (6,340)FRM(1,FORMAT),FRM(2,FORMAT)                       TAPE1610
      CALL CMERR                                                     TAPE1620
  120 FSCAN=IFRST                                                    TAPE1630
      RETURN                                                         TAPE1640
C*                                                                   TAPE1650
C*    ENTRY FOR POSITIONING TAPE TO CORRECT SCAN LINE FOR A SPECIFIC FIETAPE1660
C*                                                                   TAPE1670
      ENTRY FLDINT(BLOCK,FETVEC,NOFEAT)                              TAPE1680
      DIMENSION BLOCK(6)                                             TAPE1690
      DIMENSION FETVEC(NOFEAT)                                       TAPE1700
      ENDTAP = 0
      READY = .TRUE.                                                 TAPE1710
C*    CHECK FETVEC
      DO 125 I=1,NOFEAT
  125 IF(FETVEC(I) GT.NC)GO TO 126
      GO TO 127
  126 WRITE(5,470) NC
      NOFEAT=I-1
      IF(NOFEAT LE.0)CALL CMERR
  127 CONTINUE
      LINSTR=BLOCK(1)                                                TAPE1720
      IF (LINSTR GE IFRST) GO TO 130                                 TAPE1730
      WRITE(6,430)IFRST
      LINSTR=IFRST                                                   TAPE1740
      BLOCK(1)=IFRST                                                 TAPE1750
  130 CONTINUE                                                       TAPE1760
      IF(BLOCK(2) GE.IFRST)GO TO 132
      WRITE(6,430)IFRST
      BLOCK(2)=IFRST
  132 CONTINUE
      FLINE=FIRST SCAN ON RECORD CONTAINING LINSTR                   TAPE1770
      FLINE=LINSTR-MOD((LINSTR-IFRST),NDSPR)                         TAPE1780
      LSKIP=((FLINE-FSCAN)/NDSPR-1)*NRPDS                            TAPE1790
      IF (LSKIP) 135,138,138
  135 FSKIP = ((BLOCK(1) - IFRST) / NDSPR ) * NRPDS + 1
      IF (FSKIP  GE  IABS(LSKIP))  GO TO 138
      CALL NTRAN(IUNIT,22,10,22)
      CALL NTRAN(IUNIT,7,FSKIP,22)
      GO TO 139
C*                                                                   TAPE1800
```

```
C*    SKIP DOWN THE TAPE TO BEGINNING LINE OF THIS FIELD.                TAPE1810
C*    AND INITIATE READ FOR FIRST DATA SET                               TAPE1820
C*                                                                       TAPE1830
  138 IF (FSCAN EQ FLINE) GO TO 140                                      TAPE1840
      CALL NTRAN(IUNIT,7,LSKIP,22)
  139 CALL BUFILL                                                        TAPE1860
      FSCAN=FLINE                                                        TAPE1870
  140 CON TINUE                                                          TAPE1880
      NSCAN=LINSTR                                                       TAPE1890
      IF(BLOCK(5) LE NS)GO TO 145
      WRITE(6,440) NS
      BLOCK(5)=NS
  145 IF(BLOCK(4) LE.NS)GO TO 146
      WRITE(6,440) NS
      BLOCK(4)=NS
  146 CONTINUE
      LINEND=BLOCK(2)                                                    TAPE1910
      LININC=BLOCK(3)                                                    TAPE1920
      SAMSTR=BLOCK(4)                                                    TAPE1930
      SAMEND=BLOCK(5)                                                    TAPE1940
      SAMINC=BLOCK(6)                                                    TAPE1950
C*    LINC= NO OF RECORDS TO SKIP AFTER EACH SCCAN LINE                  TAPE1960
      LINC=(LININC/NOSPR - 1)*NRPDS                                      TAPE1970
      IF(LINC LT 0)LINC=0                                                TAPE1980
      IF (FORMAT.EQ.3) GO TO 195
C*                                                                       TAPE1990
C*    ESTABLISH AREAS ON EACH SCAN LINE TO UNPACK                        TAPE2000
C*                                                                       TAPE2010
      ANC=ANCLNS + SAMSTR + SVD - 1                                      TAPE2020
      IF(FORMAT EQ 1)ANC=ANC+2                                           TAPE2030
      FC=1                                                               TAPE2040
      LC=NCAR                                                            TAPE2050
      K=1                                                                TAPE2060
      DO 190 I=1,NOFFAT                                                  TAPE2070
      DO 170 IREC=K,NRPDS                                                TAPE2080
      IF(IREC.GT.1)ANC=2 + SAMSTR + SVD - 1                              TAPE2090
      IF (FETVEC(I).GE FC.AND.FETVEC(I) LE LC) GO TO 150                 TAPE2100
      IF (FETVEC(I).GT LC.AND.IREC.LT NRPDS) GO TO 160                   TAPE2110
      WRITE (6,380)FETVEC(I)                                             TAPE2120
      CALL CMERR                                                         TAPE2130
  150 IBYTE(I)=(FETVEC(I)-FC)*NS + ANC                                   TAPE2140
      JREC(I)=IREC                                                       TAPE2150
      GO TO 180                                                          TAPE2160
  160 FC=LC+1                                                            TAPE2170
      LC=LC+NCPR                                                         TAPE2180
  170 CONTINUE                                                           TAPE2190
  180 K=IREC                                                             TAPE2200
  190 CONTI NUE                                                          TAPE2210
C*                                                                       TAPE2220
C*    NSAMP - NO. OF SAMPLES TO UNPACK FOR EACH FEATURE IN FETVEC        TAPE2230
C*                                                                       TAPE2240
195   NSAMP = (SAMEND - SAMSTR) / SAMINC + 1
      RETURN                                                             TAPE2260
C*                                                                       TAPE2270
C*                                                                       TAPE2280
C*    ENTRY FOR READING AND UNPACKING ONE SCAN LINE OF DATA              TAPE2290
C*                                                                       TAPE2300
      ENTRY LINERD(IDATA,ENDTAP)
      DIMENSION IDATA(1)                                                 TAPE2320
      IF (READY) GO TO 200                                               TAPE2330
      WRITE (6,410)                                                      TAPE2340
C*******************************************************************
C***UNPACK GODDARD DATA TAPE
200   IF (FORMAT.NE 3) GO TO 205
      CALL UNPKIT(IBUF,ISCAN)
      K=0
      DO 202 I=1,NOFFAT
      DO 202 J=SAMSTR,SAMEND,SAMINC
      K=K+1
      JJ=J+(FETVEC(I)-1)*810
202   IDATA(K)=ISCAN(JJ)
      GO TO 235
C*******************************************************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

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C*                                                                      TAPE2350
  205 IADR=1                                                            TAPE2360
      ADD = (NSCAN-FSCAN)*DSL                                           TAPE2370
      STOBIT = (36 - NBITS) + 1
      SKPBIT = STOBIT - 1
      INCBIT = IABS( (SAMINC - 1) * NBITS)
      DO 230 IFT=1, NOFLAT                                              TAPE2380
      J=JREC(IFT)                                                       TAPE2390
      JJ=(J-1)*MAXREC + 1                                               TAPE2400
C*                                                                      TAPE2410
C*    CHECK STATUS OF THIS RECORD BEFORE UNPACKING                      TAPE2420
C*                                                                      TAPE2430
  210 IF (IST(J) GE 0) GO TO 220                                        TAPE2440
      IF(IST(J) GE -1)GO TO 210
      IF(IST(J) EQ -2)GO TO 250
      WRITE (6,290)                                                     TAPE2470
      WRITE (6,310)NSCAN,IST(J)                                         TAPE2480
      WRITE(6,340)
      GO TO 250                                                         TAPE2500
C*                                                                      TAPE2510
C*    UNPACK DATA FOR THIS FEATURE                                      TAPE2520
C*                                                                      TAPE2530
  220 IP = ADD + IBYTE(IFT) - 1
      IBIT = MOD( (IP*NBITS), 36) + 1
      BEGWRD = (IP* NBITS) / 36 + JJ
      CALL BYTRAN(IBIT,IBUF(BEGWRD),INCBIT,NSAMP,NBITS,STOBIT,IDATA(IADR
     *),SKPBIT)
      IADR=IADR+ NSAMP                                                  TAPE2560
  230 CONTINUE                                                          TAPE2570
C*    FINISHED UNPACKING ONE SCAN LINE OF DATA                          TAPE2580
 235  IF ((NSCAN+LININC) GT.LINEND) GO TO 260                           TAPE2590
      NSCAN= NSCAN+LININC                                               TAPE2600
      IF(NSCAN LT (FSCAN+NDSPR))RETURN                                  TAPE2610
      FSCAN=FSCAN + NDSPR*(1 - LINC/NRPDS)                              TAPE2620
      CALL NTRAN(IUNIT,7,LINC,22)
      IF (NSCAN LT.(FSCAN+NDSPR)) GO TO 240                             TAPE2640
      CALL NTRAN(IUNIT,7,1,22)
      FSCAN=FSCAN+ NDSPR                                                TAPE2660
  240 CONTINUE                                                          TAPE2670
C*                                                                      TAPE2680
C*       INITIATE READ FOR NEXT SCAN                                    TAPE2690
C*                                                                      TAPE2700
      CALL BUFILL                                                       TAPE2710
      RETURN                                                            TAPE2720
C*                                                                      TAPE2730
C*    END OF DATA                                                       TAPE2740
C*                                                                      TAPE2750
  250 IF(NSCAN GT.LINSTR)NSCAN=NSCAN-LININC                             TAPE2760
      BLOCK(2)=NSCAN                                                    TAPE27??
      WRITE (6,320)NSCAN                                                TAPE27??
      ENDTAP = -1
C*                                                                      TAPE2790
C*    REWIND TAPE AND POSITION AT FIRST SCAN LINE                       TAPE2800
C*                                                                      TAPE2810
      CALL NTRAN(IUNIT,22,10,22)                                        TAPE2820
      CALL NTRAN(IUNIT,7,1,22)
-->   IF (FORMAT EQ.3) CALL NTRAN(IUNIT,22,7,1,22)
      FSCAN=IFRST                                                       TAPE2840
      CALL BUFILL                                                       TAPE2850
  260 READY= FALSE                                                      TAPE2860
      RETURN                                                            TAPE2870
  265 WRITE(6,340)
      WRITE(6,420) ISTAT
      CALL OVERR
  270 FORMAT(' END-OF-FILE ENCOUNTERED ON HEADER RECORD')               TAPE2880
  280 FORMAT(' UNRECOVERABLE ERROR READING HEADER RECORD')              TAPE2890
  290 FORMAT(' ERROR WHILE READING DATA RECORD')                        TAPE2900
  300 FORMAT(' A LINE NO  IS LESS THAN OR EQUAL ZERO')                  TAPE2910
  310 FORMAT(' LAST SCAN LINE READ',I5,' ISTAT=',I5)                    TAPE2920
  320 FORMAT(' FIELD BOUNDARY FOR THIS FIELD DEFINED BEYOND SCOPE  OF DATAPE2930
     *TA'/' THIS FLIGHT LINE CONTAINS',I6,' SCAN LINES')                TAPE2940
  330 FORMAT(/' INTERNAL DIMENSIONS TOO SMALL FOR DATA'/' NO. OF CHANNELTAPE2950
     *S ON DATA TAPE=',I7,' NO  OF POINTS/CHANNEL=',I7/)                TAPE2960
```

```
      340 FORMAT(' CHECK THE FOLLOWING POSSIBLE ERRORS'/' 1  DATA TAPE IS NO
         *T IN UNIVERSAL OR LARSYS FORMAT'/
         *' 2  IF DATA TAPE IS 9-TRACK, THE -ASG- CARD SHOULD HAVE AN -N- OPTAPE3000
         *TION'/4X,'AND A MESSAGE TO OPERATOR SHOULD BE ON 588 FORM'/        TAPE3010
         *' 3  IF THE DATA TAPE WAS GENERATED ON A MACHINE OTHER THAN THE 11TAPE3020
         *08'/4X,'THE -ASG- CARD SHOULD HAVE AN -A- OPTION')                  TAPE3030
      350 FORMAT(' ERROR READING FIRST DATA RECORD--ISTAT=',I3)              TAPE3040
      360 FORMAT(' ONLY ONE OR LESS RECORDS PER CHANNEL ACCEPTABLE AT THIS TTAPE3050
         *IME')                                                              TAPE3060
      370 FORMAT(' NO  OF RECORDS PER DATA SET=',I5,' MUST BE LESS THAN OR ETAPE3070
         *QUAL 15')                                                          TAPE3080
      380 FORMAT(' FEATURE NUMBERS' I5,' AND ABOVE ARE NOT ON DATA TAPE'/   TAPE3090
         *)                                                                  TAPE3100
      390 FORMAT(' NO  OF BITS/PIXEL=',I5,' ONLY 8 BITS ACCEPTABLE AT THIS TTAPE3110
         *IME')                                                              TAPE3120
      400 FORMAT(' DATA ORDER INDICATOR=',I5/' DATA MUST BE ORDERED BY PIXELTAPE3130
         *')                                                                 TAPE3140
      410 FORMAT(' FLDINT MUST BE CALLED TO INITIALIZE PARAMETERS FOR A NEW TAPE3150
         *FIELD')                                                            TAPE3160
      420 FORMAT('  LENGTH OF HEADER RECORD IS', I5)
      430 FORMAT(' FIRST SCAN ON THIS TAPE IS NUMBERED',I6,' FIELD DEFINITIO
         *N IN ERROR')
      440 FORMAT(' NUMBER OF SAMPLES OF PER SCAN ON THIS TAPE IS',I6,' FIELD
         * DEFINITION IN ERROR')
      470 FORMAT(' THIS TAPE CONTAINS ONLY',I6,' CHANNELS')
C*                                                                          TAPE3170
C*      INTERNAL ROUTINE TO INITIATE READS FOR ONE SCAN LINE)               TAPE3180
        SUBROUTINE BUFILL                                                   TAPE3190
        CALL NTRAN(IUNIT,22)                                                TAPE3200
        K=1                                                                 TAPE3210
        DO 310 I=1,NRPDS                                                    TAPE3220
        CALL NTRAN(IUNIT,2,MAXREC,IBUF(K),IST(I),22)
        K=K+MAXREC                                                          TAPE3240
  310   CONTINUE                                                            TAPE3250
        RETURN                                                              TAPE3260
        END                                                                 TAPE3270
```

APPENDIX E

TABLES OF WEATHER DATA AVAILABLE AT THE TEXAS WATER DEVELOPMENT BOARD FOR TEST SITE 3, SAN ANTONIO BAY AREA

TABLE 1

TNRIS
TEXAS WATER ORIENTED DATA BANK

NWS PRECIPITATION
FOR
ID NUMBER 00009364

LOCATION, VICTORIA WB AP YEAR = 1972
LAT: 28 51 00 LONG: 96 55 00 BASIN: 17 COUNTY: VICTORIA

DAY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.03	TRACE	TRACE	0.00	0.00	0.00	0.00	0.00	TRACE	0.00	0.14	0.00
2	0.00	0.00	0.00	0 00	0.12	0.22	0.00	1.20	0.00	0.00	0.00	0.00
3	TRACE	0.00	0.00	0 00	0.03	0.00	0.00	2.66	0.00	0.00	0.15	0.00
4	0.20	0.00	0.00	0 00	0.00	0.27	0.34	0.00	0.00	0.00	0.00	TRACE
5	0.00	0 02	0.00	0 00	0.10	0.00	TRACE	0.00	0.00	TRACE	TRACE	0.01
6	0.00	0.06	0.00	0 00	1.02	0.00	0.00	0.00	TRACE	0.00	0.25	0.01
7	0.00	0.00	TRACE	0 00	7.49	0.00	0.00	TRACE	0.00	0.00	0.00	0.01
8	TRACE	0.00	0.01	0 00	TRACE	0.03	0.22	0.00	0.00	0.00	0.00	0.01
9	0.00	0 00	0.00	TRACE	0 00	0.01	0.26	0.00	0.00	0.00	0.00	0.03
10	0.01	0 03	0.00	0 00	1.65	1.07	0.67	0.40	0.00	0.00	0.00	0.16
11	0.00	0.36	0.00	0 00	0.01	0.09	0.26	0.01	0.02	0.00	0.03	TRACE
12	0.00	0.00	TRACE	0.00	0.23	0.00	0.67	0.00	0.00	TRACE	0.03	0.04
13	0 00	0 00	0.28	0 00	TRACE	1.08	0.07	0.00	0.00	0.00	0.76	0.00
14	0.00	0 00	0.02	0.00	0.40	TRACE	0.00	TRACE	0.16	0.00	0.00	0.09
15	0.00	0 00	0.27	TRACE	0.18	TRACE	0.04	TRACE	0.15	0.00	0.00	0.00
16	0.00	0.00	0.00	0 00	0.04	0.39	1.11	0.06	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.01	1.02	0.00	0.08	0.00	0.03	0.00
18	TRACE	0.00	0.00	0.00	0.00	0.00	0.75	TRACE	TRACE	0.00	0.35	TRACE
19	TRACE	0.00	0.00	0 00	0.00	0.00	TRACE	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.97	0 00	0.00	0.00	1.70	0.00	0.00	0.00	0.00	TRACE
21	TRACE	0.00	0.00	TRACE	0.00	0.00	TRACE	TRACE	TRACE	0.51	0.05	0.00
22	0.00	0 00	0 00	0.00	0.00	0.00	0.13	0.00	0.10	0.05	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	TRACE	0.05	0.00
24	TRACE	0.00	0.00	0 00	0.00	0 00	TRACE	TRACE	2.05	0.02	0.35	0.30
25	0.00	0.00	TRACE	0.00	0.00	0.00	TRACE	TRACE	0.94	TRACE	0.00	0.00
26	0.02	0.00	TRACE	0.02	0.00	0.00	0.00	0.00	1.80	0.01	0.00	0.00
27	0.00	0.00	TRACE	0.33	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00
28	TRACE	TRACE	0.00	TRACE	0.00	0.00	TRACE	0.05	0.00	TRACE	0.00	TRACE
29	0.04	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.07	2.85	TRACE	TRACE
30	1.41	-	0.00	0.00	0.00	0.00	0.04	0.00	0.13	0.00	0.00	TRACE
31	0.03	-	0.00	-	TRACE	-	0.00	0.00	-	TRACE	-	0.00
MONTHLY TOTAL	1.74	0.72	1.55	0.35	11.24	3.17	7.30	4.38	5.97	3.44	2.19	0.36

ANNUAL
TOTAL FOR 1972 = 42.41

39-E-1

C 1/2

ORIGINAL PAGE IS
OF POOR QUALITY

39-E-2

TABLE 2

TNRIS

T E X A S   W A T E R   O R I E N T E D   D A T A   B A N K

09/02/75 — NWS PRECIPITATION FOR ID NUMBER 00007140 — PAGE . 001

LOCATION: POINT COMFORT — YEAR = 1972

LAT: 28 40 00 LONG: 96 33 00 BASIN: 15 COUNTY: CALHOUN

DAY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	1.00	0.13	0.00	0.00	TRACE	0.00	0.00	0.00	0.00	0.00	0.08	0.00
2	TRACE	0.00	0.00	0.00	0.13	0.26	0.00	0.24	0.06	0.00	TRACE	0.00
3	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.54	0.00	0.00	1.70	0.00
4	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.31	0.00
5	0.00	0.02	0.00	0.00	0.00	0.00	0.58	0.00	TRACE	0.00	0.00	0.00
6	0.00	0.10	0.00	0.00	0.24	0.00	0.00	0.00	TRACE	0.00	0.07	0.00
7	0.00	0.00	0.00	0.00	7.30	0.00	0.00	0.00	0.00	0.00	0.00	0.10
8	TRACE	0.00	0.03	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01
9	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.01
10	TRACE	0.00	0.00	0.00	1.30	1.35	1.45	0.61	0.00	0.30	0.00	0.03
11	0.00	0.50	0.00	0.00	0.30	0.36	0.00	0.00	0.00	0.23	0.12	0.01
12	0.00	0.24	0.00	0.00	1.01	0.00	0.13	0.00	0.00	0.03	0.01	0.02
13	0.00	0.00	0.00	0.00	0.00	TRACE	TRACE	0.00	0.05	TRACE	0.92	0.00
14	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.58	0.00	0.00	0.08
15	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.02	0.00	TRACE	TRACE
16	0.00	0.00	0.22	0.00	0.00	2.17	0.13	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.80	0.34	1.37	0.12	0.00	0.00	TRACE	0.00
18	0.16	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.52	TRACE
19	TRACE	0.00	0.00	0.00	0.00	0.00	0.08	0.73	0.00	0.00	0.00	0.00
20	TRACE	0.00	TRACE	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00
21	TRACE	0.00	0.62	0.02	0.00	0.00	0.38	0.00	0.00	1.20	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	2.20	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	1.31	0.11	0.46	0.00
25	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	3.50	0.05	0.03	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.02	0.00	0.00
27	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
28	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.10	0.03	0.00	0.00	0.00
29	0.00	0.45	0.00	0.00	0.00	0.00	0.00	TRACE	0.00	5.06	0.00	0.00
30	2.24	-	TRACE	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00
31	0.19	-	0.00	-	0.01	-	0.00	0.00	-	0.00	-	0.00
MONTHLY TOTAL	3.72	1.44	0.88	2.35	11.49	4.52	5.40	4.36	6.64	8.90	4.45	0.26

ANNUAL TOTAL FOR 1972 = 54.41

TABLE 3

TNRIS
T E X A S W A T E R O R I E N T E D D A T A B A N K

09/02/75 NWS PRECIPITATION FOR ID NUMBER 00007186

LOCATION: PORT O'CONNER YEAR = 1972
LAT: 28 26 00 LONG' 96 24 00 BASIN' 17 COUNTY: CALHOUN

39-E-3

DAY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.50	0.30	0.19	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
2	0.-5	0.02	0.02	0.00	0.13	TRACE	0.00	0.31	0.00	0.00	0.00	0.00
3	TRACE	0.00	0.00	0 00	1.17	0 05	0.00	0.28	0.00	0.00	0.15	TRACE
4	TRACE	0.00	0.00	0.00	0.00	TRACE	0.00	1.40	0.00	0.00	0.65	0.00
5	TRACE	0 00	0.00	0 15	0.00	0.00	TRACE	0.00	0.00	0.00	TRACE	TRACE
6	0.00	0.10	0.00	0.00	0.10	0 00	0.00	0.00	0.00	0.00	0.00	TRACE
7	0.00	0.05	0.00	0 00	0.20	0.00	0.00	0.00	0.00	0.00	TRACE	0.00
8	0.05	0 00	0.00	0 00	1.65	TRACE	0.00	0.00	0.00	0.00	0.00	0.05
9	0.00	0.00	0.45	0.00	TRACE	0.07	0.35	0.00	0.00	0.00	0.00	TRACE
10	0.00	0.00	0.01	0.00	TRACE	0.35	0.00	0.00	0.00	0.00	0.03	0.03
11	0.02	0.28	0.00	0 00	0.82	0.08	0.00	1.12	0.00	0.00	0.00	TRACE
12	0 00	0 10	0.00	0.00	TRACE	0.00	TRACE	0.00	0.10	0.27	0.18	0.03
13	0.00	0.02	0 00	0 00	0.68	0.00	0.13	0.00	0.35	0.00	0.82	0.03
14	0.02	TRACE	0.00	0.00	0.35	0 00	0.00	0.00	0.96	0.00	0.03	0.05
15	0.00	TRACE	0.03	0 00	0.20	0.00	0.00	0.00	1.57	0.00	0.00	0.07
16	0.00	TRACE	0.05	0 00	0.00	0.08	0.22	0.00	0.03	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0 05	1.06	0.00	0.03	0.00	0.00	0.00
18	0.25	0.00	0.00	0 00	0.00	0.00	0.09	0.00	0.00	0.00	1.82	0.00
19	TRACE	0.00	0.00	0 00	0.00	0.00	0.05	TRACE	0.00	0.00	0.75	TRACE
20	TRACE	0.00	0.00	0.00	0.00	0.00	0.11	0.02	0.00	0.00	0.00	0.05
21	TRACE	0.00	0.10	0.00	0.00	0.00	0.04	0.00	0.25	2.34	0.00	0.02
22	0.02	TRACE	0.00	0.18	0.00	0.00	0.75	0.00	0.03	1.30	0.25	0.00
23	TRACE	0.00	0.00	0 00	0.00	0 00	0.60	0.00	1.01	4.36	0.05	TRACE
24	0.00	0.00	0.00	0 00	0.00	0.00	0.16	0.00	2.20	0.03	0.18	0.00
25	0.00	TRACE	0.01	0.00	0.00	0.00	0.00	0.00	2.16	0.00	0.75	0.00
26	TRACE	0.01	TRACE	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00
27	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.68	TRACE	0.00	0.00
28	TRACE	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
29	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60	0.00	0.00
30	1.15	-	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.13	0.00	TRACE
31	0.45	-	0.00	-	TRACE	-	TRACE	0.00	-	0.00	-	0.00
MONTHLY TOTAL	3.52	2.29	0.88	1.10	5.50	0.68	3.56	3.33	10.04	12.03	5.66	0.33

ANNUAL TOTAL FOR 1972 = 48.92

TABLE 4

TNRIS

T E X A S   W A T E R   O R I E N T E D   D A T A   B A N K

09/02/75

NWS PRECIPITATION
FOR
ID NUMBER 00007529

LOCATION REFUGIO
LAT: 28 18 00 LONG: 97 17 00 BASIN: 20 COUNTY: REFUGIO

YEAR = 1972

DAY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.05	0.07	0.00	0.00	TRACE	0.00	0.00	0.00	0.05	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.20	0.71	0.00	0.92	0.54	0.00	TRACE	0.00
3	0.03	0.00	0.00	0.00	0.00	TRACE	0.00	2.86	0.00	0.00	0.33	0.00
4	0.10	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	TRACE	TRACE
5	TRACE	TRACE	0.00	0.00	TRACE	0.00	0.12	0.00	0.00	0.00	0.00	0.04
6	0.00	0.02	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00	0.05	TRACE
7	0.00	0.00	0.02	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.03	0.00	TRACE	0.00	TRACE	0.74	0.00	0.05	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.05
10	0.02	TRACE	TRACE	0.03	1.53	0.10	TRACE	0.04	0.00	0.00	0.00	0.07
11	0.00	0.38	0.00	0.00	0.06	0.94	TRACE	TRACE	TRACE	TRACE	0.12	0.04
12	0.00	0.05	0.00	0.00	1.04	0.00	0.30	0.27	0.38	0.00	TRACE	0.07
13	0.00	0.00	0.00	0.00	0.05	TRACE	0.20	0.46	0.10	0.00	0.80	0.00
14	0.00	0.00	TRACE	0.00	0.44	0.02	0.00	0.00	0.57	0.00	0.00	0.05
15	0.00	0.00	0.11	TRACE	0.06	0.12	0.03	0.00	0.21	0.00	0.00	TRACE
16	0.00	0.00	0.78	0.00	0.08	1.00	1.60	0.00	0.00	0.00	0.00	0.00
17	TRACE	0.00	0.00	0.00	0.90	0.00	0.45	0.00	0.00	0.00	TRACE	0.00
18	0.04	0.00	0.00	0.00	0.00	0.00	TRACE	0.00	0.00	0.00	TRACE	0.03
19	TRACE	0.00	0.00	0.00	0.00	0.00	0.09	0.39	0.00	TRACE	0.00	0.00
20	TRACE	0.00	TRACE	0.00	0.00	0.00	TRACE	0.00	0.12	TRACE	0.00	TRACE
21	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.53	0.66	0.26	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	TRACE	0.00	TRACE	0.13	TRACE	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.25	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	2.03	0.02	0.58	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	TRACE	0.03	0.00	0.00
26	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	TRACE	0.00	0.00
27	0.00	0.00	0.00	3.39	0.00	0.00	0.00	TRACE	1.52	0.00	0.00	0.00
28	TRACE	0.00	0.00	0.06	0.00	0.00	0.03	0.00	0.00	TRACE	0.00	0.00
29	TRACE	0.97	0.00	TRACE	0.00	0.00	0.00	TRACE	TRACE	0.46	0.02	TRACE
30	1.54	-	0.02	TRACE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.40	-	0.00	-	TRACE	-	0.00	0.00	-	0.00	-	0.00
MONTHLY TOTAL	2.26	1.49	0.93	3.48	10.10	3.76	4.09	4.99	6.40	1.30	2.41	0.35

ANNUAL
TOTAL   FOR 1972 =   41.56

39-E-4

TABLE 5

TNRIS

TEXAS WATER ORIENTED DATA BANK

09/02/75 — NWS PRECIPITATION FOR ID NUMBER 00007704 — PAGE : 004

LOCATION: ROCKPORT — YEAR = 1972

LAT: 28 01 00 LONG: 97 03 00 BASIN: 20 COUNTY: ARANSAS

39-E-5

DAY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.06	0.21	TRACE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
2	0.00	0.00	0.00	0.00	0.93	TRACE	0.00	0.37	3.01	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.03	0.00	0.00	3.13	0.00	0.00	0.66	0.00
4	0.02	0.00	0.00	0.00	0.00	TRACE	0.00	0.00	0.00	0.00	0.05	TRACE
5	0.00	TRACE	0.00	TRACE	0.01	0.00	0.23	0.00	0.00	0.00	0.00	0.00
6	0.00	TRACE	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.35	0.02
7	0.00	0.00	TRACE	0.00	4.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	TRACE	0.08	0.00	TRACE	1.68	0.07	0.00	0.00	0.00	0.00	TRACE
9	0.00	0.00	0.00	0.00	0.00	0.18	0.87	0.00	0.00	0.00	0.00	TRACE
10	0.13	TRACE	0.00	0.00	1.46	0.32	0.00	0.14	0.00	0.00	0.00	0.03
11	0.00	0.58	0.00	0.00	0.05	0.50	0.00	0.06	0.08	TRACE	0.32	0.02
12	0.00	0.05	TRACE	0.00	0.51	0.00	0.10	0.00	0.07	0.00	0.00	0.04
13	0.00	0.00	TRACE	0.00	0.34	0.00	TRACE	0.00	0.36	0.00	0.78	0.00
14	0.00	0.00	0.04	0.00	0.06	TRACE	0.00	0.00	0.09	0.00	0.00	0.04
15	0.00	0.00	0.00	TRACE	0.26	0.48	0.00	0.00	0.65	0.00	0.00	0.00
16	0.00	0.00	0.56	0.00	TRACE	2.13	1.18	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.06	0.37	1.03	0.00	0.00	0.00	TRACE	0.00
18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02
19	TRACE	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.47	0.00	0.00
20	0.00	0.00	TRACE	0.00	0.00	0.00	0.02	0.00	0.00	0.19	0.00	TRACE
21	0.00	0.00	0.00	0.08	0.00	0.00	0.15	0.00	0.00	0.38	0.42	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.06	0.04	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.15	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	TRACE	2.97	0.04	0.52	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16	0.00	0.07	0.00
26	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.00
27	0.00	0.00	0.00	4.27	0.00	0.00	0.00	0.00	1.98	0.00	0.00	0.00
28	0.04	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
29	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00
30	1.21	-	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	TRACE
31	0.19	-	0.00	-	TRACE	-	0.00	0.00	-	0.00	-	0.00
MONTHLY TOTAL	1.73	2.04	0.68	4.43	7.83	5.66	4.41	3.75	11.53	1.19	3.54	0.17

ANNUAL TOTAL FOR 1972 = 46.96

APPENDIX F

MERGE PROGRAM

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DB0200-02*LANDSAT MERGE
      C***THIS PROGRAM WILL MERGE SECTIONS OF TWO LANDSAT DATA TAPES
      C***CARD INPUT
      C***   CARD 1 STARTING LINE, ENDING LINE, BEGINING SAMPLE
      C***   CARD 2 ID FOR SECOND TAPE
      C***
            DIMENSION IBUF(733),JBUF(733)/733*0/,
           *CARD(5)/'PASS,BOTH 10.,16N,        .     '/
      C***COPY HEADER RECORD FROM FIRST TAPE
            CALL NTRAN(10,10,2,9,IBUF,ISTAT,22)
            CALL NTRAN(13,10,1,9,IBUF,ISTAT,22)
            CALL NTRAN(10,2,139,IBUF,ISTAT,22)
            CALL NTRAN(13,1,139,IBUF,ISTAT,22)
      C***READ CONTROL CARD AND ESTABLISH LINE AND SAMPLE LIMITS
            READ(5,100) LINE1,LINE2,NSAM
      100   FORMAT()
            MOVE=LINE1+1
            CALL NTRAN(10,10,7,MOVE,22)
            LAST=LINE2-LINE1+1
            ISTART=NSAM-MOD(NSAM-1,18)
            WRITE(6,200) ISTART
      200   FORMAT(' THE FIRST SAMPLE NUMBER FROM TAPE 1 IS ',I4)
            ISTART=ISTART-(ISTART/18)*2
            NPIX=720-ISTART+1
      C***COPY SECTION OF FIRST TAPE
            DO 20 I=1,LAST
            CALL NTRAN(10,2,733,IBUF,ISTAT,22)
            K=0
            DO 10 J=ISTART,720
            K=K+1
      10    JBUF(K)=IBUF(J)
      20    CALL NTRAN(11,1,NPIX,JBUF ISTAT,22)
      C***CHANGE TAPES
            CALL NTRAN(11,10,22)
            CALL EQUIP('FREE,S 10.  .  ')
            READ(5,300) TAPE
      300   FORMAT(A6)
            CARD(4)=TAPE
            CALL EQUIP(CARD)
            CALL NTRAN(10,10,7,MOVE 22)
      C***COPY SECTION OF SECOND TAPE
            DO 40 I=1,LAST
            CALL NTRAN(11,2,NPIX,JBUF,ISTAT,22)
            CALL NTRAN(10,2,733,IBUF,ISTAT,22)
            K=NPIX
            JJ=ISTART-1
            DO 30 J=1,JJ
            K=K+1
      30    JBUF(K)=IBUF(J)
      40    CALL NTRAN(13,1,733,JBUF,ISTAT,22)
            CALL NTRAN(13,9,22)
            STOP
            END
```

JURKPT PRINTS

APPENDIX G

AN ANALYSIS OF COST-BENEFIT APPROACHES SUITABLE FOR LANDSAT INVESTIGATION #23790

prepared by Koren Sherrill

TABLE OF CONTENTS

1 0 A COST-BENEFIT STRATEGY FOR THE EVALUATION OF LANDSAT-DERIVED INFORMATION PRODUCTS

1 1 Some Preliminary Considerations

Cost-benefit analysis is inherently controversial[1] Both the theory and the empirical methods used in cost-benefit estimates rest on assumptions that may or may not be acceptable to the policy-maker The theoretical foundations of cost-benefit analysis are derived from welfare economics, which is in itself a highly controversial area of analysis within the economics profession Empirically, cost-benefit analyses are attempts, not always explicitly stated, to simulate the market equilibrium positions of hypothetical demand and supply curves of the good (product or service) being analyzed If it is possible to estimate the nature of the demand and supply curves of the good in question, and if the analyst can simulate the various market equilibrium positions of the various demand and supply curves, then he is able to estimate the changes in either the demand or supply curves

The difficulties of estimating the nature of these relationships are often insurmountable, and the issues involved in cost-benefit analysis are often hard to resolve from the perspective of policy decisions For example, the concept of consumers' surplus is

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[1]An excellent discussion of the cost-benefit methodology can be found in E J. Mishan, Cost-Benefit Analysis An Introduction (New York Praeger Publishers, 1971)

at the heart of cost-benefit analysis This concept may be dear to some academicians, but it often offers little in the way of guidelines for implementing policy

Recognition of the controversial aspects of cost-benefit analysis should not, however, be construed as a renunciation of the usefulness of this type of analysis for certain areas of policy evaluation One leading economic theorist has stated that "the application of cost-benefit analysis to the determination of expenditure policy has proved of great practical value in applying efficiency considerations to expenditure decisions "[2] Ultimately, the important issues in program evaluation are whether existing programs are the most efficacious ways to obtain the benefits "[3] And the cost-benefit methodology can often provide a means by which the analyst can give a rough approximation of whether costs are indeed justified by benefits received

Given the controversial nature of cost-benefit analysis, it is necessary for this investigation to state at the outset some of the less obvious assumptions which will be made throughout the course of the evaluation, and to distinguish these from assumptions which will not be made and tasks which will not be undertaken First of all, it is assumed that the distribution of income is given (constant at time of analysis). Costs and benefits

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[2]Richard A Musgrave, "Cost-Benefit Analysis and the Theory of Public Finance," Journal of Economic Literature, September, 1969, pp. 797-806, at p 799.

[3]American Economic Review, June, 1975, pp at p. 266

will not be analyzed with respect to their impacts on the distribution of income among individuals in society A corollary of this assumption is that the implications of potential changes in social welfare from developing this technology will not be explored in this investigation

Secondly, it is assumed that price is a measure of social value This assumption is necessary since the evaluation will be structured around the measurement of price The opportunity costs of deploying resources in the development of an operational remote-sensing technology in the state will not be analyzed since this would lead into an evaluation of the efficacy of the distribution of public expenditures The sine qua non of the theoretical foundation of cost-benefit analyses is the concept of opportunity cost Since every choice of an alternative excludes other alternatives that might have been chosen, the true "cost" of the alternative chosen is measured by the benefits that are foregone by the exclusion of the second "best" or second most desirable alternative Thus, the opportunity cost of a project such as the LANDSAT project is the benefits that are lost to society as a result of allocating resources to this project rather than to some other project, but an evaluation of the nature of foregone benefits would be a difficult and lengthy task

To the extent that remote by sensed data can be used to generate "newer" and "better" information, this newer and better information will enhance understanding of the environmental and ecological processes along the coastal areas of the state An knowledge of natural processes along the coast could affect coastal management goals and objectives, whether explicitly or implicitly The availability of newer and better information, along with the enhanced understanding of ecological processes that results from having newer and better information available, could affect the nature and consequences of government policies with respect to the private sector Changes in government policies regarding preservation, conservation, or development of the coastal area could affect, to some extent, the spatial distribution of population and employment patterns along the coast These possible long-range changes will not be incorporated into the design strategy for evaluating the costs and benefits of implementing an operational remote sensing system, since an analysis of long-range changes is more appropriately a task for a cost-benefit evaluation of broader coastal management policies

The design strategy in this investigation for an evaluation of the feasibility of implementing an operational LANDSAT system will focus strictly on a straightforward estimation of some of the more obvious costs and benefits associated with this LANDSAT project Methodologies for addressing a few of the more theoretically difficult aspects of the costs and benefits associated with an operational LANDSAT system will be briefly discussed in the final sections of this report, but only for the sake of alerting the reader to some of the more difficult issues.

Finally, it must be emphasized that the conclusions resulting from a cost-benefit evaluation should not be the sole or even one of the main justifications for either recommending or rejecting the use of state monies to develop an operational LANDSAT system The crux of the difficulty in performing cost-benefit analysis is that benefits have to be stipulated if the analysis is to be performed And there is nothing in the nature of cost-benefit analysis that provides for a stipulation of benefits. In other words, the nature of "benefits" is external to the analysis Therefore, cost-benefit analysis cannot and should not be the sole measure of the feasibility of public investments Cost-benefit analysis provides no substitute for the basic problem of evaluating final social goods All it can do is expedite efficient decision-making after the basic problem of evaluation is solved The role of cost-benefit evaluations should be to highlight some of the issues involved in deciding on the disposition and allocation of public investment projects

There are several conceptually and methodologically distinct approaches to a cost-benefit evaluation of LANDSAT-derived information products These include (1) a cost-savings analysis, (2) a cost-effectiveness analysis, and (3) applications modeling or a simulation of the possible costs and benefits associated with the application of an operational remote sensing technology to various informational needs in the state. Each of these methods of analysis focuses on the costs and benefits of using LANDSAT technology to satisfy information needs and to reduce the uncertainty inherent in the governmental decision-making process However, the particular type of analytical framework actually employed at the completion of this investigation will depend on the questions and hypotheses that are deemed relevant to the evaluation Ultimately, the objective of the analysis is an assessment of the "value" of LANDSAT data as information inputs for coastal projects and programs This assessment is important because the economic "value" of remotely sensed data will vary depending on (1) the nature of the institutional framework within which the decision-making process takes place, (2) the informational needs of a specific user or agency, (3) the capacity and technical sophistication of present information systems, and (4) the extent to which remote-sensed data can replace and/or supplement existing data

In view of these considerations, a complete and thorough evaluation of the costs and benefits of implementing an operational LANDSAT technology might entail a phased evaluation, in which each phase of the evaluation would be structured around the assessment of specific aspects of the implementation of an operational system Therefore, a comprehensive research and design strategy for estimating the possible costs and benefits of an operational system could be structured around different phases, with each phase addressing specific objectives For example, one phase of the evaluation could focus on cost-savings estimations, a second could address the development of cost-effectiveness criteria for determining the most efficient combination of remotely sensed and field data for product generation, a third could come to grips with the task of developing models to simulate the costs and benefits associated with different applications of remotely sensed data to informational needs in the state, and a final phase could focus explicitly on estimating the economic value of LANDSAT-derived information products

The main advantage of using a phased approach to an evaluation of LANDSAT data is that specific aspects of the role of LANDSAT data in supplying information can be evaluated separately from other aspects Different perspectives on the analysis can also be gained by using this phased approach, which is an important consideration because the nature of economic analysis is uniquely determined by the analytical perspective adopted, i e , by the manner in which the phenomenon to be evaluated is defined, by the evaluation criteria employed, and by the hypotheses posed during the course of the investigaiton Much of the confusion surrounding the validity of economic analysis in general, and cost-benefit analysis in particular, stems from the fact that conclusions emerging from economic analyses will often change readically if the questions and hypotheses around which the analysis is structured are posed in a different manner For example, in cost-benefit studies, if there are different assumptions concerning the length of time during which the project is operational, or if different assumptions are uses regarding the rate of changes in remote-sensing technology, then these changes will have a substantial impact on the magnitudes of the costs and benefits associated with the project

Each phase of a phased approach to a cost-benefit evaluation would define LANDSAT data and LANDSAT-derived information from different perspectives and would pose different questions to be addressed during that phase This type of approach would provide additional insight into the nature and significance of the research problems at hand and could stimulate further research into cost-benefit analyses of LANDSAT data as both an informational and managerial tool

However, a thorough and detailed analysis of the costs and benefits of implementing an operational LANDSAT system would involve more time, expertise, and money than is available in our current budget In view of these constraints, the cost-benefit evaluation in this investigation probably should be a comparison of the costs of generating information using current capabilities for specific products with the costs of generating technically similar information products using satellite data The important assumption made here is that LANDSAT-derived information is not qualitatively different from information generated using conventional data sources for particular types of products In this type of appraoch, the objective is to determine whether, and to what extent, information obtained from an operational LANDSAT system is cheaper than comparable information obtained from conventional sources, in terms of collection costs, interpretation costs, and display costs.

A cost-savings evaluation will not only show the extent to which implementation of an operational LANDSAT system will lower the unit costs of generating an information product, such as a land use map, but will also provide an estimate of benefits realized Thus, in this rather narrowly defined context, "benefits" are equated with cost-savings The details of the proposal evaluation strategy are discussed in the next section

1 2 The Cost-Savings Approach To Benefits Estimation

1 2 1 Definition

The cost-savings approach will document the difference in costs between information products derived from satellite data and those derived from non-satellite data The savings in costs (dollars saved) will be the "benefit" to an agency or user Since information products derived from satellite data will usually be somewhat different in kind, we propose to evaluate information products derived from satellite data that the decision-maker could find just as usable and roughly "equivalent" to the information that he presently uses LANDSAT-derived information products that are similar to non-LANDSAT information products will be analyzed, rather than totally new kinds of information products, partly because information on the cost of producing some existing products, such as the Bureau of Economic Geology land use maps, of the Texas coast, is expected to be available

The cost-savings evaluation will focus on the unit costs of producing information products that are derived from technologically competing data sources This approach will entail the following a careful documentation of the costs associated with the experimental phase of the LANDSAT project, an estimate of the costs of producing satellite-derived information products under operational conditions, collection of data on the costs of producing non-Satellite-derived information products, cost comparisons, and estimates of the present value of the annual stream of costs and benefits that will be associated with the implementation of an operational LANDSAT system The conclusions emerging from a cost-savings evaluation should indicate whether there are pecuniary advantages to be gained by using LANDSAT imagery to generate certain types of information products Also, to the extent that the use of LANDSAT imagery produces lower operating costs for the production of information, these lower costs represent economic gains that should be internalized

It should be pointed out that in estimating the cost savings associated with implementation of an operational LANDS'T system, the assumption is made that the demand for information products by decision-makers is perfectly inelastic That is, it is assumed that reductions in the unit price of information products resulting from the implementation of an operational LANDSAT system will not affect the demand for information This assumption is necessary in order to compute the annual stream of benefits that will accrue to the state as a result of implementing a new information system. The implications of the different assumptions concerning the elasticity of demand for information products will be discussed in greater detail in section

1 2 2 Cost Recording

The first step in a cost-savings evaluation of LANDSAT-derived information is a documentation of the costs of acquiring and processing the imagery and of the costs of displaying the information product These costs will be documented through cost sheets that will be used to keep track of equipment and personnel employed in each phase and task of the LANDSAT project A sample of the cost sheets and the accounting procedures to be used in various phases of the LANDSAT project are included as Appendix B

The purpose of using cost sheets to tabulate the hours of equipment and personnel expended on each task is to enable the analyst to estimate the equipment and labor costs associated with the experimental investigation from satellite imagery At the end of the investigation, the analyst will be able to make an accurate statement about the various costs associated with each task

The usefulness and applications of satellite imagery will be tested at four predetermined sites in the Texas coastal area (figure 1) Testing the usefulness of satellite imagery at the San Antonio Bay Test Site, for example, involves the completion of at least nineteen steps (Appendix B) There are six steps associated with acquiring the imagery,

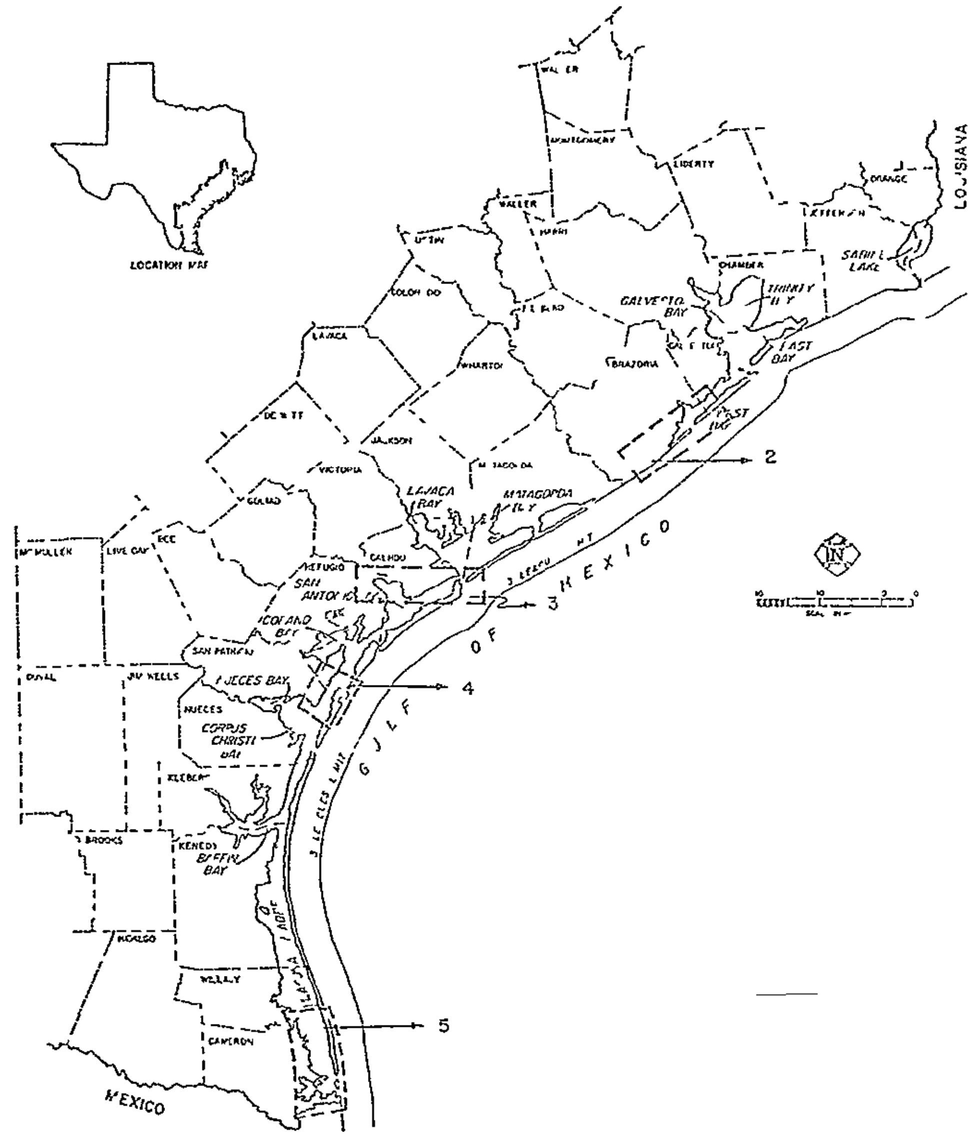

Figure 1 Approximate location of small test sites for LANDSAT Investigation #23790 Test site 1 is the entire coastal strip approximately 27 miles wide

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four associated with extracting information from the imagery, and nine steps associated with displaying the information Each of these steps represents a part of the task of an information product on the San Antonio Bay area The hours of equipment usage and labor time expended during each of these steps will be recorded on a daily basis Records on computer time and computer costs will also be recorded by task and step Other major costs associated with the San Antonio Bay area test, such as data costs, will likewise be recorded by task It is not necessary to keep track of such costs as miscellaneous supplies used at the San Antonio Bay test site, since the total costs of supplies can be estimated at the end of the project Thus, at the end of the image interpretation task for San Antonio Bay, we will have a complete record of the hours of equipment, labor, and computer time used

Tasks functionally similar to those performed at San Antonio Bay will be performed at the three other test sites in the coastal area The hours of equipment and personnel expended on each of these tasks in the remaining three test sites will be documented in an identical manner At the end of the LANDSAT project, when the information products to be generated at each of the four test sites have been completed and evaluated, there will be a cumulative record of the total hours of equipment, labor, and computer time expended during the eighteen month investigation for each of the steps involved in producing information from satellite imagery.

Although the work that will be done at each of these test sites represents an experimental investigation of the usefulness of satellite-derived information products, the steps involved in these experiments are designed to simulate operational monitoring system (Section 3 1 2 of the text of this report) The costs of the steps performed at each of the test sites will be used to estimate the costs of an operational system

1 2 2 Estimating the Costs of an Operational LANDSAT System

The costs of the experimental operations will be collected in terms of hours expended. Hours expended during this phase can be multiplied by the actual prices of the various inputs, such as wage rates per hour, computer costs per hour, and equipment costs per hour, in order to generate a profile of dollars expended by input and by task, but this type of excercise is really secondary to the cost-savings evaluation The resource costs of the experimental operations, in terms of input hours expended, will be used to estimate resource hours expended in an operational setting.

The cumulative records of total input hours expended during the experimental phase will be used to estimate the learning curve, which will in turn be used to estimate a standard man-hour, a standard computer-hour, and a standard equipment-hour A standard hour is a measure of the average input requirement needed in order to perform a given task in an operational setting A standard man-hour is a measure of the average labor requirements for the completion of a given task, a standard equipment-hour is a measure of the average amount of equipment time needed to perform a given task, and so on The assumption is made that the person performing the task has already been trained and is experienced in what he is doing, thus no allowance is made for learning time. Under ideal conditions, a standard man-hour would be a measure of the minimum labor time needed to perform a certain task, however, ideal conditions are rarely attained in the real world These standard hours will then be multiplied by expected average input prices in order to estimate the costs of generating information products in an operational setting

The main premise of the learning curve, or the manufacturing progress function, in engineering jargon, is that "just as the effort exerted by a single worker decreases as he acquires experience and skill in doing a set of tasks, so the labor hours or labor cost per unit of product produced by a group of workers will decrease as experience is gained by the group in producing the product "[1] Application of the learning curve concept entails an estimation of the expected rate of progress in learning to perform the tasks A learning progress rate of 80 percent, for example, means that as output is doubled, the labor time expended on the last unit of the output will have dropped to 80 percent of its original value [2] And as output

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[1]Harvard Business School, "Fawcett Optical Equipment Company," mimeographed copy of case materials used in the Harvard Graduate School of Business Administration, 1960 Other discussions of the learning curve can be found in Paul W Marshall, et al, Operations Management Text and Cases (Homewood Richard D Irwin, Inc , 1975), F J Andress, "The Learning Curve as a Production Tool," Harvard Business Review, January-February 1954, W. B Hirschmann, "Profit from the Learning Curve," Harvard Business Review, January-February 1964, and Abernathy and Wayne, "Limits of the Learning Curve," Harvard Business Review, September-October 1974

[2]A learning progress rate of 80 percent is a fairly standard rate This figure was imparted during conversation with E B Deakin.

is again doubled, say from 20 to 40 units, the labor time expended in producing the 40th unit of output will have declined to 80 percent of its value in producing the 20th unit It is unrealistic to expect a constant learning progress rate as output is expanded indefinitely. The learning curve will therefore continue to decline throughout the relevant ranges, but after a point, the curve will flatten out with respect to the X-axis This is illustrated in Graph 1 Estimation of the point at which the learning curve will start to flatten out entails estimation of changes in the learning progress rate that are expected to occur as efficient operational status is achieved As peak efficiency is approached, the learning progress rate will approach 100 percent, which means that as output is doubled, the labor time expended in producing the last unit of output will approach 100 percent of the amount of labor time expended on producing the original unit The implication is that as the learning progress rate approaches 100 percent, labor approaches 100 percent efficiency, and the labor time expended at expected peak efficiency provides a measure of standard man-hours

A quantitative estimate of the learning experience associated with the LANDSAT project can be obtained from the cumulatime record of labor hours expended during experimental operations As similar tasks are performed at each of the test sites, we would expect a decline in the number of labor hours expended per task. Since satellite technology is fairly new, it is expected that developing and testing the capabilities of satellite-derived information products will entail considerable learning That is, much of the labor time expended in producing maps based on satellite data will be expended in learning new techniques, assessing the capabilities of satellite technology in satisfying information needs, developing guidelines for implementing an operational system, and debugging the system The decline in labor hours expended per task can be obtained from the information compiled during the experimental phase And the labor hours expended in performing tasks at the end of the experimental operations can be used, along with other considerations deemed relevant, to estimate a standard man-hour

A standard man-hour can be measured in any of several ways Since there will be qualitatively different categories of labor employed during the LANDSAT project, e g , a Geologist I, a Geologist II, a General Biologist, etc , it is possible to estimate a standard man-hour for each of these different job classifications "Ground Truth" interpretation (task 8, Text Site 3) in an operational setting, for example, might entail 1 5 standard man-hours of Geologist I work, 0 5 standard man-hours of Geologist II work, and 2 0 standard man-hours of General Biologist work These standard man-hours are then multiplied by the respective wage rates that are expected to prevail if and when LANDSAT becomes operational Thus, in this context, a standard man-hour refers to a single specific occupational skill required for completion of a single specific task.

A standard man-hour can also be defined to be a composite measure of the various occupational skills needed to complete a single specific task In this situation, a standard man-hour for "Ground Truth" interpretation can be estimated and would be multiplied by a composite wage index in order to estimate labor costs It is also possible to estimate a composite standard man-hour for a set of tasks The wage rate used in this situation would be a weighted index of the expected wage rates of the various occupational skills employed in performing the set of tasks

Similar procedures will be used to estimate standard equipment-hours and standard computer-hours Although equipment and computers do not "learn" tasks in the same manner as does labor, the learning curve concept can be applied to both items A Richards Light Table, for example, will be used in "Ground Truth" interpretation, and the hours that the Table is used in performing this task will be recorded on a daily basis, along with hours of labor expended on this particular task As the task of "Ground Truth" interpretation will be performed at each of the five test sites, we can expect that the hours of equipment useage will decline during the experimental operations This decline will occur because labor will become experienced in identifying the task requirements that must be satisfied by the Light Table This is not to imply that labor will necessarily become more skilled in using the Light Table, but only that labor will develop skills in identifying the minimum amount of required equipment usage It is, of course, possible that hours of equipment usage for certain tasks will not decline throughout the duration of the experimental investigations In this case, estimation of a standard equipment-hour will still be derived from the accumulated data on hours expended during the investigations The general accounting procedures that are to be used in estimating equipment costs in an operational setting are described in Appendix A

Standard computer-hours and computer costs in an operational setting are estimated in an identical manner

The separate estimations of labor costs, equipment costs, and computer costs involved in the production of an information product in an operational setting will be aggregated in order to provide an estimate of the dollar costs of generating a land use map derived from satellite data

Several points are in order concerning the reliability of these cost estimates for product generation in an operational setting

One anticipated difficulty, albeit minor, is devising ways to allocate costs of joint products X and Y are said to be joint products if the production of X results in the production of both X and Y at the end of the production process [1] Since

[1]The classical example of joint products in the economics literature is the production of mutton and wool The production of mutton usually involves the production of wool, unless the animal is hairless at the time of its demise The converse does not, of course, follow.

two information products will be generated at each of the test sites, it is possible that certain tasks associated with producing one of the information products will not need to be repeated in the production of the remaining product That is, certain aspects of the production process are characterized by "indivisibility". Since there are no hard and fast accounting rules that can be used to allocate the costs of production among joint products, some "reasonable" estimation procedure will have to be devised Moreover, recognition of the fact that the two maps produced at each test site may in some manner be joint products should not jeopardize the reliability of the estimates of production costs under operating conditions

Inflation can play havoc with the best cost estimates To the extent that increases in the general price level will affect not only the absolute prices but also the relative prices of inputs that are required in the production process, these price changes could have a substantial and damaging effect on cost estimates The best procedure to follow in this situation is to estimate all costs in constant dollars, which are defined with respect to any particular base year or period Assuming that the experimental operations will be completed at the end of 1976, the cost estimates should be based on the actual input prices that prevailed at that time That is, the cost estimates would be in terms of 1976 dollars

It should also be pointed out that it is hazardous to inflate the costs estimates by the percentage rate of change in the general price level, since the percentage rates of change in the prices of inputs that are required in an operational LANDSAT system may deviate substantially from the rate of change in the general price level. This latter consideration is also relevant to determining the cost estimates of producing a comparable information product using non-satellite technology Since the immediate objective of the cost-savings evaluation is to compare the operating costs of producing satellite-derived information with the operating costs of producing non-satellite-derived information, cost estimates of producing information based on conventional non-satellite methods must also be prepared And if all that is available are actual cost data in 1970 prices, for example, it is obviously not legitimate to compare 1970 costs with 1976 costs It is also not legitimate to inflate the 1970 cost figure by the rate of change in the general price level during the 1970-76 period Since the actual recorded costs of producing information derived from conventional technology will presumably not be available for 1976, these costs will have to be estimated

1 2 3 Estimating The Benefits Of An Operational LANDSAT System

The discussion in the preceding section has focused on methods for estimating the costs of generating two particular information products--land use maps--in an operational LANDSAT setting The costs of generating these two products using LANDSAT technology will then be compared with the costs of generating technically equivalent products using conventional technology The cost differences between the two methods of producing information will be used to project the stream of benefits, i e , "cost-savings", that will accrue to the state as a result of implementing an operational system

To the extent that the adoption of a superior technology, such as LANDSAT, into the production of information process will reduce the cost of producing that information, and thereby release monies that can be used to purchase additional resources, the immediate justification for adopting the superior technology rests on cost-savings Since money represents command over resources, a certeris paribus reduction in the monetary costs of producing the information means that the opportunity costs of the information are reduced, or that the "real" costs of the information in terms of foregone alternatives are reduced Quantifying the reduction in the cost of producing information from LANDSAT technology necessitates some knowledge of the amount of information that is needed, and the frequency with which this information will be produced In order to be able to estimate the annual stream of cost-savings of benefits that will accrue to the state as a result of the implementation of an operational LANDSAT technology, it is necessary to estimate the rate at which information will be generated during a specific period, say ten years. To take an extreme case, if the technical nature of a land use map is such that it has to be updated, or "produced" every two years, then, during a ten year period, the magnitude of the total undiscounted cost-savings would amount to the initial cost difference between the two methods multiplied by five. If, however, the technical nature of a land use map is such that has to be updated every six months, then the magnitude of total undiscounted cost-savings during the ten year period will be equal to the initial cost difference multiplied by twenty. Obviously, the present value of the annual stream of benefits that results from implementing an operational LANDSAT system will depend on the frequency with which information is produced.

The economic value of "newer" or "better" information is that it reduces the uncertainty inherent in the decisionmaking process. Thus, the economic value of newer or better techniques for producing information is conceptually different from the cost savings value of newer or better techniques for producing the same information. "Whatever educational or scientific value is placed on technically superior information, and whatever the power or elegance of the technology and its product, the test of its economic value is its impact on decisionmaking "[1]

A major methodological difficulty arises when the analysis calls for a quantitative estimation of the economic value of newer and better information, when that information is an input into a social good. The crux of the difficulty is in attempting to simulate market outcomes, or in determining the value of a good that normally cannot be valued by market outcomes. The prices of private goods are determined by the interaction of supply and demand within the market setting, and these prices reflect the economic value of goods. Therefore, since price is a measure of economic value, the price of a good, as determined within the market setting, is a measure of its value to society. And if benefits are reflected in price changes, or are made calculable with reference to price, cost-benefit evaluations are more manageable.

Thus, the benefits from irrigation may be measured in terms of increased agricultural output, flood control results in cost-saving since measurable damage to capital assets or resources is avoided, better roads reduce automotive costs and save trucking time, which can be valued, public health measures reduce medial care cost, which can be valued, investment in education raises

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[1]Earth Resources Survey Benefit-Cost Study prepared by Earth Satellite Corporation and the Booz-Allen Applied Research Corporation, 1974, vol. V, p I-10. Within the context of the LANDSAT project, the economic value of newer and better information is that it reduces the uncertainty in coastal management, by increasing management's understanding and knowledge ecological processes in coastal areas

earning power, and so forth.

The common characteristic of these cases is (1) that the social good is not a final but an intermediate good, i e , a good which enters into the production of further output, and (2) that this further output is in the nature of a private good which may be valued efficiently at the market. Since the social good enters into the production of a final good, the benefits of this intermediate good can be measured in terms of the market price of the final private good. "It is thus in the case of the intermediate social good that cost-benefit analysis can perform most effectively."[2]

Information per se is neither a social nor a public good, but possesses the characteristics of a private good, since it can be rationed by a price system (A good or service is defined to be a public good or service if users can consume the good without paying for it A "public good" should not be confused with a government-owned good) Consumption of information can be rationed by a price signal, and the value of information can be determined within the market framework by observing the prices that users are willing to pay. It is conceptually possible to directly estimate the prices that private users would be willing to pay for LANDSAT information by appealing to market information if LANDSAT information could be used as an input into the production of a final private good.

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[2] Musgrave, "Cost-Benefit Analysis and the Theory of Public Finance," op. cit , p 800.

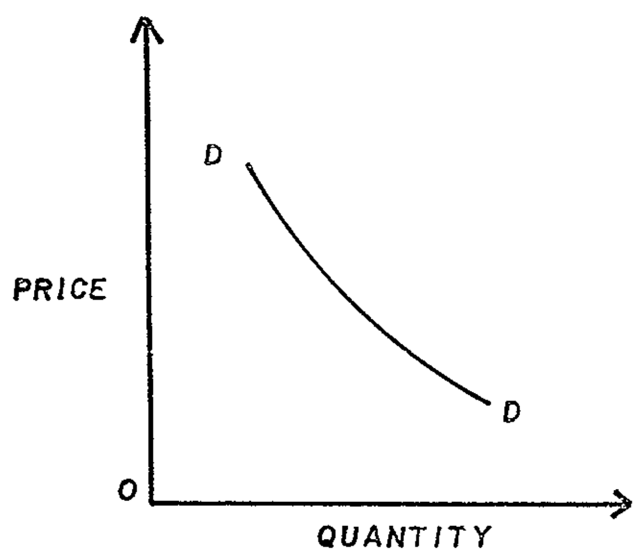
However, since the most probable use of LANDSAT information is as an input into coastal management, which is in turn an input in the production of both a social good and a public good (a "better" coastal environment), the problem of estimating the economic value of LANDSAT information is compounded. Information is usually defined to be an intermediate good, or an input into the production of a final good. In some cases, estimation of the economic value of information is not a difficult procedure. In the case of determining the economic value of agricultural information, for example, the problem is to estimate the marginal productivity of an incremental unit of information in the production of agricultural output. Since crops are private goods, the economic value of crops, or the prices of various crops, is determined within the market setting. This information can be used to compute the economic value of an additional unit of information in the production of crops.

The problem of determining the value of LANDSAT information is that "a better coastal environment" is a public good (anyone can benefit from a better environment without having to pay for it), and the economic value of "a better coastal environment" cannot be determined within the actual market setting. In this case, an appeal to market information as an aid to estimating the value of LANDSAT information would involve estimating the value of "a better coastal environment" by observing the prices that persons would be willing to pay for a better environment

Scarcity of actual data is clearly the limiting factor here, since we do not know how much persons are willing to pay for this type of good

There are two type of methodologies that can be employed to quantify the value of newer and better information. One of these is the intermediate goods approach, alluded to in the preceding discussion. The application of this methodology as the basis for evaluation would entail the assumption that LANDSAT information is an intermediate good, and the problem would amount to estimating the value of the marginal product of information in the production of another good, e.g , goods for coastal management decisions. This methodology, using the intermediate goods approach, is appropriate in situations where the final good possesses the characteristics of a private good that is generated when the demand and production costs are favorable Final goods generated for governmental decision-making, however, are not necessarily determined by market supply and demand The other methodology is the cost-savings approach, a much simpler procedure. Both methods, however, involve estimation of a demand curve for information, since the nature of user demand is the only basis for evaluation of LANDSAT information. And since we do not have recourse to market standards of evaluation, the only alternative is to estimate the value of LANDSAT information by estimating the demand for the product on the part of decision-makers who are charged with coastal monitoring

The demand for a good or service represents the amount of the good or service that would purchased--"demanded"--at all possible prices, ceteris paribus. The ceteris paribus assumption, which means that all other relevant considerations, such as income, purchasing power, the prices of all other goods and services, and tastes and preferences, are held constant, means that changes in these other variables are not allowed to affect the demand for the good in question. This information is summarized in Graph 1



Graph 1 "Typical" Demand Curve

The demand curve shows the amount of the good or service that would be demanded at every possible price at a given moment in time The demand curve, as formally defined in economics, is thus a purely hypothetical concept that rests on rather restrictive assumptions. The theoretical estimation of a demand curve carries with it the following assumptions (1) the consumer of the good purchases the good under conditions of perfect competition, (2) the consumer is in equilibrium, maximizing total utitlity, and the marginal utilities of incremental units of expenditure are equal, (3) prices are constant, and (4) the marginal utility of money is homogeneous of order minus one with respect to prices and money income. The demand curve is thus derived from equilibrium principles.

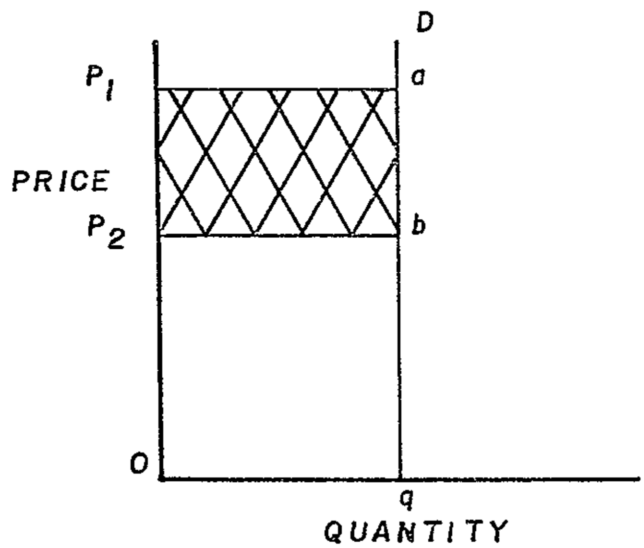
The demand relationship, thus stated, is the answer to a set of hypothetical questions concerning the quantities of a good that would be demanded if the price of the good were changed under circumstances outlined as above. "The peculiarity of the concept is well illustrated by the fact that only one point on a demand curve can ever be observed directly with any degree of confidence, because by the time we can obtain the data with which to plot a second point, the entire curve may well have shifted without our knowing it."[3]

The purpose of the preceding discussion is to illustrate that much of the confusion surrounding the meaning of the demand concept in applied economics, particularly in studies oriented

[3]William J Baumol, Economic Theory and Operations Analysis, 2nd ed , (Englewood Cliffs Prentice-Hall), p. 210

toward public policy, is an outgrowth of misconceptions regarding the exact nature of the information that an estimated demand relationship is supposed to convey. These difficulties notwithstanding, it is not possible to estimate benefits unless we have some understanding of the demand for the good being analyzed. Benefits ultimately depend on user demand. As mentioned earlier, the chief premise of cost-benefit analysis is on measuring changes in the supply and demand curves of the good in question, and, without knowledge of the demand curve, cost-benefit analysis cannot be performed However, the reader should be alert to the fact that the validity of "benefits" estimation is directly related to the validity of demand estimations.

There are various statistical methods that might be applicable in estimating the parameters of the demand for LANDSAT information, and some of there will be discussed in Appendix H However, the simplest method for estimating the demand curve for LANDSAT information is to assume that the demand for this new information is perfectly inelastic, an assumption that is commonly made in cost-savings evaluations. The price elasticity of demand is simply a measure of the percentage change in quantity demanded that results from a given percentage change in price. If the demand for information is inelastic with respect to price, changes in the unit costs of acquiring information will not affect the quantity of information that is demanded or desired by decisionmakers. In other words, a reduction in the unit costs of acquiring information does not imply that additional information will be desired. The estimation problem is this case is to determine the amount of the information that is demanded, or the level of q in Graph 2



Graph 2. An inelastic demand curve for information

This could be done by determining the amount of information that is required for the operation of a coastal monitoring program, irrespective of the type of information technology employed The prices of producing information using both conventional and LANDSAT technologies will be available from the cost estimations. In Graph 2, p_1 is the cost of producing information using conventional technology, while p_2 represents the cost of producing information using LANDSAT technology The distance

$op_1 - op_2$ represents the cost-savings per unit of information that accrues as a result of using LANDSAT data in the production of information in an operational setting. The distance oq represents the amount of information demanded The area op_1aq represents the total cost to the state of using conventional non-satellite technology to produce the desired amount of information, oq, while the area op_2bq represents the total cost to the state of using LANDSAT technology to produce the desired amount of information, oq. The difference between op_1aq and op_2bq is the area p_2p_1ab, which is a measure of price change, (dp) multiplied by the number of units of information that is demanded, q. The benefits or cost-savings that accrue to the state as a result of implementing an operational LANDSAT system is measured by q(dp), which is indicated by the shaded area in Graph 2

Two caveats are in order concerning the validity of the cost-savings technique for benefits estimation.[4] The problems associated with this type of benefits estimation are identification of the alternatives "saved", and identification of the implications of using cost-savings as the basis for evaluation. In regard to the first problem, the real costs of a conventional non-satellite information system as an input into coastal monitoring have to be identified, as well as the benefits of a conventional information system. Thus, the analysis has to include a clear idea

[4]Julius Margolis, "Shadow Prices for Incorrect or Nonexistent Market Values," in Robert H Haveman and Julius Margolis, eds, Public Expenditures and Policy Analysis (Chicago Markham Publishing Company, 1970), pp 314-329, at p 326

of the nature of the alternatives to an operational LANDSAT system. A cost-benefit evaluation of a LANDSAT system needs to include a cost-benefit evaluation of alternative systems, for conceptually this is the real basis of comparison Cost comparisons without reference to benefit comparisons are of limited value. This implies that the estimations of potential cost-savings available through the implementation of an operational LANDSAT system should include the assumption that comparable information produced with conventional non-satellite technologies is worth at least as much as it costs to produce That is, the evaluation should address the question of whether or not LANDSAT-derived information is of more or less value in the decisionmaking process than non-satellite information, and this involves determining the comparative benefits of the two systems

In regard to the second problem, that of identifying the implications for benefits estimation of using cost-savings as a basis of evaluation, there are several perspectives than can be adopted The assumption of inelastic demand can greatly overestimate the benefits resulting from an operational LANDSAT system The newer and better information resulting from an operational LANDSAT system might simply not have been available, given the cost structure of a conventional non-satellite system, and it is therefore erroneous to assume a benefit equal to the unit cost-savings multiplied by the augmented "new" information In other words, an overstatement of benefits can result unless the information generated by the two information-producing technologies is strictly comparable and unless the amount and types of information available given the LANDSAT system would have been available under a conventional non-satellite system. This perspective recognizes that information produced from competing technologies may be qualitatively different, and hence, not strictly comparable in terms of benefits assessment The only way to guard against commiting this type of error during the actual course of the evaluation is to use careful judgment in assessing the bases for comparison, since there is nothing inherent in the cost-benefit methodology that would indicate whether, and to what extent, the conclusions are erroneous

Before proceeding with the discussion, it might be helpful to reiterate several points Broadly defined, cost-benefit evaluation entails (1) estimation of supply curves for the goods being analyzed and evaluated, (2) estimation of demand curves for the goods being evaluated, and (3) combination of the information obtained in (1) and (2) above as a basis for supply and demand analysis A particular cost-benefit analysis will be characterized by varying degrees of complexity and difficulty according to the complexity of methodologies used to estimate the supply and demand curves. Assumptions too, can play a critical role in increasing or decreasing the degree of complexity of the analysis Assumptions concerning the elasticities of supply and demand are perhaps the most crucial in estimating the benefits of a particular project, but other assumptions play a critical role in shaping the nature of the conclusions that flow from the evaluation It is for this reason that the analyst has to be exceedingly cautions in spelling out the exact nature of the assumptions that will be employed during the course of the evaluation The main assumption that is invoked in cost-benefit analysis is, that price is a measure of social value, and, if prices do not reflect actual social values, they can be adjusted to do so, by estimating shadow prices If this assumption is not admitted, the validity of the methodology is seriously jeopardized

The objective of estimating the comparative costs of producing information from two different technologies--conventional non-satellite and LANDSAT--is to enable us to estimate supply curves for information In Graph 2, for example, the segments p_1a and p_2b represent supply curves for producing information from conventional non-satellite and LANDSAT technologies, respectively. The shape of these supply curves indicates that the supply of information is assumed to be perfectly elastic with respect to price, and that there are constant returns to scale in the production of information Both of these propositions can be investigated during the actual course of the evaluation The assumption of perfect elasticity in this context is probably a realistic assumption for the relevant ranges of output

The objective of estimating a demand curve for information is to enable us to compute the benefits that might accure from an operational LANDSAT system It will greatly simplify the evaluation to assume that the demand for information is perfectly inelastic with respect to price, since invoking this assumption might enable us to avoid some of the more formidable problems of estimating demand functions for information under alternative situations. The assumption of inelastic demand does not appear to be altogether unreasonable, since this approach will enable us to estimate the minimum amount of benefits associated with the implementation of an operational LANDSAT system

Given the data on the costs of producing information in an operational LANDSAT setting, including both fixed and investment costs, the costs of producing technically comparable information using non-satellite technology, the assumption of perfectly inelastic demand for information, and an estimation of both the amount of information demanded and the frequency with which it is demanded, a quantification of the costs and benefits associated with an operational LANDSAT system is possible

Assume, for example, that a LANDSAT system will be operational for ten years (The validity of this assumption will be discussed shortly) An additional assumption is that the implementation of an operational LANDSAT technology will cost $300,000, and that all of these costs will be incurred in the initial year This $300,000 constitutes the initial experimental, investment, and fixed costs which must be incurred before the system is operational The cost-savings evaluation will provide an estimation of benefits received through the implementation of an operational LANDSAT technology, these cost-savings can be calculated on an annual basis for each of the ten years Let us assume for the purposes of illustration that an operational information system based on LANDSAT technology provides $200,000 a year in "benefits". This annual benefit of $200,000 represents the cost-savings that will accure to the state and/or state agencies as a result of using LANDSAT technology to produce the same types of information products that are currently demanded and are currently produced using conventional technologies Let us make the further assumption that the annual costs of operating and maintaining a LANDSAT information system are $50,000.

It is not valid to sum benefits and costs over the eleven year period in order to obtain a measure of total benefits and costs Simple summation would imply a discount rate of zero percent, clearly an unreasonable and untenable assumption. Total costs incurred are, of course, $800,000 (the initial outlay of $300,000, plus annual operating costs of $50,000 per year for ten years), while total benefits are $2,000,000 (cost-savings of $200,000 per year for ten years) The stream of costs and benefits is illustrated in the following diagram

	Year 0	Year 1	Year 2	Year 3	.	Year 10
Costs	300,000	50,000	50,000	50,000		50,000
Benefits	-0-	200,000	200,000	200,000		200,000
Net Benefits	-300,000	+150,000	+150,000	+150,000		+150,000

The values of these costs and benefits to the state have to be discounted or deflated by an interest rate in order to estimate the present values of these annual flows This is a common procedure employed in evaluating the relative merits of investment alternatives The present value of a benefit is the value of having the benefit today rather than at some time in the future The present value of a benefit or cost is calculated by applying an interest rate (the discount rate) to costs incurred and benefits received in each year after the first year, or Year 0 in the preceding diagram The present value is the amount which, if invested at the rate of interest specified and for the length of time specified, would yield the benefit in the specified future year Selection of the appropriate social discount rate or interest rate with which to evaluate public investment projects is an unsettled issue in cost-benefit analysis[5] Theoretically, an appropriate discount rate is one that reflects society's rate of time preference for future goods over current goods, the problem, however, is to determine the actual rate of time preference. (If society is indifferent between having $100 now and $110 next year, the social rate of time preference is 10 percent). A discount rate of ten percent is often used to evaluate public investment projects, accordingly, we recommend that this discount rate be used to

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5 See, for example, Wm. J. Baumol, "On the Social Rate of Discount," American Economic Review, September, 1968, the Comments on this article which appeared in the American Economic Review, December, 1969, pp 909-930, and Mishan, Cost-Benefit Analysis, op cit., pp. 181-267

discount the costs and benefits of an operational LANDSAT system to the present.

The formula for determining the present value is

$$PV = \frac{R_1}{(1+r)^1} + \frac{R_2}{(1+r)^2} + \frac{R_3}{(1+r)^3} + \quad + \frac{R_n}{(1+r)^n},$$

where R_1 equals the net benefits received in year 1, R_2 equals the net benefits received in year 2, R_n equals the net benefits received in the period$_n$, r represents the discount rate, and n indicates the time period Or, summed over the ten year period,

$$PV = \sum_{n=1}^{10} \frac{R_n}{(1+r)^n}$$

Given a discount rate of 10 percent, the present value of the net benefits (net of operating costs) accruing to the state as a result of implementing an operational LANDSAT system, given the above cost structure, is

$$PV^1 = \frac{1,500,000}{(1 + 10)^{10}} = \$579,000$$

The initial cost outlay of $300,000 has to be subtracted from this figure, thus the present value of the net benefits (net of operating costs and initial outlay costs) associated with implementing an operational system is, in the present example, $279,000.

The present value of the stream of costs is given by

$$PV = 300,000 + \sum_{n=1}^{10} \frac{C_n}{(1+ 10)^n}$$

, where C equals total costs, and n equals 10 The present value of there costs is $493,000 The present value of the stream of total gross benefits is $772,000 The benefit-cost ratio is 1.6.

Another issue in cost-benefit analysis concerns the problem of estimating future costs and benefits in an inflationary world General changes in the price level do not represent much of a problem, if costs and benefits are affected proportionately, leaving the cost-benefit ratio unchanged. The major difficulty for estimation procedures lies with changes in relative input prices and with price changes that affect costs and benefits disproportionately The easiest way to avoid complicated estimating procedures is to estimate the future streams of costs and benefits in terms of constant dollars, defined in reference to a particular base year, while recognizing that changes in relative prices may affect these estimates

One issue that is specific to this particular LANDSAT evaluation is the assumption concerning the length of the time period during which a LANDSAT system is expected to be operational What is at issue here is not so much managerial or administrative decisions as to the administrative feasibility of an operational LANDSAT system for a particular length of time, but rather the length of the time period during which LANDSAT technology is assumed to be constant This is a crucial assumption, for the period of time during which the system is assumed to be operational without the addition of new technology will greatly affect the values of the streams of costs and benefits associated with the system We therefore recommend that four different time periods be assumed for the evaluation five years, ten years, fifteen years, and twenty years The appropriate length of time during which existing LANDSAT technology is expected to be operational without substantial adoptions of new technology (which would probably entail substantial new cost outlays) is a task for experts in the field of remote sensing technology

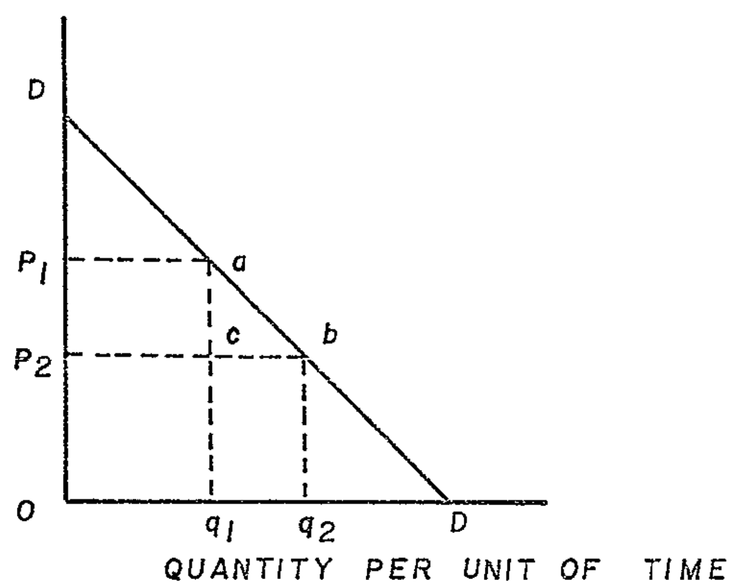
Generally speaking, the assumption of inelastic demand can lead to an understatement of benefits, if the "true" price-demand relationship is not perfectly inelastic with respect to price In the preceding discussions, we have assumed, for simplicity, that supply is perfectly elastic with respect to price and that demand is perfectly inelastic with respect to price Dropping one or both of these assumptions will not invalidate the analysis, since the assumption of perfectly inelastic demand in the calculation of benefits will provide a minimum measure of the benefits associated with the implementation of an operational LANDSAT system However, if the "true" demand for information is elastic with respect to price, additional benefits--"additional" in the sense that these benefits are not captured by the assumption of inelastic demand--will be realized by the implementation of an operational system

If the demand for information is elastic with respect to price, this means that, as the unit price of information is reduced, users of information will demand additional units of the information Thus, this perspective recognizes that the quantities of information demanded from competing technologies may be different, depending upon how users of information respond to changes in the price of information, and recognizes that the introduction of a new technology ought affect the rate of data acquisition (It should be noted that the demand for new information may be income elastic, i e., as an agency's general budget for information is increased, or as a budget for coastal monitoring is increased, some of this additional "income" may be spend on "newer and better" information However, investigation of the income elasticity of demand for information need not detain us here, for this concept is irrelevant to the analysis, given the assumption of a constant budget) Relaxation of the assumption of inelastic demand leads directly into some of the more difficult aspects of estimating the demand for information, since estimation of a demand curve for information entails estimating how users of information will respond to hypothetical changes in the price of information

Assuming that we have been able to determine the "true" demand function for LANDSAT information, and that demand relationship is elastic with respect to price, benefits estimation will involve (1) a measure of the savings per unit of information times the original amount of information demanded and (2) a measure of the consumers surplus realized on additional amounts of information demanded solely because of the reduction in the unit price of information

The nature of this quantification process is best understood by relying on a graphical exposition In Graph 3, p_1 is the price of information prior to the introduction of Landsat technology, while p_2 is the price of information after the introduction of an operational LANDSAT technology The downward shift in the supply function from p_1a to p_2b indicates that the costs of producing information--land use maps--have been reduced. The shape of the supply curve indicates that the supply of information is perfectly elastic with respect to price [6]

DD is the demand curve for information, while the shape of the demand curve indicates that the demand for information is responsive to changes in the price of information.[7]



Graph 3 Benefits estimation given an elastic demand for information

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[6] Different assumptions concerning the elasticity of supply will change the conclusions, but not the thrust of the analysis

[7] Once again, different assumptions regarding the degree of elasticity of demand will affect the magnitude of benefits, but not the substance of the analysis

The amount of information demanded prior to the introduction of LANDSAT technology is q_1 at price p_1. The quantity of information demanded a subsequent to the introduction of price-reducing LANDSAT technology is q_2 at price p_2.

The net social benefit of any amount of output is the area under the demand curve minus the cost of the output. The area under the demand curve thus represents the maximum amount that users would pay rather than do without the good. With respect to the original situation, i.e , prior to the introduction of LANDSAT technology, users of information are willing to pay a maximum of $ODaq_1$ for information. Since they actually pay Op_1aq_1, which is less than $ODaq_1$, the net social benefit is measured by the triangle p_1Da, which is equal to the consumers' surplus associated with demanding q_1 units of information derived from non-LANDSAT technology at price p_1

After the implementation of an operational LANDSAT system, users demand q_2 units of information at price p_2. The maximum amount that users are willing to pay rather than do without the information is measured by $ODbq_2$. Users actually pay Op_2bq_2, which is less than $ODbq_2$, the amount they are willing to pay, thus, the new social benefit in this case is measured by the triangle p_2Db, which is equal to the consumers surplus.

The total net benefits associated with a conventional non-LANDSAT technology for producing information are measured by the triangle p_1Da, while the total net benefits associated with an operational

LANDSAT technology are given by the triangle p_2Db The gain in net benefits resulting from the introduction of an operational system is measured by the strip p_2p_1ab The gain in total net benefits has two components The first of these is the savings per unit of information multiplied by the original quantity of information demanded before the price change, or the cost-savings on the original amount of information. This cost-savings is measured by the rectangle p_2p_1ac. The second component of the increase in total net benefits is the consumers' surplus on the additional amount of information demanded as a result of the price change, and this is measured by the triangle abc.

One final consideration needs to be mentioned before concluding this section In a cost-benefit evaluation, benefits that arise because of economic growth--growth in either population or per capita real incomes or both--also need to be taken into account. Indeed, benefits induced by increased growth may often be the main justification for a public investment project. As population increases, and as real per capita income increases, there will be a greater demand in the future for the coastal environment for recreation, second homes, retirement communities, etc.[8] And as the demand for coastal resources increases, coastal management will become critical for the preservation of

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[8]An excellent overview of population trends in the U.S in terms of both growth projections and distributions, is provided in U S. Commission on Population Growth and the American Future, Population, Distribution, and Policy, Vol. V (Washington, D.C U S Government Printing Office, 1972).

coastal areas and ecologically delicate areas for the enjoyment of future generations. Even in the absence of a comprehensive coastal management program, additional and superior information, such as that provided by LANDSAT--for monitoring the impact of increased consumption of coastal resources will assume greater importance and social value in future coastal programs

2.0 A COST-EFFECTIVENESS APPROACH FOR "MIXED" INFORMATION PRODUCTS

An information product is a refined data package that conveys useable information to a decision-maker or potential decision-maker. As stated earlier, the economic value of information is that it reduces the uncertainty inherent in the decision-making process. Information *per se* has no economic value, although it may have aesthetic value An example of an information product, at least within the context of the LANDSAT project, would be a map showing certain characteristics of selected physical features, such as a map of wetland types in a particular region or county A map *qua* information product has no economic value, but this is not to imply that there are no exonomic condiserations in producing the map *qua* information product.

The discussion in this section will focus on some of the economic considerations that are relevant in a cost evaluation of "mixed" information products that can be used in coastal or other types of resource management programs. The economic considerations that are relevant to this type of analysis from the basis for the cost-effectiveness methodology.

An information product is generated by using one, or some combination, of available and data collection and analysis techniques, or procedures Three methods for generating information products for management of coastal resources, for example, could include collection and analysis (interpretation and display) of LANDSAT data, collection and analysis of high altitude and low altitude aircraft survey data, and ground surveys carried out by persons on foot or in earth-bound vehicles A coastal wetlands map could be produced by using any one, or any combination, of these techniques, given the relevant product clarity and system capability constraints

Techniques such as these are the inputs into a production function for information, just as labor and capital are the inputs into a production function for automobiles. Any production function specifies the nature of the relations between inputs and output, be it a production function for information, for automobiles, or for snowsleds (think snow...). The task of the government decision-maker or the automobile manufacturer is to determine the most cost-effective method of combining the inputs or techniques in order to generate the output

Each technique for producing an information product has two aspects cost and effectiveness.[1] Associated with each type of data and analysis technique are varying levels of both cost and effectiveness. If the decision-maker has to choose among one of these techniques, the following considerations are

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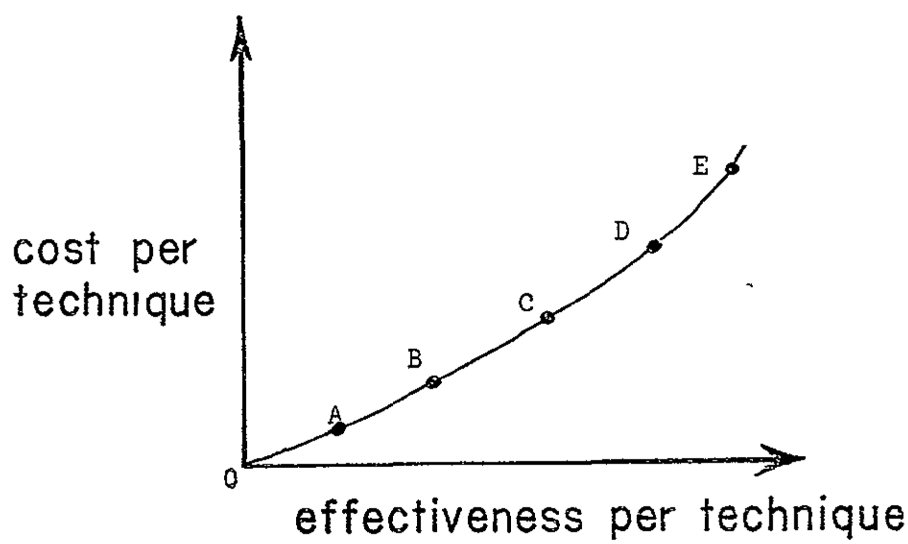
[1]A detailed elaboration of the following discussion on cost and effectiveness can be found in William F. Sharpe, <u>The Economics of Computers</u> (New York Columbia University Press), 1969.

relevant (1) given m techniques with identical costs, the most effective technique is the "best" technique, and (2) given r techniques with equal effectiveness, the least costly technique is the "best" technique

The amount of cost and level of effectiveness associated with each technique for generating an information product can be plotted on a graph, with each point representing the combined cost and effectiveness of one technique (Graph 4)



Graph 4. Cost-effectiveness combination graph for producing an information product.

Points can be joined to produce a curve showing the nature of the trade-off between cost and effectiveness as different combinations of techniques or single techniques are used to produce similar information. Point A, for example, might represent the cost and effectiveness of using satellite imagery alone for producing a map, point B might represent the cost and effectiveness of using both aircraft and satellite imagery for producing a map, point C might represent the cost and effectiveness of using high altitude and low altitude aircraft data to produce a map, while point E might represent the cost and effectiveness of using ground surveys to produce the same map

The obvious problem confronting the decision-maker is to select the most operationally feasible point on the cost-effectiveness curve This can be done after a careful and rigorous assessment of the costs and effectiveness associated with each technique. These assessments of costs and technical effectiveness can be performed by accountants and technical staff, respectively, after the relevant data have been collected during the experimental phase of the LANDSAT project

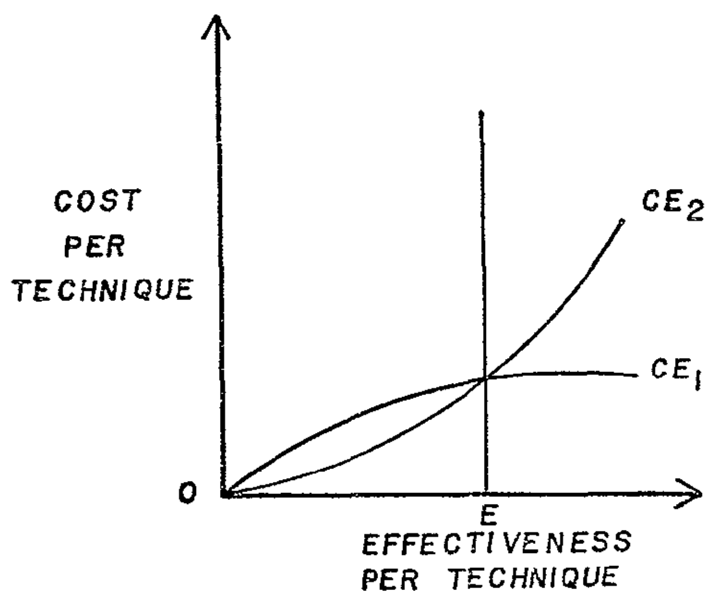
The main justification for a cost-effectiveness evaluation of both satellite data and other available data as inputs into the production of information is that the use of satellite data vs aircraft-acquired data is not an either/or proposition from a strictly technical or managerial point of view. Since these various sources of data are, in many instances, complementary, the two together (plus ground surveys, if necessary and/or feasible) might form an adequate source for a resource information or monitoring base. For example, satellite data can be useful to obtain large areal coverage, for generalized land use classification and for pinpointing areas that require aircraft-acquired data for more detailed and specialized study.

These considerations lead directly into the concept of cost-effectiveness evaluations of alternative techniques for the production of similar information. A comprehensive cost evaluation of LANDSAT data uses might include one or two case studies, documenting the cost and effectiveness of integrating satellite and non-satellite data as an alternative information technique

A final justification for a cost-effectiveness evaluation of satellite data vis-a-vis non-satellite data is that such an evaluation will provide the basis for cost comparisons among satellite capabilities, current capabilities, and the capabilities of a "mix" of techniques. Not only are cost comparisons per se a vital ingredient in the decision-making process, they are a necessary ingredient for determining and evaluating the information and monitoring requirements for managing coastal resources.

A cost-effectiveness evaluation of alternative techniques must consider both cost and effectiveness as variables If the decision-maker sets a minimum level of effectiveness arbitrarily, and then proceeds to find the least costly technique for producing an information product that fulfills the predetermined effectiveness criterion, the technique selected may be a less than optimal technique when evaluated in terms of both cost and effectiveness. In short, the adoption of "minimum requirements" criteria for selecting a technique may lead to the use of inefficient techniques--i e , inefficient within the context of cost-effectiveness.

This argument of cost-effective efficiency may be illustrated by means of a graph (Graph 5). Assume that the required minimum level of effectiveness is set at E, and that the decision-maker wishes to find the least costly technique for achieving this level of effectiveness in an information product If the true cost-effectiveness relationship of this information technique is represented by the cost effectiveness curve CE_1, the optimal level of effectiveness may be greater than OE, since incremental increases in the level of effectiveness are accompanied by less than proportional increases in associated costs The implication is that the decision-maker stands to gain either by increasing



Graph 5. Cost-effectiveness relations and the minimum requirements approach

the effectiveness criterion or by changing the techniques in order to achieve greater effectiveness, i.e., additional increments of effectiveness are relatively cheap

In the second situation, assume that the true cost-effectiveness relation is illustrated by the curve CE_2. In this case, the optimal level of effectiveness is less than OE, since a relatively small reduction in the required level of effectiveness would be accompanied by a larger than proportional reduction in cost The implication in this case is that the required level of effectiveness is too costly in terms of alternative techniques

The analysis could be also expanded to include a discussion of the implications of setting minimum cost requirements, and similar conclusions would follow.

The minimum requirements approach to technique selection should not be dismissed out of hand, however. Careless application of the minimum requirements approach to selection of techniques for the generation of information products can lead to less than optimal results, as the above discussion has demonstrated. There are, of course, minimum requirements that an information product has to meet if the data that it conveys are to be useful in reducing the uncertainity of decision-making. The data have to be of a certain nature, the levels of resolution and synopticity have to meet certain standards, and the frequency and availability of the data might be an important factor in technique selection. Cost constraints are important also, especially in terms of allocating public monies among competing agencies, projects, and objectives. Given these considerations, a careful evaluation of the techniques generating information products from satellite data, as well as other data analysis techniques or combinations of techniques, should focus on assessing the nature of cost-effectiveness relations associated with each technique within a range of acceptable and feasible values of both costs and effectiveness.

A strict evaluation of the cost savings associated with any one technique cannot be divorced from cost-effectiveness considerations This is particularly crucial in evaluating the use of satellite data in the production of information products, since this data and the techniques used to analyse it will be different in kind from current capabilities and techniques. If satellite data generates information that is comparable to currently available information products, i e., if the effectiveness of satellite analysis techniques are comparable to the effectiveness of current techniques, the above considerations on cost-effectiveness are inapplicable to the study And if this is indeed the case, the cost-savings method is the most applicable method to use for an evaluation of LANDSAT-derived data.

APPENDIX H

METHODOLOGIES FOR ESTIMATING STATISTICAL DEMAND FUNCTIONS

prepared by Koren Sherrill

There are several methods that can be used to estimate demand functions for goods and/or services.[1] The most commonly used and generally acceptable method involves collection of data on the past and/or expected future behavior of relevant variables and using these data to estimate a regression equation that specifies the nature of the interrelationships among the variables

This method involves gathering enough data to derive a specific equation from the relationship $X = f(P_x, P_y, P_z, M)$, where X is the amount of the good (LANDSAT information) that is demanded, P_x is the price of good X, P_y and P_z are the prices of other goods, such as information derived by aerial survey, ground surveys, etc , and M is aggregate income, or the potential users' budgets Mishan has suggested that goods y and z could be chosen as being close and important substitutes for x, or else y could be a close substitute and z a close complement of x, the relative prices of all other goods being ignored. Sometimes the price of one or more factors

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[1]A good bibliography on estimating demand functions is provided in H. H Liebhafsky, The Nature of Price Theory (Homewood· The Dorsey Press, revised edition), pp. 214-217 Some of the more commonly exployed methodologies for estimating statistical demand functions are illustrated in E. J. Working, "What Do Statistical 'Demand Curves' Show?", in Kenneth E Boulding and George J. Stigler, eds Readings in Price Theory (Homewood Richard D Irwin, Inc., 1952), pp. 97-115, Frederick W Bell, "The Pope and the Price of Fish," American Economic Review, December, 1968, pp 1346-1350, and William J. Baumol, Economic Theory and Operations Analysis (Englewood Cliffs Prentice-Hall, Inc , second edition), Chapter 10, "On Empirical Determination of Demand Relationships "

are to be included in the function. In any statistical estimate of the price-demand curve for X, the ceteris paribus clause will operate to hold constant only those variables, other than P_x, that are included in the function F. All those variables that are not included in the function F--an almost unlimited number of goods and factor prices--are assumed, provisionally at least, to be of neglible importance [2] After the relevant data are collected, the particular equation that specifies the nature of the relationships among the variables is determined or estimated by the method of least squares This method involves estimating a curve that describes, as accurate as possible, the relationships among the variables being analyzed The estimated curve is one that best "fits" the data, in that the sum of the deviations between the plotted data and the estimated curve is minimized.

Another method of estimating demand functions, and one which has a relatively recent history, is referred to as decision theory, information theory, or Bayesian analysis. This method represents a mix of game theory, probability and statistics, and economic theory. The methodology itself is too lengthly to describe here, but excellent sources on this methodology can be found in other studies[3] and will not

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[2]E. J Mishan, Cost-Benefit Analysis An Introduction (New York, Praeger Publisher, 1971), p 35

[3]See Earth Satellite Corporation and Booz-Allen Applied Research Corporation, Earth Resources Survey, Cost-Benefit Study, study prepared for the U.S Department of the Interior, November 22, 1974, Vol. V, "Approach and Methods of Analysis", Mishan, Cost-Benefit, op cit., pp. 268-315; and Baumol, Economic Theory and Operations Analysis, op cit., pp 512-568.

be repeated here. The Earth Satellite Resources Survey emphasized the use of information theory to determine the value of information, and this study is particularly relevant to the LANDSAT project Mishan and Baumol have also written excellent introductions to the applications of information theory to determine the value of information in situations characterized by uncertainly, and it is recommended that the final cost-benefit evaluation of the LANDSAT project should incorporate some of these methodologies in estimating statistical demand function for LANDSAT information As mentioned earlier, however, some of the more formidable procedures for estimating demand curves for LANDSAT information can be circumvented by assuming an inelastic demand for LANDSAT information. Given this assumption, which is not an unreasonable assumption to make in the context of this evaluation, the only estimating task that remains is to determine the frequency which with which LANDSAT information is needed by decision-makers who are charged with coastal management programs. And since coastal monitoring, whether by LANDSAT or conventional non-ERS technologies, is a crucial input into coastal management programs, some attention needs to be devoted to estimating the nature of the demand for LANDSAT information, however elementary these estimating procedures may be.