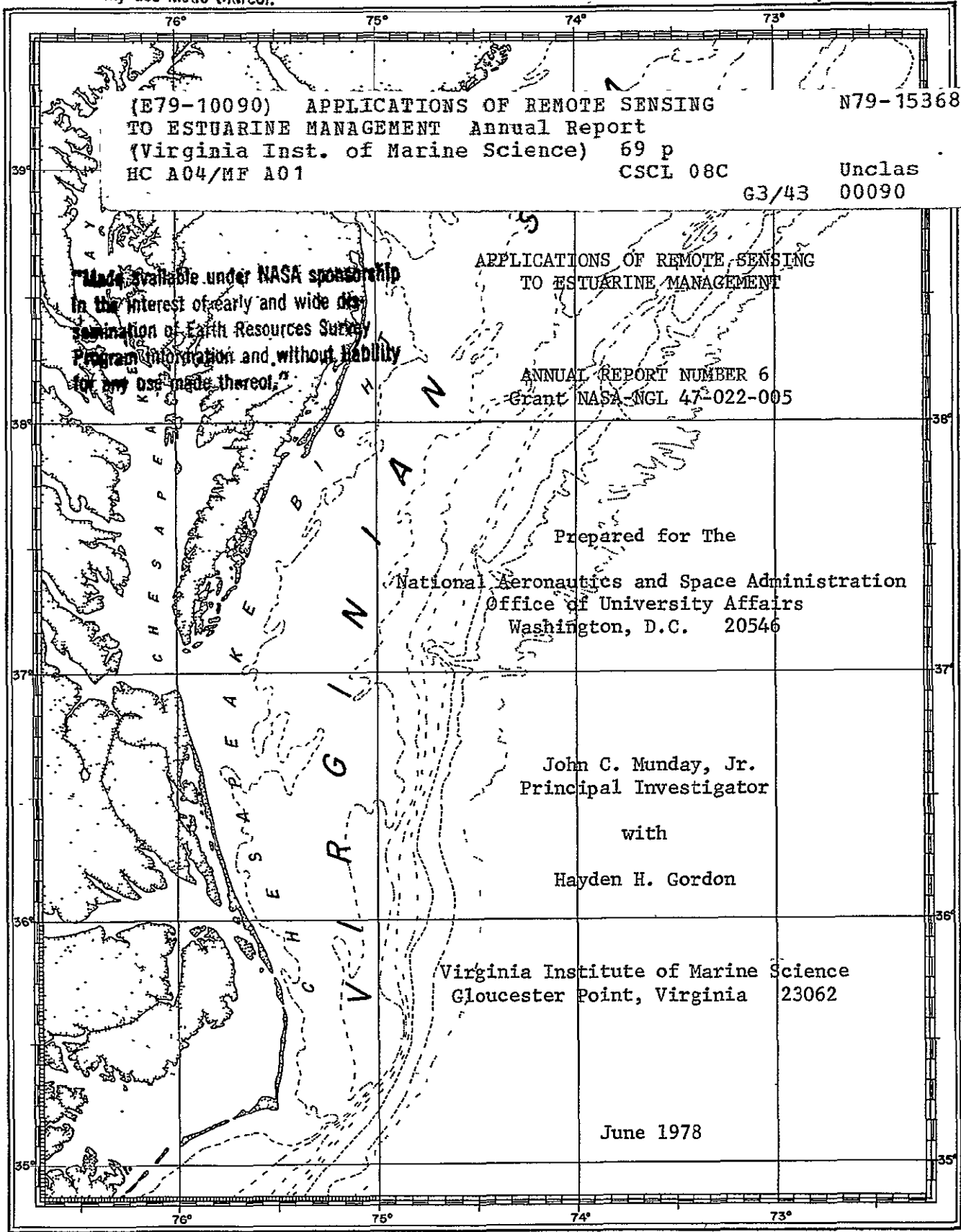


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7.9-1009.0  
CR-157982



(E79-10090) APPLICATIONS OF REMOTE SENSING TO ESTUARINE MANAGEMENT Annual Report  
(Virginia Inst. of Marine Science) 69 p  
HC A04/MF A01 CACL 08C Unclas  
G3/43 00090 N79-15368

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APPLICATIONS OF REMOTE SENSING  
TO ESTUARINE MANAGEMENT

ANNUAL REPORT NUMBER 6  
Grant NASA-NGL 47-022-005

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

John C. Munday, Jr.  
Principal Investigator

with  
Hayden H. Gordon

Virginia Institute of Marine Science  
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## ABSTRACT

Progress has been made toward implementation of a Virginia state-wide remote sensing program and resource information system. VIMS and other Virginia educational institutions, the legislative branch, executive branch agencies, NASA, and the National Conference of State Legislatures have cooperated in examining state needs which could be met using remote sensing. As a result, the Legislature has passed a resolution to establish a joint study committee which will cooperate with executive agencies in initiating remote sensing demonstration projects, and continuing the development of a Virginia Resource Information System. VIMS has cooperated with the Canadian government in further development of a technique for suspended solids mapping from historic Landsat data without surface truth; the technique is being used in sediment budget studies in the Bay of Fundy, Nova Scotia, in advance of construction of a tidal-energy barrage. The VIMS Remote Sensing Center is now meeting user data needs daily, and contributing to coastal and marine resource management decisions, particularly involving shoreline and wetlands preservation.

## ACKNOWLEDGMENTS

We thank the National Aeronautics and Space Administration, Office of University Affairs, Washington, D.C., for support of this project. We also thank various governmental agencies involved in the applications, including the U.S. National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, the Canada Centre for Remote Sensing, Ottawa, Canada, and the Atlantic Geoscience Centre, Department of Energy, Mines, and Resources, Dartmouth, Nova Scotia, Canada.

Many VIMS personnel made major contributions to the applications, and many contributed to field operations, data reduction, photo and art work, and secretarial assistance. We wish to especially thank Mr. Charles Alston, Mr. Harold Hennigar, and Mrs. Beth Marshall.

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## SUMMARY OF APPLICATIONS

### 1. Remote Sensing Program Implementation in Virginia.

VIMS began in late 1976 to assist the Virginia Air Pollution Control Board in an examination of state needs which could be met using remote sensing, particularly Landsat. This effort developed into a cooperative project involving the legislative branch, executive branch agencies with programs in environmental and geographical resources and management, educational institutions with remote sensing expertise, and NASA, with assistance from the National Conference of State Legislatures. VIMS helped guide this project which involved meetings, workshops, planning studies, and testimony before public agencies. It has now resulted in the passage of a joint legislative resolution which establishes a joint study committee, authorizes the initiation of remote sensing demonstration projects, and calls for continued development of a Virginia Resources Information System. This System will be developed under the auspices of the Virginia Department of Agriculture and Commerce in the Office of Commerce and Resources. A primary data source will be Landsat data. Water quality monitoring has high priority as a demonstration project.

### 2. Landsat Chromaticity Technique Applied to Sediment Budget Study for Tidal Power Project.

In a cooperative effort begun in 1975, VIMS and the Canada Centre for Remote Sensing (CCRS) have been developing a technique for mapping suspended

solids from Landsat data in the absence of surface information. This technique has now been validated with theoretical study and several sets of field data from the Bay of Fundy, Nova Scotia. Techniques have been implemented on the General Electric Image 100 multispectral analysis system at CCRS. The Atlantic Geoscience Centre at Dartmouth, Nova Scotia, part of the Department of Energy, Mines, and Resources, Canada, has embarked on a sediment budget study utilizing Landsat data analyzed by this technique. The sediment budget study will guide decision-making in plans to construct a tidal barrage in the Bay of Fundy. The tidal barrage is intended to harness tidal power for electric power generation.

### 3. Remote Sensing Center Applications to User Needs.

New space and equipment have been provided this year to establish remote sensing activities in the context of a VIMS Remote Sensing Center. The Center is providing assistance to various users in acquisition of aerial photography, photointerpretation, data reduction, and coastal resource analysis. The users include VIMS staff engaged in contract work and operational monitoring and advisory work for the Commonwealth; the users also include outside agencies such as the U.S. Fish and Wildlife Service. The user load on Center operations amounts to two full-time employees, one of which is attached to the Center. In a typical Center project, a marsh of one hectare in Lynnhaven Inlet, Virginia Beach, was preserved after analysis of historical and new photographs led to a plan to put dredge spoil in a different location. In another project, a landowner had illegally destroyed a small marsh on Sarah Creek, Gloucester County, and was ordered to reconstruct it. The plan for reconstruction was based on analysis of historical and new aerial photographs.



REMOTE SENSING PROGRAM  
IMPLEMENTATION IN VIRGINIA

1. Background Information

Virginia has had remote sensing activities for the purpose of gathering scientific, engineering and environmental information over the past ten years. These activities have been primarily research and development (R & D) efforts conducted by VIMS and other educational and research institutions in the State. It has been recognized in the past year that an opportunity now exists to formalize not only the R & D effort, but to also define a series of technology transfer projects into a State remote sensing program, supported by the Executive and Legislative branches of the government. The purpose is to provide the agencies of the Commonwealth with the significant benefits of an organized operational program as is already underway in other states.

The development of a State Remote Sensing Program had its beginning in 1974-75. The Division of State Planning and Community Affairs (DSPCA) was designated by the Secretary of Commerce and Resources to develop a State-wide program. Prior to that time, VIMS and numerous State agencies and University investigators had cooperated with the National Aeronautics and Space Administration (NASA) and other Federal departments, in programs that utilized remote sensing data from both aircraft and satellites. In February 1975, a meeting was held with representatives of interested State agencies for the purpose of developing a State-wide remote sensing program. This

meeting was chaired by DSPCA and representatives from numerous agencies were present including the following:

Department of Conservation and Economic Development,  
Marine Resources Commission,  
Old Dominion University, and  
University of Virginia.

Representatives from NASA and the U.S. Geological Survey also participated. The effort initiated by this meeting was to be part of a larger land-use and policy planning program. Progress was made during the following year and a half, in developing a State program, to be administered by a small staff in the DSPCA, working closely with the Governor's cabinet and the interested State agencies. With the reorganization of the State government in July 1976, the administration of the program was broken up and further development of a State program remained dormant until Senator Frank E. Moss (D-Utah) wrote a letter to Governor Godwin in September 1976, seeking state advice on the Landsat program.

Senator Moss solicited Virginia's requirements for Landsat data, comments on an Earth Resources Information System, and recommendations on proposed legislation to meet these needs. An interim reply, drafted by the State Air Pollution Control Board Staff, who had been assigned to respond to this letter, was sent to Senator Moss in mid-October 1976 expressing support for the program. Included in the letter was a copy of the resolution adopted by the Williamsburg Southern Governor's Conference which Governor Godwin chaired in August 1976, that strongly endorsed the continuation and improvement of the Landsat system. The information provided by Senator Moss was

distributed to numerous interested State agencies for comment. VIMS and seventeen other agencies replied and a summary of their comments provided the basis for the final reply to Senator Moss, which was sent to him on December 21, 1976. Continued support for the Landsat experiment was expressed as a key step in providing information required by the states in order to manage their natural resources more effectively. It was recommended that NASA be provided with the resources to enable NASA to enter into more joint Landsat efforts with the states in order to hasten the transition to a fully operational system.

The comments provided by Virginia were given considerable attention by the Senate Subcommittee on Science, Technology and Space. Senator Adlai E. Stevenson, now the Committee Chairman, wrote Governor Godwin on May 13, 1977, commending the Commonwealth for its comments, and asked him to testify regarding the revised legislation. Since the Governor had another commitment on the appointed hearing date, Dr. William Hargis, Director of the Virginia Institute of Marine Science, was designated as the State's spokesman. In his June 9<sup>th</sup> letter to Senator Stevenson, Governor Godwin endorsed the proposed legislation to develop and establish an Earth Resources and Environmental Information System as a most essential action. He cited numerous areas in which remote sensing had the potential for helping Virginia improve its natural resources management.

The testimony presented by Dr. Hargis on June 14, 1977 was prepared from input by State agencies and research and educational institutions, and consisted of a Virginia position paper and a summary presented orally by Dr. Hargis. Dr. Hargis responded to many questions asked by Subcommittee

Senators and staff, and his testimony was well-received. Representatives from Georgia and Nebraska also testified at the hearing along with a representative for the National Conference of State Legislatures, and Mrs. Eilene Galloway, a special consultant to the Senate Committee on Aeronautical and Space Sciences.

## 2. Development of a Remote Sensing Program for the State of Virginia

Subsequent to the Senate Subcommittee Hearing in June, 1977, the State Air Pollution Control Board (SAPCB) asked State agencies to further define their remote sensing data requirements, to continue the development of a State remote sensing program. A number of them stated in general terms their requirements and all indicated a need for education and training in order for them to apply this technology to their data needs. From a survey of the research and educational institutions involved in remote sensing, namely Virginia Institute of Marine Science, Old Dominion University, University of Virginia, and Virginia Polytechnic Institute and State University, the SAPCB determined that these institutions are the best qualified state groups to assist State agencies in remote sensing, educational and technology transfer efforts. Thus, the program as it develops will depend on the assistance provided by the research and educational institutions.

During the development of the proposed State program, contacts with NASA centers have been extensive. These include the Headquarters in Washington; the Goddard Space Flight Center, Greenbelt, Maryland; the Langley Research Center, Hampton, Virginia; and the Wallops Flight Center, Wallops Island, Virginia. Formal correspondence and personal visits have resulted

in extremely helpful exchanges of information and good working relationships. NASA has provided assistance in the project phases to date, and will assist in joint projects which receive State government (Executive and Legislative) support with both program approval and budget authority.

It was early recognized that, in order to pursue program definition, an urgent need existed to establish formal Legislative Branch support for the effort. Information briefings were therefore provided to the three committees of the General Assembly having concerns relating to this program, namely the Senate Agriculture, Conservation, and Natural Resources Committee, the House of Delegates Agriculture and Conservation Committee, and the House of Delegates National Resources Committee. NASA and NCSL representatives assisted State personnel in such presentations. VIMS provided guidance and testimony in these presentations. They were made during the General Assembly's 1978 Session. One critical hearing held jointly by all three committees took place on January 18, 1978. Following these briefings, sponsoring patrons were found to present appropriate legislation to the General Assembly during its 1978 Session. A joint resolution was prepared and passed by both houses of the Assembly in February and March, 1978. The text of the Resolution is contained in Appendix A.

The State's remote sensing efforts to date have been supported out of general administrative budgets, or related to work associated with Federal grants such as this NASA grant at VIMS. In order to more properly attack the program definition required for this effort to be a success, executive budget support explicitly targeted for development of a remote sensing program is needed. Such funds would be used to administer and coordinate the

effort at the state level, and provide for execution funds to the State agencies participating in the program's development. Recommended budget levels have been prepared. Without such support, the remote sensing effort of the State would likely be limited to a low priority effort based on Federal funds supplied to the research and educational institutions primarily for R & D work. It is to be noted that Federal funds granted to research and educational institutions available to indirectly support state program development are increasingly scarce; consequently, institutional support for program development in the absence of a state budget is already in an inevitable decline.

To better inform state agencies with operational program responsibilities of potential remote sensing benefits, state agencies were invited to participate in a number of workshops and conferences during 1977 and 1978. Various agencies were represented in organizational meetings in the summer and fall of 1977, when VIMS and other educational institutions presented program possibilities and discussed the development of a state remote sensing program in the light of data needs of the various agencies. In December, 1977, agency representatives attended the NCSL regional workshop on state uses of remote sensing held in Lanham, Maryland. A formal state workshop for state agency representatives was then organized and held in January, 1978. This workshop included NASA and NCSL representatives as participants; the agenda included presentations by VIMS and other educational institutions about ongoing activities and potential projects which would benefit state agencies. Other meetings were held in the months of February and March leading up to a second state workshop on April 11, 1978. At this workshop, the Secretary

of Commerce and Resources addressed the heads and other representatives of 20 state agencies, and introduced a program including the four regional NASA centers, NCSL, and VIMS and the other educational institutions. A principal feature of this workshop was the consensus that a Virginia Resource Information System would be the focus for meeting state data needs, and that a primary methodology to be incorporated into this system will be remote sensing.

### 3. Present Status

The present status of the Commonwealth resource system and remote sensing program is that responsibility for program development has been assigned to the Department of Agriculture and Commerce, under the Office of the Secretary of Commerce and Resources. A program document has been circulating among state agencies since January. This document presents the concept of the Virginia Resources Information System and discusses the use of remote sensing methodology, and lists, by program area, potential technology transfer projects along with proposed schedules and agency involvements. VIMS has had substantial input to this document. In the immediate future, discussions of specific projects with individual agencies will continue, toward the goal of defining and initiating demonstration projects within the coming twelve months.

#### 4. Definition of a Landsat Water Quality Demonstration Project

Landsat has a proven capability for measuring several important water quality variables, namely suspended sediment, chlorophyll, water transparency, and temperature.

At present costs for surface survey programs, water surveys by boats cannot be extended to include all of Virginia's water bodies. It would be too expensive. Consequently, many water bodies may suffer declining water quality before being noticed and included in a water quality monitoring and control program. Landsat can be used to fill the gap as an inexpensive means of monitoring water quality, particularly in the manner of an alarm system that particular water bodies need attention.

An effort was therefore initiated with the Virginia State Water Control Board (SWCB) to develop a Landsat water quality monitoring program. This effort was first begun with the Piedmont Regional Office (PRO) in Richmond, Virginia because PRO personnel had been involved in a Landsat study in the past and were familiar with the Landsat system and its general potential.

The Piedmont Regional Office of the Virginia State Water Control Board has jurisdiction over 52 water bodies of 20 acres or more in size. These include both saline and fresh waters from the James River to the Appalachian Mountains at the edge of the Piedmont Plateau. Water quality monitoring activities of the Office are situated in the Division of Surveillance and Field Studies. The director of this Division has authority and responsibility to sample and test the waters of his jurisdiction on a regular basis for a set of more than 15 water quality variables, and to direct treatment modifications, order cessation of polluting activities, or advise other regulatory agencies of the Commonwealth of needed actions within their jurisdictions, whenever water quality standards are breached.



The Division Director is convinced of the utility of Landsat data for synoptic mapping of water quality classes in a large number of water bodies, as a result of an earlier cooperative project with NASA in 1974 and 1975 (Trexler and Barker, 1975). For two reasons this project was discontinued: first, Commonwealth agency budgets in 1976 were cut almost 10%, forcing the Director to reduce the level of monitoring activities below the earlier level, and leaving no resources to put toward a Landsat monitoring effort; and second, it appeared at that time that Landsat monitoring would be useful only when simultaneous surface information was available to individually calibrate each Landsat overpass. This latter constraint was viewed as requiring that diminishing resources be rearranged to provide for Landsat calibration, an impossibility if existing monitoring programs were to be maintained as required by law.

New Landsat investigations (Alföldi and Munday, 1977, 1978) have shown that useful, quantitative data on suspended sediment concentrations and water color can be obtained from multitemporal Landsat data, even when surface information is available for only one or a few of the Landsat passes. These results involve the use of chromaticity analysis, with a spectral method of adjusting Landsat data to account for atmospheric variations from pass to pass. The consequence is that older Landsat data may be utilized in conjunction with new data, so long as at least one pass in the series to be used is calibrated by acquisition of surface information. The data may then be reduced and analyzed for changes in water quality over the entire period of the Landsat program.

Chromaticity analysis is advantageous, moreover, because it produces an easily understood graphical display of water quality changes. The results

can be quickly interpreted. Consequently, the Landsat data can function as a water quality alarm system, which will bring to the attention of the Division Director any situations which are changing and which need to be scheduled for special water sampling. The data can also be used as a basis for visual presentations by the Director to other agencies and levels of government, to evoke responses and galvanize action in their jurisdictions.

The Division Director has stated that on the basis of Landsat data he is ready and has authority to take specific actions. In the past, for example, the Division Director has altered sampling schedules and locations as needed, has notified the Commonwealth Soil Conservation and Water Conservation Commission of soil erosion problems causing an increase of water turbidity, and has requested the Commission of Game and Inland Fisheries to remove beaver dams because they reduced flow and aggravated pollution problems. Thus, he is ready to alter monitoring schedules, change the location of sampling programs, order the cessation of polluting activities, and advise other Commonwealth agencies of needed actions within their jurisdictions.

Attention is presently centered on Lakes Kerr, Gaston, Chesdin, Anna, and Swift Creek Reservoir. It is acknowledged that these water bodies, and other smaller water bodies used for public recreation, are in need of additional monitoring which can be provided by Landsat. Specific problems in these water bodies have been discussed. For example, several tributaries and arms of Lakes Kerr and Gaston are already known to be suffering from an advance of pollution, but it is not known how fast the advance is occurring, because full sampling and analysis programs have been in effect for only two years. Landsat data from a five year period can be used to determine

the rate of advance, and thus to warn of future dates when serious pollution problems will exist at critical downstream points where water intakes for industries and municipalities are located. It will be possible to identify in more detail the specific actions which might be taken as actual Landsat data analysis gets underway.

Several steps have been taken this year toward implementation of this water quality monitoring program. The steps were guided by the policy that, given the developing state program in remote sensing, any Landsat water quality demonstration project should be immediately transformable into an operational state program. The significance of this policy is that quick results have been sacrificed in favor of developing SWCB long-range participation in the state remote sensing program, and building a Landsat user center accessible to the SWCB as well as other state agencies.

For the program in the PRO, water bodies have been identified, and available field and laboratory data retrieved from EPA STORET files. Data for the period before 1975 are meager, and even the more recent period, 1975-1978, involves extensive data collection on only a few water bodies. Some of these water bodies are streams not suitable for Landsat data analysis. Therefore, the PRO Division Director has rearranged future surveys to coincide with Landsat overpasses as far as possible. This will ensure the future availability of surface data for calibration of Landsat CCTs.

Steps have also been taken to arrange the necessary computer facilities for Landsat data analysis, in such a manner as to provide for a Landsat user center available and open to all state users in the Tidewater Virginia area. The Southeastern Regional Computing Center at the College of William and Mary is an appropriate center for implementation and testing of Landsat

data analysis programs; this center serves remote terminals at various regional universities and research groups, including VIMS, ODU, and some eight other institutions, and it is centrally located between Richmond and the Tidewater urban area. Further, it is built around the same model computer system as installed at the VPI Computer Center, another of Virginia's regional computer centers. This last feature makes it possible to quickly and easily transfer capability to VPI. Discussions are in progress with the Director of the Southeastern Regional Computing Center with respect to implementation of the ORSER system, a Landsat general purpose software system which will be purchased by VIMS from the Pennsylvania State University. This software will be utilized for a variety of applications of Landsat data beyond water quality, including the mapping of land cover by personnel in coastal zone management and non-point pollution programs.

Other computer programs will be incorporated into the system. A computer program for automatically finding and identifying water bodies on a Landsat tape is available from the University of Wisconsin (Fisher et al., 1978). Another Wisconsin program classifies water bodies according to trophic state (a measure of nutrient enrichment and plant growth) (Scarpace et al., 1978). Also, a system has been jointly developed by VIMS and the Canadian government for using Landsat to quantitatively measure suspended solids concentration in water bodies, and this system can be applied to historical Landsat data (which reach back to 1972) to show turbidity changes with time over the past 6 years. Thus, water quality trends can be established using old data. NASA Goddard has expressed its readiness to assist in merging all the above programs into a Landsat water quality software package, and to assist in its implementation in Virginia.

As these elements of a Landsat water quality monitoring system are being assembled, meetings are being held which jointly involve SWCB, NASA, VIMS, and other state remote sensing program planners in the Department of Agriculture and Commerce. The consensus developing from these meetings is that deliberate steps forward should be made, and that special attention should be given to combining efforts of all state agencies interested in remote sensing applications, because a cooperative effort will be most efficient and productive of new applications in the future. Water quality applications are recognized to have high priority. The indications are that progress toward implementation of an operational Landsat water quality monitoring system will be measured and steady over the next year.

LANDSAT CHROMATICITY TECHNIQUE APPLIED TO  
SEDIMENT BUDGET STUDY FOR A TIDAL POWER PROJECT

1. Origins of the Sediment Budget Study

In the search for energy resources, tidal power is often discussed but exploited very little. The site of the world's largest average tide, the Bay of Fundy, Nova Scotia, has been proposed for extraction of tidal power for decades; for engineering and capital reasons, no serious attempt has been made in the past to harness the Bay of Fundy tide. Recently, however, the Government of Canada has embarked on engineering studies. This change should be viewed as significant, because Canada in the last decade has taken on large engineering projects involving the environment, such as the James Bay power project and the trans-Canada gas pipeline; thus, the Bay of Fundy engineering studies are possibly the first of a series that could lead to a tidal barrage. In this context, it is necessary to have accurate information with respect to not only the volumetric water flows in the Bay of Fundy, but also the material transport of the system, in particular, the flux of sediment.

Sediment flux is important for its potential to scour parts of a barrage and erode its foundations. It is also of concern for its potential to fill in the volume now behind the proposed site, and thus reduce the projected water flow and power output from the barrage. The Department of Energy, Mines, and Resources of the Government of Canada has therefore supported a study of the sediment budget of the Bay of Fundy. This study is being carried out by Dr. Carl Amos at the Atlantic Geoscience Centre

(Dartmouth, Nova Scotia). At the outset in 1974, the study was based on field work. Because the average tide in the Bay of Fundy is over 10 m, field work involving vessels is difficult. A necessary aspect of the study is to obtain a synoptic view of the mass of sediment in the system at a single time. However, the large tide and high currents cause the system to change rapidly. The search for better methods to study the sediment budget led Dr. Amos to consider the potential of the Landsat system for synoptic measurement of suspended solids at the water surface.

## 2. Suspended Soil Solids Measurement from Landsat

Since the launch of Landsat 1 in 1972, many investigators have used Landsat to measure suspended solids. The methods used have involved the simple correlation of Landsat response to measures of suspended solids concentration. Various relationships have been assumed between the Landsat response and the concentration. Often, an adequate relationship for the particular data in a single study has been a linear equation between Landsat radiance and the concentration, but at times a large range of concentrations has necessitated the use of a non-linear relationship to obtain a close correlation.

The degree of correlation is adversely affected by several variables outside the control of the investigator, namely, atmospheric haze, thin cloud cover, white caps, sun glint, and water inclusions other than suspended solids. In 1974 a study was begun to develop a method for correction of effects due to these variables, a method which would not depend on extensive modeling of the atmosphere nor on collection over a wide area of data on these variables during a Landsat overpass. The method development

centered on ratio normalization of Landsat radiances, which produces coefficients analogous to human color vision chromaticity coefficients. Hence, the method has been termed a chromaticity technique. The initial development was based on a densitometric analysis of Landsat images. It was shown that the chromaticity transformation yields coefficients which can be very easily manipulated to correct for atmospheric haze and other environmental variables, without the need for surface information (Munday, 1974a, 1974b). The potential was thus established for the technique to be applied to Landsat data collected in the past in the absence of simultaneous surface information, making possible the use of historical Landsat data for quantitative analysis of suspended solids.

### 3. Testing of the Chromaticity Technique for Suspended Solids Mapping

In the period from 1975 through the present, and especially in 1977, the basic concepts underlying the chromaticity technique and its implementation for quantitative measurement of suspended solids have been tested with Landsat CCT data. Dr. Amos has provided a continuing series of sets of field data coincident with Landsat overpasses, which have been used to directly calibrate the respective Landsat CCT responses and produce contour maps of suspended solids for each of the dates (Amos, 1976). As of late 1977, seven dates of Landsat passes were accompanied by field data. These seven dates included passes of both Landsats 1 and 2, as well as both high and low gain data from Landsat 2. The field data were analyzed in conjunction with analysis of the respective Landsat CCTs by Mr. Thomas T. Alföldi of the Canada Centre for Remote Sensing (CCRS) and by J.C. Munday



(VIMS) on a General Electric Company Image 100 multispectral data analysis computer at CCRS. At the same time, many other Landsat CCTs were utilized in a study of the applicability of the chromaticity technique for discrimination of various targets other than suspended solids in water, under the influence of the interfering atmospheric and other variables mentioned earlier. This practical testing of the chromaticity technique has resulted in a series of publications (Alföldi and Munday, 1977; Alföldi and Munday, 1978; Amos and Alföldi, 1978). To summarize the results of these investigations, it has been found that radiance noise of equal proportions in all bands is removed by the chromaticity transformation, and residual chromatic effects of other noise are easily perceived on a chromaticity diagram. Chromaticity loci have been defined for pure water, suspended solids, chlorophyll, bathymetry, dry versus wet sand, snow, ice, air pollution, haze, and clouds of variable thickness. Contaminating shifts of the sediment, chlorophyll, and bathymetric loci by sun glint, whitecaps, thin clouds, haze, and air pollution may be graphically or automatically corrected and standardized. Multidate suspended sediment sampling in the Bay of Fundy has produced a correlation coefficient to Landsat data from seven dates, after the above correction, of  $r = 0.95$ . The regression coefficients between the surface data and the satellite data can thereafter be used with the chromaticity-based atmospheric adjustment to calibrate other satellite scenes with no surface sampling.

Theoretical study has also been carried out over the same 1975-1978 period, to investigate whether the ratio normalization as employed in the chromaticity technique is the optimal transformation for the intended use, and to investigate the relation between the chromaticity technique and

various diffuse reflectance models used in Landsat studies of suspended solids. The study of transformations led to the conclusion that ratio normalization is theoretically optimal for the purpose of removing total radiance information from Landsat data, because it simultaneously leaves chromaticity invariant while completely removing total radiance information (Munday and Alföldi, 1975). With sets of data recently available from the field study, it has been shown by statistical analysis that a non-linear relationship between Landsat radiance and suspended solids concentration is better at curve-fitting than a linear relationship. Only for small ranges of concentration will non-linear and linear models be equally satisfactory. However, chromaticity loci for suspended solids from a large number of Landsat scenes are non-linear, requiring a non-linear model. In particular, the quasi-single-scattering diffuse reflectance model developed by Gordon and co-workers is corroborated (Munday and Alföldi, 1978, submitted).

#### 4. Systems Implementation

Operations for point-by-point chromaticity analysis and for scene-wide chromaticity analysis and display have been implemented on the Image-100. Results are displayed on the color television monitor and computer terminal, and can be output on line printer or reproduced on hard (paper) copy in seconds. Both modes of operation can be used for diagnostic analysis of substantial portions of a Landsat scene in less than 90 minutes of user time. Preliminary considerations indicate that a Landsat water quality alarm system emphasizing either suspended solids or a water quality index

could be implemented for large areas containing thousands of lakes; estimates are that a system providing twice-yearly coverage (or more) of lakes in the Province of Ontario, Canada, would require an effort of roughly 0.5 man-year annually.

At the present level of automation, an experienced person can make all necessary preparations for displaying Landsat scenes after chromaticity transformation (the area mode of operation) in about 35 minutes. This can be followed within another 40 minutes by generating, for example, eight categories of suspended sediment concentration and producing a hard copy map for 1200 km<sup>2</sup> of land area containing water bodies, at maximum resolution. Work at present is directed to further automation of the technique, and refining of the software to increase its speed. If Landsat CCTs were preprocessed to generate data records for the chromaticity analysis containing only water (instead of both land and water) there would be a substantial reduction in the times needed for water analysis.

Initial steps have been worked out with the Eastern Region Remote Sensing Applications Center (ERRSAC) at the NASA Goddard Space Flight Center, to implement these techniques and associated Image-100 software on the NASA Goddard Image-100. ERRSAC also plans to implement the technique in Fortran software appropriate for a subroutine to the Pennsylvania State University ORSER System (a Landsat and other multispectral-scanner data software analysis system written primarily in Fortran for an IBM 370 Model 168 computer; see Borden et al., 1974). A further plan is to merge the chromaticity methods with the University of Wisconsin water quality analysis programs which automatically find and identify water bodies on CCTs (Fisher et al., 1978), and produce a classification of all water bodies

into trophic status (Scarpace et al., 1978).

#### 5. Application to the Bay of Fundy

The Landsat chromaticity technique has now been applied to the quantitative determination of suspended sediment concentration in the macrotidal coastal embayment of Minas Basin, Bay of Fundy (Amos and Alfoldi, 1978, submitted). Landsat 1 and 2 data both with and without surface information are being utilized. During the course of the application, several conclusions have emerged. The chromaticity technique, firstly, has been shown to be useful for establishing a multi-date correlation with the Landsat data. A significant correlation has been found, that of  $r = 0.95$ . The error limits of the calibration are, at 1 mg/l sediment concentration,  $\pm 0.3$  mg/l, and at 148 mg/l,  $\pm 60$  mg/l. These error limits can be expressed as roughly  $\pm 30\%$  of the measured value of concentration, whatever its value, between 1 and 150 mg/l. Above 200 mg/l, the error increases exponentially. The effects of sediment shape, size, and composition appear to have, at most, only minor effects on the results with Landsat data.

Contour maps of suspended sediment in the Bay of Fundy are now being obtained, even with earlier Landsat CCTs for which no surface information was gathered. Thus, historical Landsat data are being exploited despite the absence of surface truth. The maps are being analyzed for the total amount of sediment present in the Bay of Fundy during the overpass (based on the experimental finding that sediment concentration is constant with water depth). From rates of erosion along the shorelines, the major source of sediment, the flux of sediment can be determined, and thence its capacity for scouring and filling should a tidal barrage be constructed. In addition,

the maps and Landsat images are being analyzed for their indications of tidal dynamics -- current vectors in different regions of the Bay at different phases of the tidal cycle. The results of the analyses will be extremely useful to the engineering questions presently being faced with respect to the feasibility of a Bay of Fundy tidal power station. The Department of Energy, Mines, and Resources has recently increased its level of support for these Landsat studies.

## REMOTE SENSING CENTER APPLICATIONS TO USER NEEDS

Remote sensing research projects at the Institute began in 1970, and by 1974, remote sensing services began to be provided for Institute and outside users by the research staff. The facilities have expanded gradually. User needs and research activities in 1976 grew to the point to require increased space. In the past year, additional space has been assigned to remote sensing activities to accommodate the increasing needs. Thus there is now devoted to remote sensing activities an entire small building, consisting of two work rooms and two office rooms. With this space assignment, the Institute has moved toward the establishment of a Remote Sensing Center which will serve Commonwealth and local governmental needs. The Center is seen as providing not only remote sensing project assistance, but also advisory and training services to executive branch agencies of the Commonwealth as the Commonwealth remote sensing program develops.

Users this past year have included among others the U.S. Fish and Wildlife Service, U.S. Geological Survey, the U.S. National Oceanic and Atmospheric Administration, the Virginia Marine Resources Commission, and the Virginia Office of the Secretary of Commerce and Resources. In addition there has been a steady use of Center facilities and expertise by other VIMS personnel from roughly two-thirds of the different Institute departments. Many of these Institute users are incorporating photointerpretation and data reduction techniques as a standard set of tools in their repertoire. The most frequent departmental user from the Institute has been the Department of Wetlands.

The user load on Center operations amounts now to the equivalent of two full-time persons. One equivalent full-time person is provided from the Center staff. Support for this full-time equivalent is provided by the combination of Institute funds, this grant, and user contract contributions. The second equivalent full-time person is provided by the users, at user contract expense. The funding level of the Center from all sources is roughly \$120 k per year.

As examples of the more interesting user-requested projects during 1977-1978, two wetlands projects have been selected and described below. In the first, photo measurement saved a marsh from destruction by dredge spoil disposal and provided for selection of a new site for disposal. In the second, reconstruction of a previously destroyed marsh was ordered by the courts, and the plan for reconstruction was based on analysis of historical and new aerial photographs.

1. MARSH PRESERVATION AT PLEASURE HOUSE CREEK, CITY OF VIRGINIA BEACH

The Problem

Lynnhaven Bay empties into the Chesapeake Bay southwest of the mouth of the Bay. It contains 5 square miles ( $2 \times 10^7 \text{ m}^2$ ) of water surface area, and consists of a network of large basins and small bays, interconnected with channels, and a moderate, productive marsh community. Lynnhaven Bay has one inlet opening to the Chesapeake Bay for ingress and egress of commercial and pleasure boat traffic. Statistics on commercial watercraft passage through the inlet indicate 400 to 600 trips per year, along with traffic for the numerous pleasure craft based in marinas and private residences in the Bay. The inlet is active and continuously filling, and therefore in need of maintenance dredging by the Army Corps of Engineers. Dredging was performed in 1966, 1968, 1970, and 1972, and notice was posted in November 1976 (Army Corps, Public Notice No. 18, Appendix B) to dredge as shown in the accompanying map (Figure 1). Comments were requested from state and federal agencies having jurisdiction, including: Virginia Institute of Marine Science (VIMS), Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), and National Marine Fisheries Service (NMFS).

Dredge spoil was previously disposed of at a site to the west of Lynnhaven Bay inlet on the Chesapeake Bay in 1966 and 1968, and at Pleasure House Point (Site A, Figure 1) in 1970, 1972. Further use of Pleasure House Point for dredge spoil disposal was labelled environmentally unacceptable by the EPA (letter, Appendix B) since the Point had earlier consisted of



productive marsh and had been illegally filled. Permission for further use would imply approval for past disposal practices. Also, the filled area would become more attractive as a development site for housing, which would add more pollution stress to the Lynnhaven Bay (NMFS, letter, Appendix B). The bottoms of the Bay need to be protected from pollution because 56% of its bottoms are leased as oyster grounds. The 1966, 1968 site had previously been closed since no more beach replenishment there was needed.

In order to resolve the different state and federal agency positions, a meeting was held in January 1977 at the Corps of Engineers, Norfolk, Virginia. Revised minutes from the meeting (letter, Appendix B) indicate agreement on use of Pleasure House Point for one more temporary dredge-fill cycle, with certain stipulations to discourage future development. The Corps, in addition, stated a position of no more maintenance dredging in Lynnhaven Bay inlet until a permanent disposal site could be found by the City of Virginia Beach. During the summer of 1977 the dredging was completed as agreed.

In a continuing search for future spoil disposal, Site B (Figure 1), to the southwest of Lynnhaven Bay inlet, which the Army Corps agreed would be acceptable as a permanent containment providing the City of Virginia Beach could gain clear title, was further studied. The city was already in the process of evaluating this area of sand and marsh for a potential boat ramp with parking facilities (letter, Appendix B).

In several letters to the Army Corps (Appendix B), FWS discussed the high productivity of the marsh on the southern part of Site B, and commented on the tremendous loss of marsh within Pleasure House Creek. FWS strongly desired to preserve the small remaining area of marsh on the inlet site.

However, none of the federal agencies knew how much marsh had existed in Pleasure House Creek, an important factor in the decision-making process. The problem was brought to the Remote Sensing Center at VIMS in early 1978.

#### The Use of Remote Sensing

The Remote Sensing Center uncovered historical photography of the area (USDA, 1937 and C&GS, 1962) and compared it with recent VIMS photography (1975, see Little Creek and Lynnhaven Pollution Model Tidal Prism, NASA Annual Report No. 4). All products were commonly scaled with the 1937 photography as a base (see Figure 2) and a series of overlays was made. The marsh was accurately delineated on all overlays and the areas were measured with a Numonics electronic planimeter. The changes in the marsh at the inlet site were also studied, revealing that the site accreted sand to form its present sand-marsh composition. The final remote sensing product was an overlay map with marsh acreage in a facing table. This product was given to FWS for direct inclusion in the Army Corps decision-making process.

#### Results

The planimetry revealed that there had been an 80% loss of marsh from 1937 through 1975. This large loss prompted FWS to decide that the remaining marsh must be preserved. FWS therefore stressed, upon studying the photography and the remote sensing product, that there be a dual use of the already-filled area of the inlet site (letter, Appendix B). During the peak boating months in the summer, the area would be used as a parking lot for the boat ramp. During the winter, dredge spoil would be placed on the

parking lot, and removed by trucks in the spring and used for the beach replenishment program at Virginia Beach. This proposed dual use of the already-filled area provides that the marsh on the southern end will be preserved.

#### Outcome

The matter is still under consideration by the Corps, negotiating with the City of Virginia Beach and other federal agencies, including FWS. Due to the timely remote sensing product, the Army Corps reversed its earlier thinking and now plans to preserve as much of the 1,100 square metres of marsh as possible, and still allow for the public use boat ramp so as not to interfere.

#### Conclusion

Remote sensing has been crucial in reversing Army Corps plans for dredge spoil disposal on a 1 hectare marsh in Virginia Beach, Virginia. A new plan, under consideration, is to use an alternate non-vegetated site for spoil disposal.

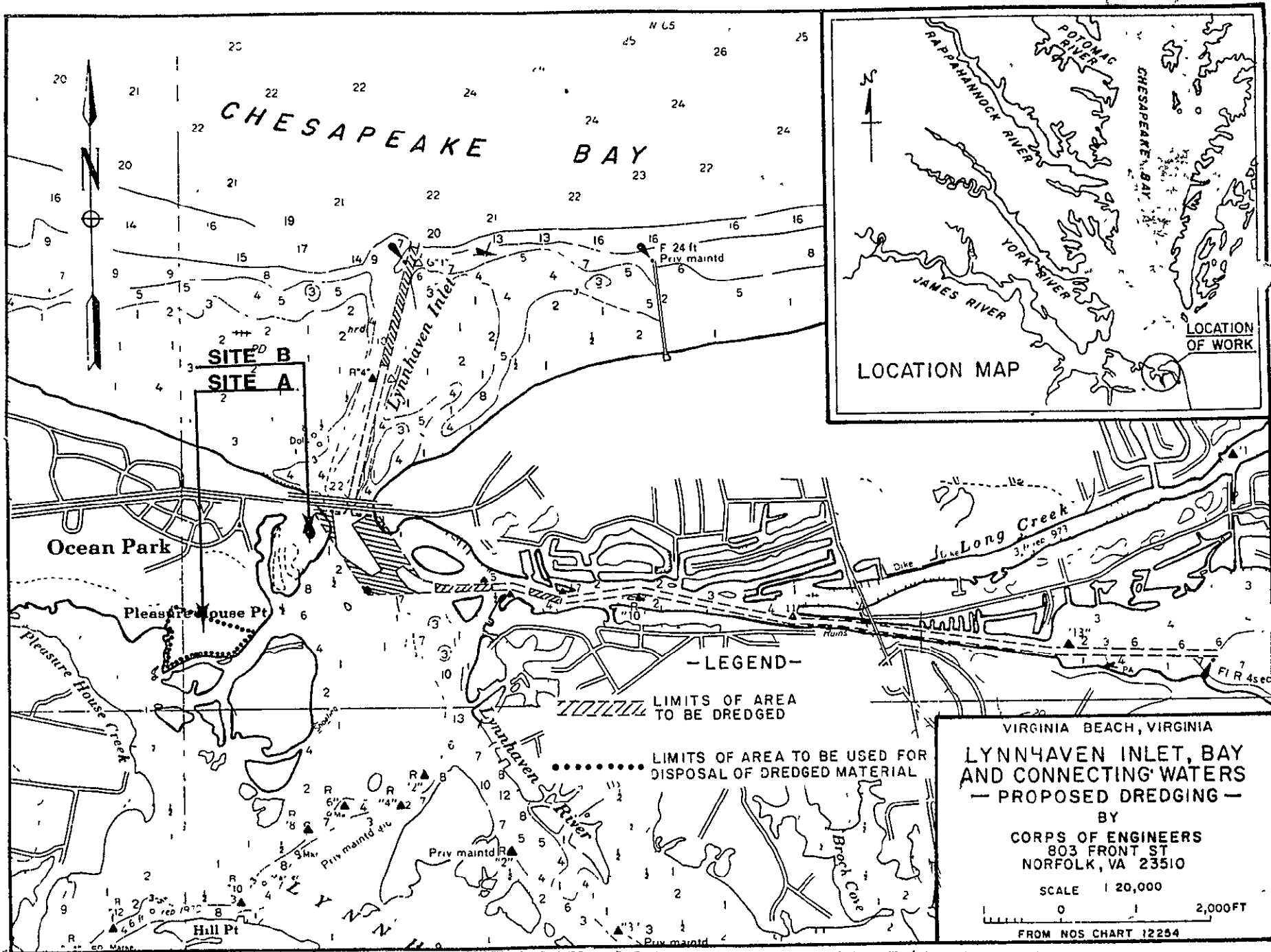


FIGURE 1. Proposed Lynnhaven Inlet Dredging and Disposal Sites.

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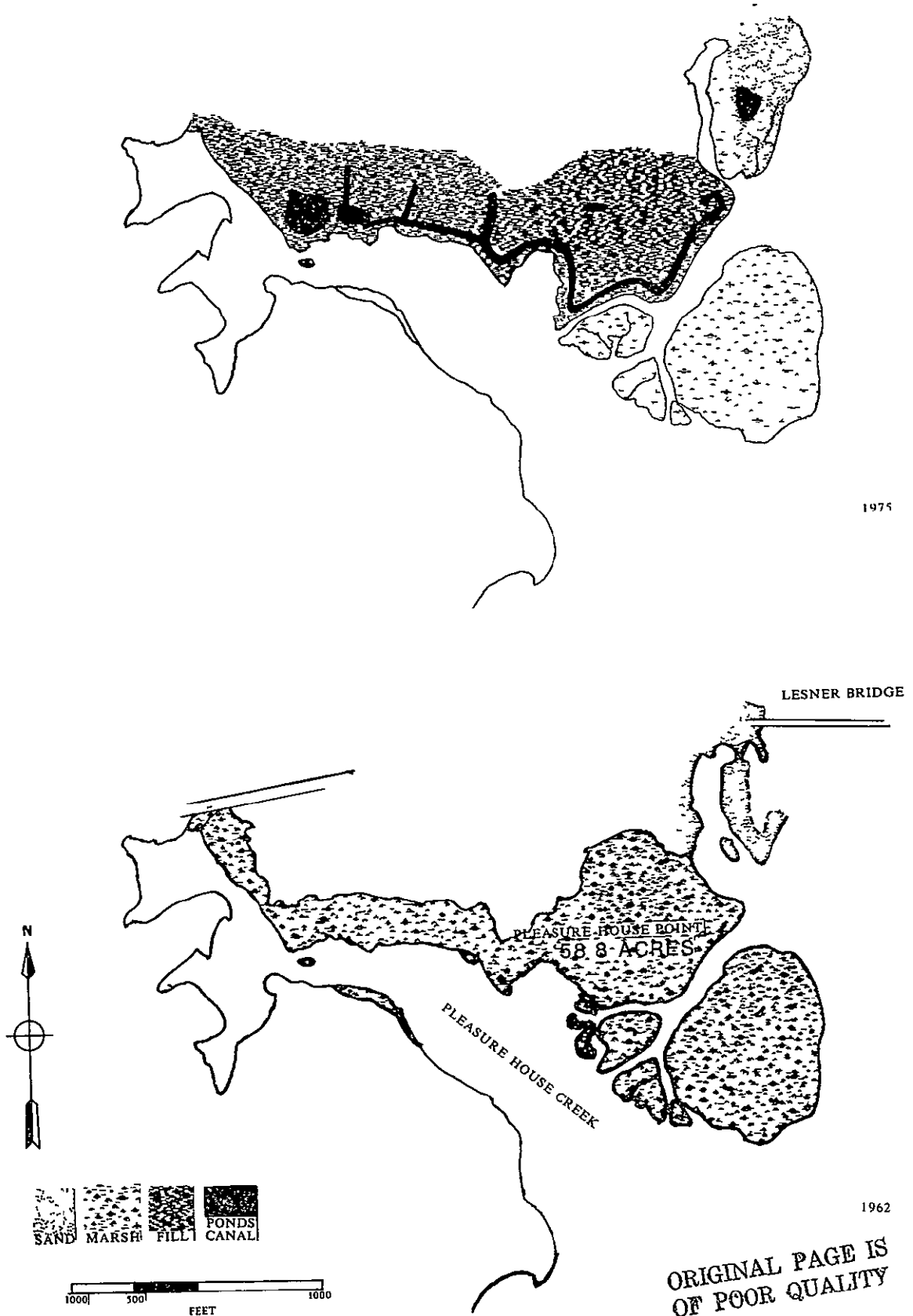


FIGURE 2. Loss of Marsh in Pleasure House Creek.

## 2. SARAH CREEK - BINSWANGER PROJECT

### The Problem

On November 9, 1973, Mr. F. Binswanger (a private individual) applied to the Gloucester County Wetlands Board for permission to build a bulkhead across a small pocket of marsh (0.2 acre, 750 square metres) in Sarah Creek, a tributary of the York River. The VIMS Wetlands Department surveyed the site, and in a report submitted in December 1973 (Appendix B) stated that the proposed bulkhead would completely destroy all marsh vegetation within the project. The decision of the Wetlands Board rendered in December 1973 was to deny the permit.

In early 1977 it was discovered by the Army Corps of Engineers on a routine field inspection that the construction of the bulkhead and fill of the wetland pocket had been illegally performed. In a letter sent April 1977 (Appendix B) the Corps directed that the bulkhead be removed and the marsh be restored to its original composition. This was so imposed by the District Court of Gloucester (including a fine), and a marsh restoration plan was formalized in November 1977 under VIMS and Army Corps auspices (see Appendix B).

### The Use of Remote Sensing

Remote sensing, furnished by the Remote Sensing Center, was used to define the restoration plan. Aerial obliques taken by VIMS prior to illegal fill activity were used as a guide for the original marsh configuration.

The Remote Sensing Center took a special vertical series of the site in November 1977 to provide a base map of the illegally altered area before any restoration. A scaled map of the proposed marsh recreation is in Figure 3. These maps were provided to the Gloucester County Wetlands Board to permit the Board to better conceptualize the illegal changes and the intended restoration.

The Board has recognized that it is most important to closely follow the fill removal and replanting to insure that the "new" marsh will stabilize. The Remote Sensing Center has been asked to help provide this information with future overflights and properly scaled drawings.

#### Current Situation

Fill removal, bulkhead removal, and marsh restoration are to begin in the Spring of 1978. A series of flights is scheduled to monitor the progress as the marsh is re-planted.

#### Conclusion

Remote sensing was a necessary and critical technique in defining a small illegally destroyed marsh in Gloucester County, Virginia, and in providing the basis for a proposed plan of marsh restoration.

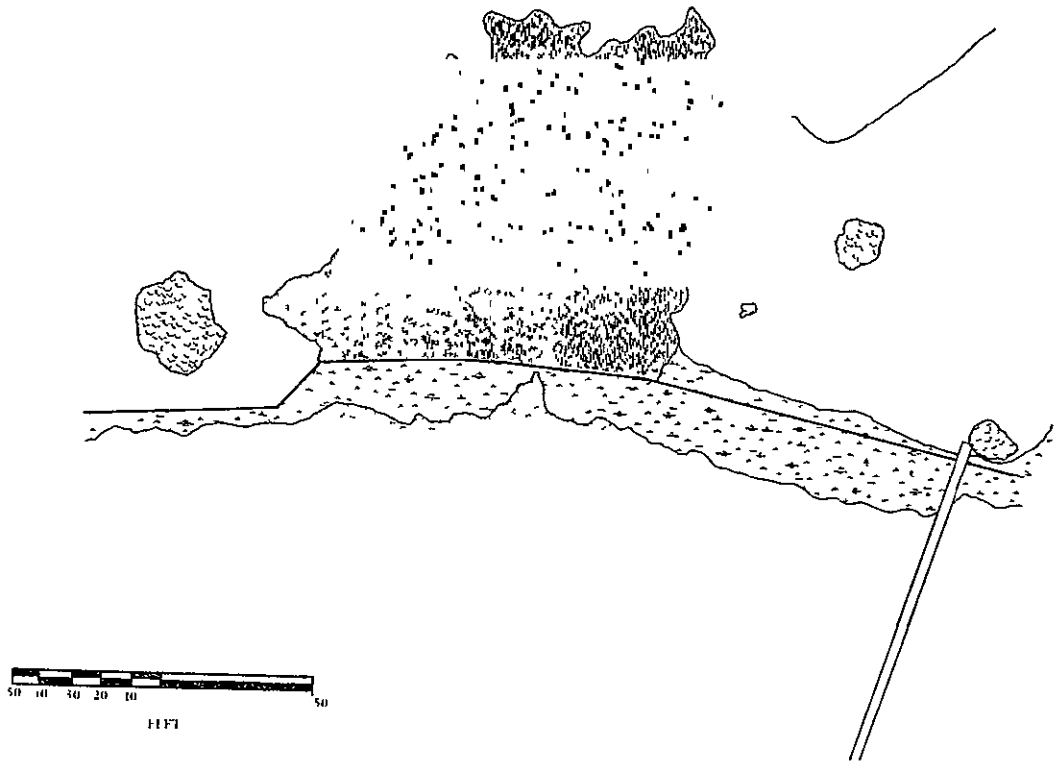


FIGURE 3a. Binswanger Project, Illegal Fill (March 1978).

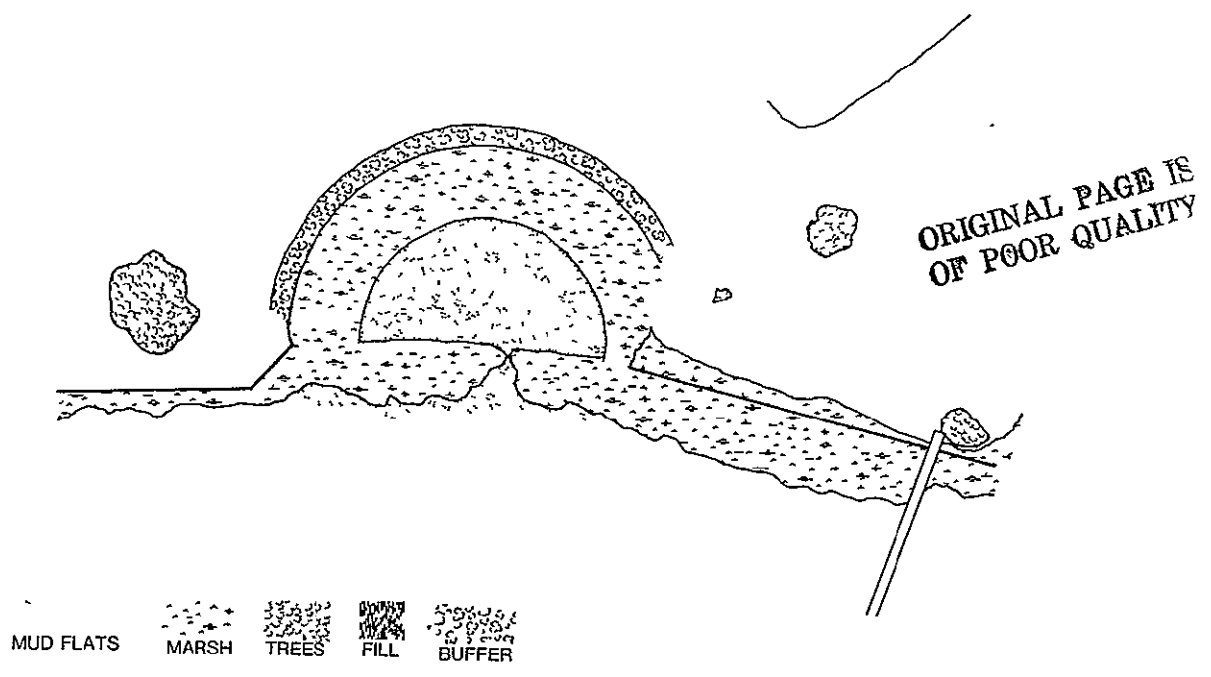


FIGURE 3b. Binswanger Project, Proposed Restoration.



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APPENDIX A

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Patrons - Quillen, Morrison, Anderson CW, McClanan, Ashworth,  
Murray, Glasscock, Keating, Heinz, Johnson, Stanbaugh, O'Brien JW, and  
Dunford

Referred to Committee on Agriculture

2 HOUSE JOINT RESOLUTION NO 175..

3 Creating a joint subcommittee to study the development of a  
4 Virginia Resource Information System.

5

6 WHEREAS, the demand for, and utilization of, land,  
7 water, forest products, minerals, energy and other resources  
8 is constantly increasing as a result of increased population  
9 and an increased rate of consumption per individual; and

10 WHEREAS, the supply and quality of natural resources  
11 throughout the Commonwealth of Virginia is finite; and

12 WHEREAS, the conversion of lands from farm, forest and  
13 water absorption uses to highways, utility rights of way,  
14 commercial, residential or industrial developments is  
15 continuing at an unprecedented rate; and

16 WHEREAS, mandatory standards for water resource, air  
17 resource and other environmental issues must be met  
18 throughout Virginia in the near future; and

19 WHEREAS, several districts in the Commonwealth are  
20 facing significant shortages in water resources; and

21 WHEREAS, many districts of the Commonwealth are  
22 experiencing rapid population growth and development; and

23 WHEREAS, the legislative and executive branches of the  
24 Commonwealth and the citizens at large have taken a strong  
25 interest in the proper management of resources and the  
26 environment in Virginia and have indentified specific

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1 recommendations directed toward its growth with a desirable  
2 balance between economic growth, environmental quality, and  
3 future resource needs; and

4 WHEREAS, there is a keen awareness by the legislative  
5 and executive branches of the Commonwealth, and by local  
6 government and citizens, of the significance, increasing  
7 complexity and lasting impact of decisions which are made  
8 relative to the use of resources throughout the  
9 Commonwealth; and

10 WHEREAS, members of the General Assembly recognize the  
11 need for an up-to-date, accurate and consistent information  
12 base in order to make intelligent decisions on resource  
13 management throughout the Commonwealth; and

14 WHEREAS, members of the General Assembly strongly  
15 believe that coordinated efforts of State agencies, research  
16 and educational institutions and cooperating federal  
17 agencies will result in greater accuracy and improved  
18 effectiveness of work relating to resource information in  
19 relation to costs; and

20 WHEREAS, members of the General Assembly strongly  
21 believe, on the basis of demonstrated experience, that the  
22 types of information obtained by remote sensing technology  
23 from high and low altitude aircraft, Landsat and  
24 meteorological satellites, and special ground or waterborne  
25 devices is extremely useful and cost effective in providing  
26 additional information that is necessary for inventorying,  
27 monitoring and evaluating Virginia's resources and  
28 environment; and

1 WHEREAS, members of the General Assembly have indicated  
2 a strong interest and intention to support the use of remote  
3 sensing to assist in resource and environmental management  
4 programs within the Commonwealth, while supporting the  
5 expansion of technology transfer capacity from NASA's Earth  
6 Resources Laboratory and from other cost effective sources;  
7 now, therefore, be it

8 RESOLVED by the House of Delegates, the Senate  
9 concurring, That the General Assembly of Virginia hereby  
10 endorses the continuation and improvement of remote sensing  
11 systems through the implementation of the Landsat follow-on  
12 program and other available remote sensing capabilities  
13 together with coordinated technology transfer efforts by  
14 agencies, research and educational institutions of the  
15 Commonwealth as steps in the development of a Virginia  
16 Resource Information System that will provide accurate and  
17 up-to-date information for management decisions related to  
18 natural and other resources of the Commonwealth. In carrying  
19 out the purpose specified herein, a joint subcommittee to  
20 study the development of a Virginia Resource Information  
21 System is hereby created. The joint subcommittee shall study  
22 the most cost effective applications of remote sensing  
23 technology to resource and environmental information needs  
24 of the State, investigate areas for coordinated efforts  
25 between State agencies and by research and educational  
26 institutions, initiate demonstration remote sensing and  
27 technology transfer projects with Federal agencies, initiate  
28 systems for sharing data banks with other states and other

1 regions, and provide guidance on recommended legislation ,  
2 required to implement a coordinated Virginia Resource  
3 Information System.

4       The joint subcommittee shall be composed of nine  
5 legislative members to be appointed as follows: two persons  
6 shall be appointed from the membership of the House of  
7 Delegates' Agricultural Committee by the Chairman thereof;  
8 one person shall be appointed from the membership of the  
9 House of Delegates' Conservation and Natural Resources  
10 Committee by the Chairman thereof; one person shall be  
11 appointed from the membership of the House of Delegates'  
12 Mining and Mineral Resources Committee by the Chairman  
13 thereof; one person shall be appointed from the membership  
14 of the House of Delegates' Chesapeake and Its Tributaries  
15 Committee by the Chairman thereof; three persons shall be  
16 appointed from the membership of the Senate Agriculture,  
17 Conservation and Natural Resources Committee by the chairman  
18 thereof; and one person shall be chosen from the membership  
19 of the Senate by the Senate Committee on Privileges and  
20 Elections.

21       The members of the joint subcommittee shall elect a  
22 Chairman and Vice-Chairman from the membership thereof. If a  
23 vacancy occurs for any reason, successors shall be appointed  
24 by the appropriate person or committee designated herein to  
25 make the appointment. All agencies of the Commonwealth shall  
26 assist the joint subcommittee upon request.

27       The joint subcommittee shall make an interim report to  
28 the Governor and the General Assembly not later than

1 December one, nineteen hundred seventy-eight and shall make  
2 a final report not later than December one, nineteen hundred  
3 seventy-nine.

4 #

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APPENDIX B



MARSH PRESERVATION AT PLEASURE HOUSE CREEK

LETTERS



UNITED STATES  
DEPARTMENT OF THE INTERIOR  
FISH AND WILDLIFE SERVICE

Ecological Services  
P.O. Box 729  
Gloucester Point, VA 23062

June 1, 1978

Mr. Hayden H. Gordon  
Masfield Hall  
Virginia Institute of Marine Science  
Gloucester Point, Virginia 23062


Dear Mr. Gordon:

We thank you at the Remote Sensing Center for your help in the Pleasure House Creek project. From our point of view, the purpose of the study was to document the marsh losses and gains in the Pleasure House Creek area at Lynnhaven Inlet, Virginia Beach, Virginia.

We requested the work be done by the Remote Sensing Center in order to provide decision makers in the current Lynnhaven Inlet Maintenance Dredging and City of Virginia Beach Boat Ramp projects with what we consider to be "critical" data supportive of a position against the additional filling of productive wetlands in the area. Our interest was to provide the Corps of Engineers with data needed for their assessment of the project impacts on area resources. It was our concern that such information as previous wetland losses was not fully being taken into account by the Corps. This project contains all of the elements of a controversial project in terms of conflicting public demands for the use of existing public resources.

At this time we are informally advised by the Corps that their earlier position which favored the filling of wetlands is currently undergoing serious "in house" scrutiny due to the information generated by VIMS. We are fully confident that the ultimate outcome of the project will be in the best public interest since the marsh loss information filled a critical gap in basic data required by the Corps for their decision.

Sincerely,

  
Marvin E. Moriarty  
Biologist-in-Charge

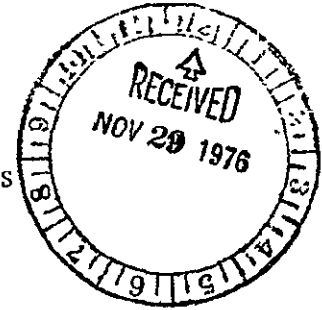


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DEPARTMENT OF THE ARMY  
NORFOLK DISTRICT, CORPS OF ENGINEERS  
FORT NORFOLK, 803 FRONT STREET  
NORFOLK, VIRGINIA 23510



NAOEN-DT

PUBLIC NOTICE NO. 18  
33 CFR 209.145

24 November 1976

24 Dec

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ECKLES

LAST READER DESTROY

The Norfolk District proposes to conduct routine maintenance dredging operations in Lynnhaven Inlet, Bay, and Connecting Waters and to deposit the material in the upland, diked disposal area shown on the attached map.

The laws under which the dredging of this Federal Project is to be reviewed are the Federal Water Pollution Control Act (33 U.S.C. 1323, 86 Stat 816) and the Marine Protection, Research, and Sanctuaries Act (33 U.S.C. 1413, 86 Stat. 1052). Related legislation involves the Coastal Zone Management Act of 1972, the National Environmental Policy Act of 1969, the Fish and Wildlife Coordination Act of 1958, the Endangered Species Act of 1973, and the National Historic Preservation Act of 1966.

Lynnhaven Inlet, Bay, and Connecting Waters is the official designation of the authorized Federal project that affords access to the Lynnhaven estuarine complex. The project provides for an entrance channel 10 feet deep and 150 feet wide from that depth in Chesapeake Bay to a mooring and turning basin 10 feet deep, 1250 feet long, and 700 feet wide in Lynnhaven Bay; a channel 9 feet deep and 90 feet wide from the mooring and turning basin to Broad Bay, via the Long Creek - Broad Bay canal. The project area is shown on the attached map.

The project was initially constructed in 1966. Maintenance of the project has been required in 1968, 1970, and 1972. The shoaling appears to have stabilized and a four year dredging frequency now seems more realistic. Material from previous maintenance dredgings has been removed by hydraulic pipeline dredge and deposited in upland disposal areas.

The dredging proposed under this Public Notice will involve the removal and disposal of approximately 160,000 cubic yards of sand. The material will be removed by hydraulic pipeline dredge and deposited in a previously used, upland, diked disposal area. The dredging will require approximately five weeks to complete, and is scheduled to be accomplished between 1 January and 31 March 1977. After completion of the dredging contract, material from the disposal area will be hauled to Virginia Beach and used for the beach replenishment program. *looks like all will be done*

There are no known or anticipated related dredging and disposal operations to be conducted by others concurrently with work on the Federal project within the immediate project area.

However, permit work of small scale may be conducted during the Federal dredging within the greater Lynnhaven area. This work should not influence, in any way, the Federal dredging.

DEC 29 1976

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ECKLES

LAST READER DESTROY

Colonel Newman A. Howard, Jr.  
District Engineer  
Norfolk District  
Corps of Engineers  
Fort Norfolk  
803 Front Street  
Norfolk, Virginia 23510

Re: NAOEN-RI, 28 October 1976  
NAOEN-RE, 19 November 1976

Dear Colonel Howard:

We received the October 28, 1976 letter from Mr. Philpott of your staff and the November 19, 1976 letter from Mr. Goodwin, describing proposed dredged spoil disposal areas to be used during the maintenance dredging of the Lynnhaven Inlet and Bay. Two sites are proposed, a 15 acre peninsula at the southwest corner of the Lesner Bridge, and a previously filled area at Pleasure House Point. We considered the proposal to use the entire 15 acre peninsula at Lesner Bridge as a disposal area and find it unacceptable. As Mr. Philpott's letter states, previous field inspections of the site revealed that significant wetlands exist throughout much of the southern portion of the peninsula. However, a large portion of the northern end is high and sandy. While EPA can consider the use of the northern segment, our wetlands policy and guidelines prohibit us from allowing the unnecessary destruction of the viable marsh and aquatic habitat throughout the remaining peninsula.

The proposed Pleasure House Point site is also unacceptable. Previous field inspections and review of our files revealed that the site was formerly a wetland area. Filling of the area for the purpose of development was completed without a Corps of Engineers permit. Although development has not yet occurred, the wetlands of the site have been destroyed. The proposed use of the area for spoil disposal would both offer passive approval of previous wetlands destruction and provide the elevation necessary for development of the resulting waterfront property. As the Lynnhaven Bay is heavily stressed by existing waterfront communities, EPA believes that the creation of further developable property would add significant water quality degradation to the system.

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EPA disagrees with the statement in Mr. Goodwin's November 19, 1976 letter declaring that a Negative Declaration is appropriate for the Lynnhaven Bay project. We believe that significant environmental degradation could result from the following project characteristics:

1. The proposed dredging is authorized to a depth of 12 feet. Such a depth appears excessive. In fact, we wish to know if boats with drafts greater than 5 feet use the channels. Unnecessary dredging leads to increased volumes of spoil and greater disposal problems. It may be possible to reduce dredging depths thereby reducing spoil quantities. Such a reduction may allow the use of more environmentally acceptable disposal areas.

2. Although much of the material to be dredged is to be utilized as beach fill, no data has been submitted confirming the suitability of the spoil for such a use.

3. Spoil disposal at the Pleasure House Point site could, as mentioned earlier, induce development. Such waterfront development would increase the environmental stress on the bay system. Therefore the impacts of disposal in the area should be fully considered.

4. To date, EPA has not been informed of alternate disposal sites or methods which were studied or could be used for the Lynnhaven maintenance program. Such information should be forwarded to this office for review.

Sincerely yours,

*Nicholas M. Ruha*

Nicholas M. Ruha  
Chief

EIS and Wetlands Review Section

cc: Fish & Wildlife Service, Annapolis  
National Marine Fisheries Service  
VIMS  
Virginia Marine Resources Commission

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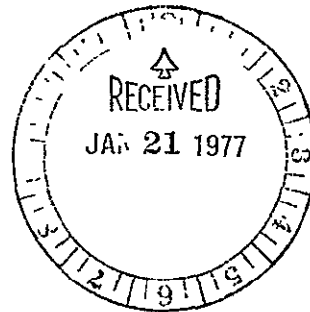


U.S. DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE  
Northeast Region  
Federal Building, 14 Elm Street  
Gloucester, Massachusetts 01930

to SAO 1. Beach  
2. File

January 11, 1977

Col. Newman A. Howard, Jr., USA  
District Engineer  
Norfolk District  
Corps of Engineers  
Fort Norfolk, 803 Front Street  
Norfolk, Virginia 23510



Dear Colonel Howard:

This letter is in response to a letter from Mr. Zane M. Goodwin, dated November 19, 1976, concerning the maintenance dredging in Lynnhaven Bay, Inlet, and connecting waters during the period January through March, 1977. In addition, this letter will serve as our response to NAOEN-DT, Public Notice No. 18, dated November 24, 1976.

We have reviewed the information provided and do not concur with your finding that a negative assessment for the project will suffice. The proposed dredging time frame is totally unacceptable in that it virtually covers the entire closed season for the protection of oysters. It should be noted that these oyster grounds, after having been closed for several years, were reopened for direct harvest again earlier last fall.

We also feel that the use of the proposed disposal area should be evaluated for its effects on the marine environment. It is our opinion that retention of fifty percent of the spoil (about 80,000 cubic yards) in this disposal area will significantly increase the potential for real estate development, which will result in adverse effects on fishery resources through water quality degradation. This fact is of particular importance in light of the recent reopening of local oyster grounds. Lynnhaven oysters are in demand along the Atlantic coast, and any factor affecting their harvest and sale would have severe detrimental impacts on this fishery.

In addition, the Lynnhaven complex is an important spawning and nursery area for several important sport and commercial species.



Colonel Newman A. Howard, Jr.

Page 2

January 11, 1977

Dredging during the latter part of the proposed time frame could result in sediment-induced interference with normal development of eggs, larvae, and juveniles of these important species.

Therefore, the National Marine Fisheries Service recommends against both the proposed dredging time frame and the indicated disposal site. Dredging should be accomplished during the months of October and November, 1977, to protect aquatic resources of the Lynnhaven. Spoil disposal should be at sea, via stock-piling at Fort Story, or on the downdrift side of Lynnhaven Inlet. While we realize the benefits of using the material for beach nourishment, we feel that the adverse effects of the project, as proposed, on fishery resources are of such magnitude that our approach is warranted.

Sincerely,

(Sgd.) Marvin F. Ecussu  
William G. Gordon  
Regional Director



IN REPLY REFER TO

NAOEN-DW

APR 15 1977

DEPARTMENT OF THE ARMY  
NORFOLK DISTRICT, CORPS OF ENGINEERS  
FORT NORFOLK, 803 FRONT STREET  
NORFOLK, VIRGINIA 23510

KIFFER  
PISAPIA  
LANN LUCHINO  
BAES S  
LEACHMAN  
MORTARIY  
CLARO  
ROACH - should I sign?  
RUDDY

13 APR 11 1977

LOWMAN  
BLACK  
BERNSTEIN  
ECKLES

FILE:

Mr. Ralph C. Pisapia  
Southern Area Office  
U. S. Department of the Interior  
Fish and Wildlife Service  
1825-B Virginia Street  
Annapolis, Maryland 21401

Dear Mr. Pisapia:

The comments received from some of the representatives attending the 13 January 1977 meeting on the Lynnhaven dredging project have been included in the inclosed revised summary of the meeting. The revisions were a result of Mr. Goodwin's 25 January 1977 letter to you and other representatives who attended the meeting.

If the summary is acceptable, please sign at the indicated location and return it to me so it can be forwarded for Mr. Ruha's signature.

Sincerely yours,

JOHN R. PHILPOTT  
Asst Chief, Engineering Division

1 Incl  
as stated

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Topics that were discussed in detail were as follows:

Acceptable Dredging Time Period - After a general discussion concerning acceptable time periods for dredging, acceptable dredging periods were agreed upon by the Corps, F&WS, EPA, NMFS. The proposed dredging could begin immediately in the entrance channel, and should be accomplished first. The turning basin and interior channels should be dredged between 15 Mar - 15 Apr. Future dredging activities in the turning and interior channels should be restricted to the periods of 1 Oct - 15 Dec and 15 Mar - 15 Apr. No restriction was mentioned for the entrance channel. F&WS expressed concern regarding dredging during flood tides. However, since the material to be dredged is sand and a 24 hour a day dredging operation is needed to meet the restrictive time periods, it was agreed that no restriction in regards to tide was considered essential or practical.

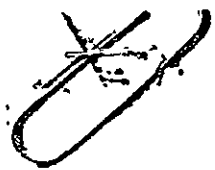
FY 77 or Interim Disposal Site - After a review and discussion of all alternative disposal sites for the FY 77 dredging of Lynnhaven and finding none other acceptable or practicable, an interim dredging site was agreed upon by Virginia Beach, CE, *We find* F&WS, EPA, NMFS representatives.

F&WS indicated they would approve temporary use of Pleasure House Point site for the current dredging if the District Engineer would state that such action would not result in adverse secondary environmental impacts. Colonel Howard said he would so state, although he acknowledged that the Corps has no control over future actions of the developer, whether the subject property was used as a disposal site or not. Another condition that would be required by F&WS was that at least 50 per cent of the sand be removed for Virginia Beach sand replenishment purposes. All attendees agreed to this proposal. At EPA's request, the District Engineer agreed to study reducing the project dimensions in order to decrease the volume of material to be left on the Pleasure House point site. Colonel Howard stated there would not be any future maintenance dredging activities in Lynnhaven until the City of Virginia Beach provides a permanent and approved disposal site. George Hanbury said the City would continue their efforts to provide such a site.

Winder Permanent Disposal Site - It was concurred in by the group that the Winder Property could be utilized jointly as both a permanent disposal site and a public boat ramp. This would eliminate the need for the dredging involved in locating a boat ramp at the upstream end of Pleasure House Creek. Mr. Hanbury said the City would abandon the Pleasure House Creek plan if the Winder property was found to be acceptable. Based on this alternative, the NMFS and EPA indicated they would be agreeable to use of both the upland and wetlands parts of the site. However, it was emphasized that every effort should be made to limit the amount of area required so as to minimize the degree of wetland destruction.

F&WS state that any determinations as to the degree of allowable wetland loss would be dependant upon a review of the detailed plans for development and utilization of such property. It was agreed that the City, Corps and the federal and state agencies should work together to develop the most viable plan for usage of the property with the objective of preserving as much of the material wetlands as possible. On this basis, Mr. Hanbury indicated that he would suggest to City Council that they initiate whatever procedures necessary to acquire the property.

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*file  
Mount dredge  
Lynn Haven  
Inlet*

11119  
RECEIVED FEB 1 1978  
GLOUCESTER POINT OFFICE

NACFI-RE

25 August 1977

See List of Addressees

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Gentlemen:

Inclosed for your review and comment is the concept plan for the proposed boat ramp-disposal site adjacent to Lynnhaven Inlet, Virginia. The boat ramp is to be a non-fee public facility and the disposal area is to be used to receive and dispense to the oceanfront dredged material removed during maintenance of the Lynnhaven Inlet, Bay, and Connecting Waters Project.

Many of the details are purposely unresolved in order that the city of Virginia Beach can be more open to outside suggestion at an early stage and thereby avoid future disagreement. Furthermore, the city does not wish to commit too much time and money into a vulnerable effort.

Present considerations for the boat ramp-parking site not evident in the concept drawing are:

1. Permeable parking area surface,
2. Concrete paved ramps, and
3. Sewage tied into existing or improved lines.

Regarding the spoil site:

1. Levees will be semipermanent (never intentionally torn down, only reconstructed as the need dictates).
2. Spill box will be at southeast corner.

NAOEM-RZ

25 August 1977

3. Discharge into site will begin at northwest corner and proceed to northeast corner.

4. Sand removal - truck haul operations will be conducted as close to discharge as possible.

Your comments to us, with a duplicate sent to the following address, would be appreciated by 25 September 1977.

Mr. Carl A. Thoren  
Assistant City Engineer  
Municipal Center  
Virginia Beach, Virginia 23456

Sincerely yours,

JOHN R. PHILPOTT  
Asst Chief, Engineering Division

1 Incl  
As stated

Copy furnished w/incl:  
Mr. Carl A. Thoren  
Assistant City Engineer  
Municipal Center  
Virginia Beach, Virginia 23456

Mr. Marvin Moriarty  
Division of Ecological Services  
U.S. Fish and Wildlife Service  
P.O. Box 727  
Gloucester Point, Virginia 23062

cc: Records  
Reading  
WRP Br  
Engr Div

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WANG/0005A

MULLER/ch

KUHLMAIER

WOOTTON

PHILPOTT

1825 1/2 Virginia Street  
Annapolis, Md. 21401

January 21, 1977

District Engineer  
Norfolk District, Corps of Engineers  
Fort Norfolk, 403 Front Street  
Norfolk, VA 23510

Dear Sir:

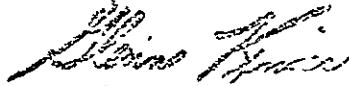
This references the 13 January 1977 meeting regarding the Lynnhaven Inlet, bay, and connecting waters maintenance dredging project attended by you and representatives of your staff, EPA, MFS, the City of Virginia Beach, and this Service. Since there was a considerably long and involved discussion of the project and alternatives, we feel a statement of our position is appropriate at this time. This letter is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 491, as amended in P. S. C. 661 et seq.).

There are several aspects of the project which we need to address. First, regarding the time of year in which the dredging will be conducted, the portion necessitating dredging outside the inlet should have minimal effect on finfish and shellfish populations of the area. Therefore, no dredge time restriction will be necessary for this outside portion. Dredging the inside portions could have adverse effects on shellfish during spawning and corrant periods. We believe that dredging during the periods March 15 to June 1 or October 1 to November 15 would avoid these effects.

Second, regarding the proposed Pleasure House Point spoil disposal site, it was our understanding that your office has considered the potential cumulative impacts for which we had expressed concern in our December 17, 1976 letter. You did not believe that secondary development and potential degradation of the waterway would be a direct result of your actions. Further, your office will file a negative assessment stating that no adverse cumulative effects are expected to result from placement of spoil on the subject site. We, therefore, will not object to the use of the site for spoil deposition.

Although we continue to support use of the Little Creek site for the boat ramp, we are willing to participate in an effort to determine if the Lesner Bridge site can be utilized with a minimum of wetland destruction.

Sincerely yours,



Glenn Kinser  
Supervisor  
Annapolis Field Office

MEMORIARTY:de:10/19/77

Copies to: Mr. Carl A. Thoren, Virginia Beach, VA

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*file  
Lynnhaven Marsh  
Dodge file*

RECEIVED OCT 26 1977  
GLOUCESTER POINT OFFICE

1825B Virginia Street  
Annapolis, MD 21401

October 20, 1977

District Engineer  
Norfolk District, Corps of Engineers  
Fort Norfolk, 803 Front Street  
Norfolk, VA 23510

Dear Sir:

This is in response to Mr. Philpott's letter dated August 25, 1977, requesting Service comments on the City of Virginia Beach's preliminary plans for a boat ramp and disposal site adjacent to Lynnhaven Inlet, Virginia Beach, Virginia.

We have reviewed the plans and note that construction of the proposed parking lot will result in the elimination of the very productive wetlands which presently occupy the southern half of the site. The disposal site, however, is similar in scope to that suggested to Mr. Relyea several years ago. We cannot comment on the exact configuration requirements for the disposal site as we do not have a recent aerial photograph of the site upon which we could overlay the plan.

Regarding the boat ramp-parking site, we continue to support the use of the Little Creek site for such facilities. We do have several suggestions regarding the Lesner Bridge site, however, which we would be willing to discuss further with the City in an effort to develop an environmentally acceptable plan for the use of this site. First, if coordinated usage of the disposal site for parking during peak ramp usage months and as a disposal site and borrow area during the winter months could be accomplished, the need to utilize the wetland area for parking would be almost totally eliminated. Second, rest and picnic areas should be situated on those areas of the site which will not require destruction of wetland habitat. Third, bank stabilization for that portion of the creek which would receive heavy boat wake pressure should be investigated. Lastly, we suggest that facility designs for the site should be superimposed upon a recent, vertical, aerial photograph showing the full extent of the wetlands.

during the FY 77 dredging. Furthermore, we would not object to the use of the Pleasure House Point site as a permanent disposal area as any indirect impacts to fish and wildlife resources resulting from potential urbanization would be negated by permanent use. It is our understanding that a final environmental statement will be filed with the CEQ prior to commencement of any dredging beyond FY 77. We anticipate reviewing the draft.

Third, regarding the proposed permanent spoil disposal site at the Lesner Bridge, we understand that the project dimensions are being reassessed in light of current boating interest needs and the limited upland spoil disposal area of this site. We are also aware that the City is pursuing a boat ramp in conjunction with the spoil area. The Lesner Bridge site, as you are well aware, contains a substantial portion of wetlands (we estimate 5.9 acres). When project dimensions and boat ramp plans are formalized, we will reconsider the commitment of these wetlands. Any reconsideration we make will take into account the following discussion. Our concern for these wetlands stems from their value to fish and wildlife resources and the insidious manner in which wetlands have been destroyed in the Lynnhaven estuary. Our 23 November 1976 letter pointed out that over 50 percent of the marshes in the area have been dredged and/or filled since 1956. It is apparent from discussions we have had with your office and the City on other proposed projects in the Lynnhaven estuary that deposition of spoil on wetlands is often the most economically feasible alternative. Such projects include the proposed Canal No. 2 flood control project, the proposed Eastern Branch of the Lynnhaven dredging project, the proposed Western Branch of the Lynnhaven maintenance dredging project, and the proposed City of Virginia Beach boat ramp site at the headwaters of Pleasure House Creek. Such analyses are not difficult to understand when the value of the wetland is considered as the real estate value on the current market. As you know, wetlands and particularly the Lesner Bridge marsh, have values other than their real estate value, which includes the export of mineral and organic nutrients that supports much of the production in the adjacent estuarine and coastal waters, nursery grounds for commercially important fish and shellfish, and waste treatment work. In general, we believe that wetlands should not be looked upon as developable land to be bartered or traded, but as sanctuaries providing sustained public benefits. The filling of wetlands is generally permanent.

-2-

Fourth, we need to address alternative permanent spoil sites for the subject project as well as the proposed boat ramp site. Environmentally acceptable alternative sites which come to mind for a permanent spoil disposal area are the Pleasure House Point site, the Fort Story site, and the upland portion of Lesser Bridge site. We understand that the upland portion of the Lesser Bridge site could be adequate if dredging were conducted in segments as space in the spoil area became available. Of the potential boat ramp sites we have been presented, the Little Creek location would appear to be the least damaging to public fish and wildlife resources.

One final point which merits consideration is the concept of the Lynnhaven estuary as a whole system. Just as there are many projects, problems, and needs in the Lynnhaven estuary which are interrelated, there are fish and wildlife resources of the Lynnhaven ecosystem dependant upon solutions to the problems and needs. A comprehensive examination of the Lynnhaven ecosystem and related projects appears to be the most orderly approach to study and find those solutions. We would, therefore, suggest that such a comprehensive study be given careful consideration by your office.

If we can be of any further assistance with any of the subjects discussed in this letter, please so advise.

Sincerely yours,

*Ralph C. Pisapia*

Ralph C. Pisapia  
Acting Supervisor  
Southern Area Office

LRHOACH:cc

Copies to: EPA, PHILADELPHIA, PA  
NMFS, OXFORD, MD  
VMRC, NEWPORT NEWS, VA  
GEORGE HAMBURY, VIRGINIA BEACH, VA  
F&WS, GLOUCESTER POINT, VA ATTN: MEMORANDUM



SARAH CREEK

LETTERS

# COMMONWEALTH OF VIRGINIA



## VIRGINIA INSTITUTE OF MARINE SCIENCE GLOUCESTER POINT, VIRGINIA 23062

December 10, 1973

### VIMS Wetlands and Subaqueous Report

APPLICANT: Frances W. Binswanger

APPLICATION NO: Gloucester Co., 114

INSPECTION: 29 November 1973; J. L. Mercer, Wetlands Research Section.

PROJECT DESCRIPTION: Location: Sarah Creek.

Proposed Activity: To construct about 250 feet of timber bulkhead at the mean low water line.

Purpose: Protection from soil erosion.

WETLANDS INVOLVED: About 8,000 sq. ft. of productive marsh containing:

|  |            |
|--|------------|
| Saltmarsh cordgrass ( <i>Spartina alterniflora</i> ) | 40%        |
| Saltmeadow hay ( <i>Spartina patens</i> )            | 15%        |
| Saltgrass ( <i>Distichlis spicata</i> )              | 15%        |
| Switch grass ( <i>Panicum virgatum</i> )             | 15%        |
| Marsh hibiscus ( <i>Hibiscus moscheutos</i> )        | 5%         |
| Cattail ( <i>Typha</i> sp.)                          | 5%         |
| Marsh elder ( <i>Iva frutescens</i> )                | 5%         |
| Saltmarsh bulrush ( <i>Scirpus robustus</i> )        | associated |

ENVIRONMENTAL SETTING: The distance from the end of the existing bulkhead to the north-eastern end of the proposed bulkhead is approximately 130 feet. Landward of this line is the area of marsh outlined above. These wetlands are contiguous to Sarah's Creek and have two narrow guts which insure tidal flushing. The marsh not only offers a protected habitat of many marine organisms but also produces a portion of significant food to the aquatic system. Much of the adjacent uplands are being actively farmed; any potential pollutants such as fertilizers, pesticides and herbicides, which may be carried to the marsh by runoff waters, are then trapped, filtered and taken up by the marsh system. The only erosion occurring along the shoreline is where the existing bulkhead forms a return wall into the fastland.

ENVIRONMENTAL IMPACT: If the proposed activity is permitted it will completely destroy all marsh vegetation within the dimensions of the project. The marsh will cease to perform its roles as described under Environmental Setting.

MINIMIZING ADVERSE EFFECTS: If possible, place the bulkhead behind and landward of all existing marsh vegetation. Thus, tidal water will not be cut off from the inner pocket of marsh.

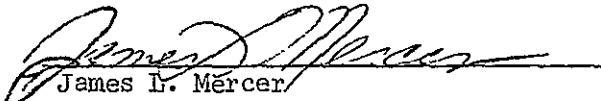
Wetlands and Subaqueous Report  
Frances W. Binswanger

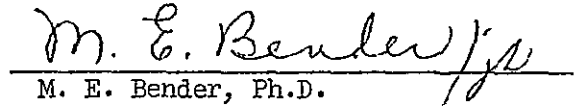
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December 10, 1973

MAJOR ALTERNATIVE: Along the area of erosion (i.e. the return wall), well placed rock riprap should be utilized to protect the fastland. The remaining shoreline covered with marsh vegetation should continue to be stable.

CONCLUSION: From an environmental viewpoint, the proposed bulkhead is undesirable. The major alternative offers the preferred action.

  
James I. Mercer  
Wetlands Research Section

  
M. E. Bender, Ph.D.  
Assistant Director

Distribution:

Mr. J. Willis Weaver, Chairman, Gloucester County Wetlands Board  
Mr. S. M. Rogers, VMRC  
Mr. Mark Harrell, C of E  
Mr. Nicholas Ruha, EPA  
Mr. Willard Spaulding, Jr., Fish and Wildlife Service  
Mr. Larry Shanks, Fish and Wildlife Service  
Mr. Joseph Davis, Jr., Div. of State Planning  
MERRMS (2)  
Applicant



DEPARTMENT OF THE ARMY  
NORFOLK DISTRICT CORPS OF ENGINEERS  
FORT NORFOLK, 803 FRONT STREET  
NORFOLK, VIRGINIA 23510

IN REPLY REFER TO  
NAOOP-P (Sarah Creek)

19 April 1977

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. M. I. Binswanger  
7751 Riverside Drive  
Richmond, Virginia 23225

Dear Mr. Binswanger:

Recent inspections by personnel of my office have revealed unauthorized bulkheading and filling of a tidal gut in Sarah Creek adjacent to your property at Achilles in Gloucester County, Virginia.

This work is in direct violation of Section 10 of the River and Harbor Act of March 3, 1899 (33 U.S.C. 403). The penalties for such violation, as provided by Section 12 of the Act (33 U.S.C. 406), are a maximum fine of \$2500 and imprisonment for up to one year. Furthermore, your work is also in violation of the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 et seq), the criminal penalties for which are a maximum fine of \$25,000 per day for each day the violation occurs and up to one year imprisonment (33 U.S.C. 1319 (c) (1)). The civil penalties may be as much as \$10,000 for each day of violation (33 U.S.C. 1319 (d)).

This letter shall therefore constitute formal notice to you to cease and desist all work in navigable waters, or the deposition of any material adjacent to such waters in such a manner that the material may be washed into these waters. Furthermore, you are hereby directed to completely remove the unauthorized bulkhead and restore the former wetland area to its original elevation and species composition. These measures should be completed within 30 days from receipt of this letter. Please contact this office prior to actual restoration so that a representative may be present during this work.

Failure to comply with this directive may result in the referral of this matter to the U. S. Department of Justice for prosecution.

Should you have any questions on this matter, please contact the Waterways Inspection Section at (804) 446-3658.

Sincerely yours,

Copy furnished:  
F&WS, Annapolis  
F&WS, Gloucester Point  
EPA, Philadelphia  
VIMS, Gloucester Point  
SWCB, Richmond  
VMRC, Newport News

RONALD H. ROUTH  
LTC, Corps of Engineers  
Acting District Engineer

MARSH RESTORATION PLAN FOR THE PROPERTY OF WILLIARD I. BINSWANGER, SR.  
ON SARAH'S CREEK, GLOUCESTER COUNTY, VIRGINIA

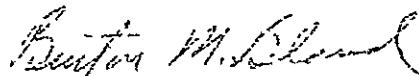
In complying with the order of the Honorable George P. DeBordit, Judge of the District Court of Gloucester, Virginia, the Gloucester County Wetlands Board at a meeting held at 7:30 p.m. on November 9, 1977 set forth the following procedures to restore the wetlands on the N.E. corner of the property owned by Williard I. Binswanger on Sarah's Creek, Gloucester County, Virginia. This plan voids that plan which was set forth on October 12, 1977.

1. The dimensions of the marsh and cove to be restored will be staked out on the ground and a scaled drawing of the area using fixed landmarks for references will be made by the Gloucester County Wetlands Board. Approximately 4,500 square feet of tidal wetlands and 2,000 square feet of intertidal mudflats are to be restored.
2. At any time after March 15, 1978 the fill material may be removed from behind the bulkhead. The elevations will range from just above mean low water to just above mean high water and a narrow tidal gate will be established making the wetlands contiguous to mean low water on Sarah's Creek. The bulkhead will not be removed until all the fill has been removed and all elevations and the size of the area has been checked and approved by the Wetlands Board.
3. Straw bales will be placed around the edge of the newly formed cove to prevent siltation of adjacent waters and to protect the new seedlings.
4. Remove that portion of the new bulkhead designated by the Wetlands Board (that which runs across the face of the cove).
5. The re-established wetlands zone will be sprigged with Saltmarsh Cordgrass (*Spartina alterniflora*) set on 2 foot centers and treated with a slow release fertilizer.
6. A vegetated buffer zone of 1500 square feet will be established between the saltmarsh cordgrass and the adjacent farm field, and planted to specified wetland grasses.
7. All work will be done on a step by step basis and each step must be approved by the Wetlands Board before other work shall begin.
8. All work, the removal of fill, the removal of the bulkhead, and the planting of vegetation shall be completed by June 15, 1978.

The staff members of the Virginia Institute of Marine Science will furnish technical assistance in the implementation of this project.

November 10, 1977

ras



Burton M. Stord, Chairman

