VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE

SPECIAL BIOSPHERE RESERVE REPORT

MANAGEMENT OF NATURAL RESOURCE INFORMATION FOR THE VIRGIN ISLANDS NATIONAL PARK AND BIOSPHERE RESERVE

Prepared by:
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U.S. MAN AND THE BIOSPHERE PROGRAM

Virgin Islands National Park

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POSTSCRIPT

Pssst! The butler didn't do it. But who did?

Do we have your attention? Wouldn't you like to know who was behind the scenes putting this series of reports together?

WE DID IT!

All twenty-nine technical reports ... all 2200 pages of research findings generated by more than a dozen institutional and individual subcontractors

. .. And the attached Biosphere Reserve "Research Report" is only a small part of the much larger technical document series which focuses on the resource base of the Virgin Islands Biosphere Reserve.

Funded by the U.S. National Park Service and done under the aegis of the Virgin Islands Resource Management Cooperative, VIRMC (see inside front cover of this report), the project involved more than one-half of VIRMC's members as subcontractors, drawn from a dozen different disciplines.

Island Resources Foundation (IRF) is proud of its behind-the-scene role as project organizer, prime contractor, program manager and publication series editor. We are equally proud of our role as an active member of VIRMC which offers great promise as an organizational vehicle for undertaking joint, interdisciplinary planning, research and monitoring projects.

Penultimately, a word of appreciation to five persons who have been extraordinarily helpful to Island Resources Foundation in carrying out its role as primary contractor for VIRMC's Virgin Islands Biosphere Reserve program. I am taking note of those who assisted with the overall technical and management tasks of coordinating more than twenty-five subcontracts, arranging for text and copy editing, and proof reading the thousands of pages of reports. For their many services I am indebted to Dr. Caroline Rogers, Executive Officer of VIRMC (for technical review), Phylis Rubin (manuscript copy editor), Jean-Pierre Bacle (for layout and publication coordination), Sandra Tate (for assisting with project administration and word processing) and Judith Towle (for fiscal management).

Except for further distribution of documents, the project management tasks of Island Resources Foundation are almost completed. We have, however, only laid one course of "baseline" foundation stone for the structure of the Virgin Islands Biosphere Reserve. Other builders of the information base are now needed, both in the Virgin Islands and elsewhere in the Eastern Caribbean. We hope that the spirit of cooperation implicit in VIRMC will continue.

Edward L. Towle, President
Island Resources Foundation
March 1988

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ABSTRACT

This study provides an overview of how natural resource/environmental information is generated, filed, exchanged and utilized by those institutions and researchers linked to the Virgin Islands Biosphere Reserve (VIBR) through the Virgin Islands Resource Management Cooperative (VIRMC). This includes information generated by the Virgin Islands National Park, agencies of the Virgin Islands Government, the University of the Virgin Islands, and occasionally by visiting researchers. Providers and users of natural resources information were surveyed to determine high priority needs for management of future information dissemination activities. Scientists and managers expressed a need for improved access to information and identified a number of issues which impede the use of information, especially for land and coastal use management purposes, under current circumstances.

Key constraints to effective development and use of the VIBR resource management database include problems with both the format and storage of detailed data from analytical and synoptic studies and from ongoing, longer term environmental monitoring activities. Too often, since researchers, as data generators, are widely dispersed among various institutions, primary source data are lost or are available in such diverse formats that they cannot be easily used by other analysts or researchers. In addition, there is no single archival source of historical information or reports on conditions in the VIBR. Use of the data and information gathered from the VIBR for on-going decision-making is limited in part by the failure to identify or analyze such information with specific sites within the Reserve.

Based on these findings, the study concludes the VIBR should:

- establish a standard geographic reference system to be applied to all information gathered from the Biosphere Reserve;
- require all source data from monitoring or research to be recorded in a common database format;
- establish a long-term program leading to the implementation of a GIS for the Reserve; and
- support the establishment of a semi-autonomous Clearinghouse to collect and disseminate natural resource data and information pertinent to research and management of the Biosphere Reserve.

Detailed recommendations are presented to carry out these suggestions.

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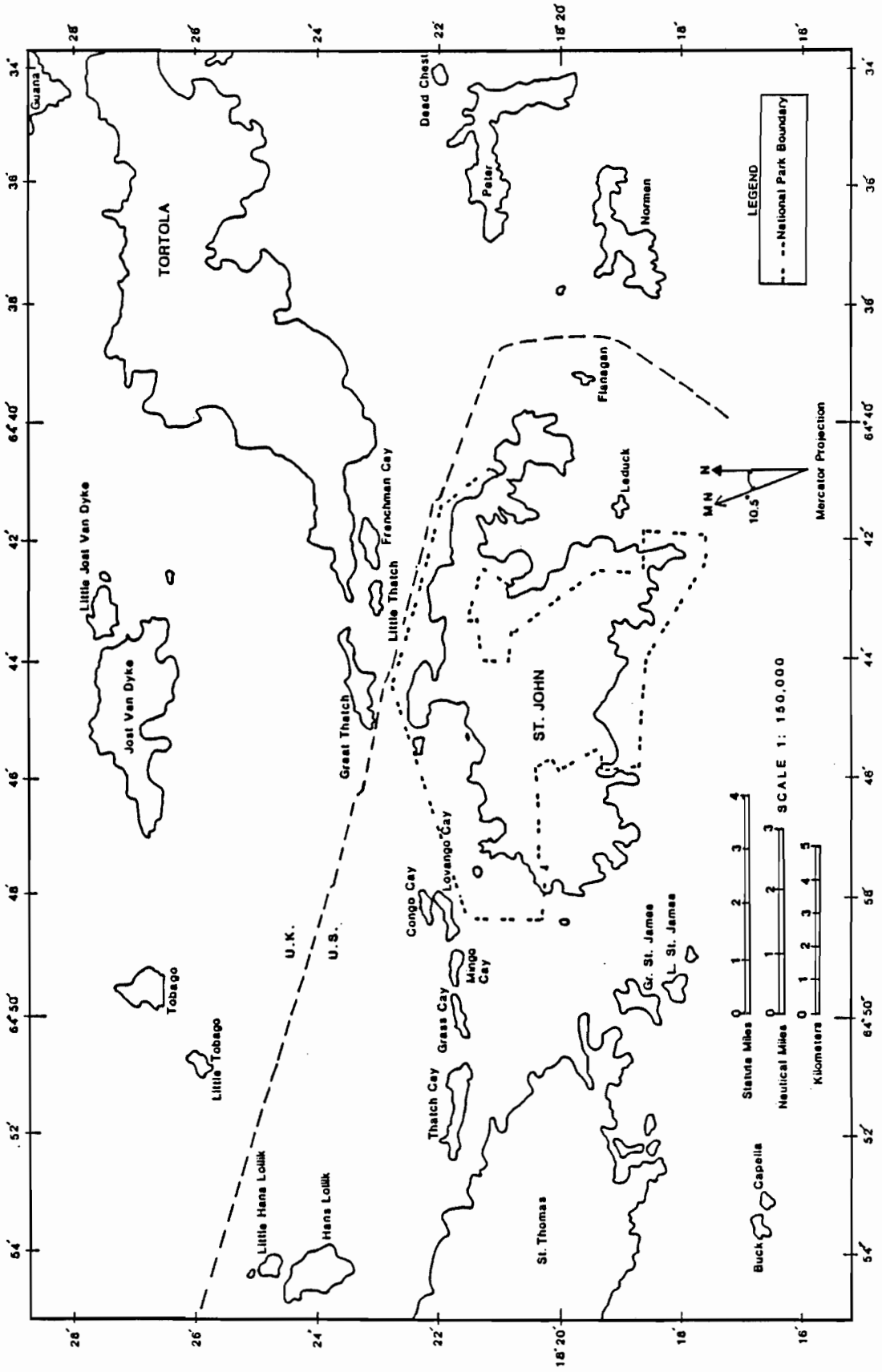

Location Map, St. John, U.S. Virgin Islands (Source: Modified After NOAA, 1972)

INTRODUCTION

Background

The Man and Biosphere Program (MAB) was initiated in 1971 by UNESCO to foster international cooperation in improving people/environment relations. An integral component of this program is managing natural resources to assure sustainable development that incorporates the needs of both people and nature. A major element of the MAB program is the establishment of an international network of natural areas representative of the world's environmental diversity and the integrated management of these resources. Of the officially designated Biosphere Reserves throughout the world, seven are in the United States, administered by the U.S. National Park Service.

One of these, the Virgin Islands Biosphere Reserve (VIBR) was designated by the UNESCO in 1976 and dedicated in 1983. The Biosphere Reserve's core area is the Virgin Islands National Park (VINP) on the island of St. John in the U.S. Virgin Islands.

The Virgin Islands Biosphere Reserve is particularly important in the context of U.S. participation in the MAB program for four reasons:

- It is not a virginal ecosystem, and it requires integrated management with a higher quotient of human involvement than most other reserves.

- It includes land and marine resources which are subject to considerable economic activity which must be managed as a whole.

- It is the only insular Biosphere Reserve in the United States with substantial coral reef communities.

- It offers the potential for serving as a teaching and management model and a training site for extending or adapting the Biosphere Reserve concept to other Eastern Caribbean sites with similar management problems within the general boundaries of the wider biogeographical Caribbean province as per the standard "Uvardy" global classification system as promulgated by IUCN.

The consensus has been that a biosphere reserve with the special characteristics of the VIBR should fulfill the following functions: conservation of ecosystems, research, education, management, integrated development, and communication. The role of information management is critical to the success of these functions.

In anticipation of the research needs of the Biosphere Reserve and under the leadership of the Virgin Islands National Park, the Virgin Islands Resource Management Cooperative (VIRMC) was established in 1982 as a collaboration of natural resource researchers and managers in the Virgin Islands. A major objective of the Cooperative is to provide for the dissemination of data and information about the Virgin Islands Biosphere Reserve for management, research and public education. The present study was triggered by the specific need to analyze the massive amount of research data generated by VIRMC as a part of its five-year baseline, interdisciplinary investigations focused on the natural environmental of the VIBR. This report provides the findings of our study and presents recommendations to improve communications and information sharing.

The objective of this undertaking was to identify key information-sharing constraints and to seek to identify workable solutions. Experience has shown that many hours and resources can be wasted searching, or needlessly duplicating, the data or information needed for proper planning, management, and policy making. This is a problem not only for the Virgin Islands National Park, which is charged with the development of the Biosphere Reserve, but also for other public and private groups which have a stake in natural resource management issues in the Virgin Islands.

Preliminary discussions and interviews quickly set the themes which are reflected in this report: questions of information management for the Virgin Islands Biosphere Reserve exist in a continuum between two distinct poles. At the "micro" level, there are important steps to be taken to improve the storage, access and compatibility of data generated about the Biosphere Reserve. At the "macro" level, there is a need to plan for the institutional structures which can provide a long-term repository for information from and about the Biosphere Reserve and its management.

Improved information access for the management of the Virgin Islands Biosphere Reserve can help to extend the Biosphere Reserve concept to other sites and ecosystems in the Eastern Caribbean, as foreseen in UNESCO's Man and the Biosphere program. As a pilot system, the VIBR clearinghouse can become a model and training site for managers of other potential Biosphere Reserve sites in the Eastern Caribbean.

The report which follows is divided into three major sections: Survey Findings, Conclusions, and Recommendations. The "Findings" section reports on specific issues which were observed or reported in the course of discussions and interviews while gathering information for this report. "Conclusions" represent our professional assessment of the qualitative and quantitative significance of issues raised by respondents. "Recommendations" are the action steps which we believe will have the greatest cost effectiveness in achieving the information management goals of the Biosphere Reserve. Within each section, the

discussion tends to progress from particular questions of data administration to general questions of the institutional format for information archiving.

Data vs Information

Before beginning the body of this report, a word on vocabulary is in order. In this report, the terms "data" and "information" are not used interchangeably. Data is (are) the source, the raw material, of information; information is the product of analyzing and synthesizing data. In everyday terms, data is field measurements, and information is the results reported after tabulating all of the field measurements. The distinction is important and basic to the following discussion because of fundamental differences -- including among the authors of this report -- about the need of the Biosphere Reserve (and its information management functions) to maintain direct access to source data from research and monitoring functions affecting the VIBR and adjacent areas of the Virgin Islands.

One viewpoint (the minority in this report) holds that it is sufficient and most economic for the VIBR to track only results -- that is, information reported after analyzing source data. The individual researchers and monitoring authorities would retain exclusive control over the source data, which would presumably be available to other researchers, analysts and resource managers on an as-needed-and-requested basis.

The view which prevails in this report is that the VIBR needs to assemble the widest possible inventory and catalogue of both source data and results. This is particularly important in the case of the VIBR because of the wide dispersal and relatively high mobility of researchers, and because of the irregular data gathering and uncertain archiving of many data sources related to long-term environmental monitoring. The extra costs of this duplicative strategy of data archiving can be justified in part because of the relatively high risk of data loss to man-made and natural disasters (including termites!) which is a feature of life in the Caribbean. These issues are also discussed in subsequent sections of this report.

SURVEY FINDINGS

Data Administration Issues

(1) Lack of Geographic References

Much (possibly most) data gathered in the course of the 29 VIRMC-commissioned studies -- and even some environmental monitoring -- has no specific geographic reference (i.e., a definite, unambiguous point, line or defined enclosed two- or three-dimensional space). There are also two detailed findings related to this general problem:

- Geographic References are not Standardized. There is no consistency in the notation of the location of important data points. Geographic references can range from traditional latitude and longitude in degrees, minutes and seconds, to imprecise "meets and bounds" type property descriptions, to the use of the old Danish estates and quarters naming conventions.

- Geographic References are Frequently Inaccurate. An unsystematic review of geographic references indicates that even those which referenced a standardized measure, such as latitude and longitude, were often incorrect or too general to enable future researchers to re-visit the exact same spot. In general, natural resource scientists are not navigators, and they are seldom assisted to verify the location of data collection points.

(2) Inconsistent Data Reporting and Formats

There are few standards and little uniformity in the format or media in which most source data is stored. In fact, there is no assurance that source data for commissioned or academic studies, other than that contained within the report itself, is maintained by the original researcher or institution.

(3) Lack of Access to Important Source Data

Interviewees repeatedly told about problems such as staff leaving government and academic positions and taking data and reports with them without leaving copies with the host institution, disappearance of documents, and the lack of funding to maintain or catalogue government archives. In addition, representatives of some private and

public interest groups feel that data and information about environmental conditions in or near the VIBR are often overlooked or withheld.

(4) Geographic Information System (GIS) Technology

GIS's Proposed for Several New Resource Management Studies. During the past year, various researchers at the University of Wisconsin, Harvard University, the University of Pennsylvania, the Yale Forestry Department (with assistance from the MacArthur Foundation), and the U.S. Geological Survey's (USGS) district office in Puerto Rico have proposed to undertake generally modest, experimental geographic information system (GIS) applications in the Virgin Islands. With the exception of USGS, these applications are promoted as offering (generally as a by-product) the promise of improving tools and techniques for resource management in the V.I. National Park or for the island of St. John and the larger geographic framework of the Biosphere Reserve. On an even larger territorial scale, the U.S. Geological Survey has agreed to assist the Virgin Islands Department of Planning and Natural Resources (DPNR) with several demonstration GIS projects under a cooperative cost-sharing arrangement, and the DPNR Commissioner is currently seeking to acquire the necessary funds for such experiments.

Personnel and Equipment in the V.I. Inadequate to Operate Most GIS Packages. In all instances, GIS applications are planned to be conducted at institutions outside of the Territory. Why is this the case?

Based on our review of computer systems in the Territory, we do not believe that there is yet a single microcomputer system which is configured to make good use of a major GIS application program. System requirements would include: A fast "286" or 386 microprocessor; an 8XXX87 math co-processor chip; EGA or VGA display, preferably on a large-size color monitor; 2 megabytes or more of LIM extended memory; 40 megabyte or larger, fast access, hard disk; a 12x18 digitizing table; a color plotter. Many GIS's can run on less elaborate systems, but each deviation from the requirements sketched above will result in a significant deterioration in overall functionality. We know of no personnel with training or experience as GIS users in the Territory.

Review of the GIS proposals being discussed with the Territory indicates that the use of this technology for everyday resource management is unlikely and that the primary benefit of these activities is to the external researchers. This does not mean that some of the results of the projects are not of value to the VINP or the natural resource community in the Territory. In fact, a careful selection from among projects like these could provide the vehicle for local investigators to start the familiarization and learning process.

Information Access and Archiving

A priority for successful information management within the VIBR is facilitating cooperation and improving database standardization among the numerous organizations and interests involved with assessing, monitoring, researching and managing marine and terrestrial resources and their ambient environments. An overview of these organizations and the associated types of natural resource information they generate is provided in Table 1. The Virgin Islands Resource Management Cooperative (VIRMC) has been established as a preliminary mechanism for achieving that cooperation. The Cooperative includes federal (U.S.) and territorial (V.I.) governmental bodies, academic groups, private sector/non-profit research and technical assistance groups, and others with a broad interest in the management of the Virgin Islands resource base. Membership in the Cooperative is listed at the end of Appendix 1.

Scientists and Managers Desire Improved Information Exchange

Those interviewed for this study expressed very clearly the need to improve communications and information exchange. For example, government officials, private developers and public interest groups all agreed it is often difficult, if not impossible, to find copies of environmental assessment reports (EARs). Even major studies and reports such as the multi-volume environmental assessment produced a little over ten years ago by the consulting firm Tetra Tech for the St. Thomas airport expansion is accessible to the public only in the library of Island Resources Foundation (IRF).

However, if the Biosphere Reserve Center on St. John, and the Biosphere Reserve itself, are to become a respectable research and development center known through the region and even internationally for high quality research, then the problem of custody, security, accessibility and retrieval of all relevant resource data in all disciplines should become a priority agenda item for VIRMC, the Virgin Islands Government, the Virgin Islands National Park and the yet to be developed management framework of the Biosphere Reserve.

At the present time, most of the known data generated about the island of St. John and the Biosphere Reserve is produced by the membership of VIRMC. In addition, however, there has always been a wide variety of independent academic researchers and other private parties who find St. John and its environs a salubrious and productive place to work, who on occasion generate useful environmental data, and who have produced significant information for use by resource managers. While some of this information ultimately is circulated because of the research-permitting activities of the National Park, much of it is lost because of slow moving academic publishing practices.

Table 1. Data types generated by organizations associated with VIRMC / VINP / VIBR.

ORGANIZATIONS / TYPES	Hydrology	Surface Water	Marine/Estuary	Geology	Soils	Vegetation	Climate/Weather/Air	Land Use	Living Resources	Vital Stats/Biblio.	Demography	Health Effects	Regulated Entities	Archeology	Socio-Economic
U.S. National Park Service	X		X	X	X	X	X	X	X	X			X	X	X
U.S. Geological Survey	X				X				X						
U.S. Fish & Wildlife Service			X			X			X	X			X		
V.I. Government (Department of Planning and Natural Res.)															
Division of Fish & Wildlife			X			X		X	X						X
Division of Env. Protection	X	X	X	X	X		X		X	X	X	X	X		
Division of Library & Museums										X				X	
Coastal Zone Management & Planning			X					X		X			X		
West Indies Laboratory			X	X			X		X	X					
University of the Virgin Islands															
Caribbean Research Institute incl. WRRC*	X	X	X				X		X	X	X				X
Division of Science & Math			X			X			X			X			
Extension Service & VIERS**	X	X	X	X	X	X		X	X	X					
Institute for Tropical Forestry (PR)	X				X	X	X	X							
University of Puerto Rico (PR)	X	X	X		X	X		X		X					
Caribbean Fishery Management Council (PR)			X							X					X
Natural Resources and Labor (BVI Govt.)			X				X			X					X
National Parks Trust (BVI)									X					X	
Caribbean Conservation Association			X						X					X	X
Island Resources Foundation			X	X			X		X	X				X	X
ECNAMP ***			X				X		X	X					X

* WRRC Water Resources Research Center

** VIERS Virgin Islands Ecological Research Station

*** ECNAMP Eastern Caribbean Natural Area Management Program

Several Computerized Databases Exist

Several organizations have developed computerized natural resource data sets and bibliographies. These organizations include the Division of Fish and Wildlife (DPNR), the VINP, West Indies Lab, and Island Resources Foundation. The Virgin Islands Division of Fish and Wildlife (a unit within the Department of Planning and Natural Resources) is using DBase III+ on an IBM AT with a 40 Mb hard disk to enter field data on fish landings for the National Fisheries Service. Similarly, the VINP is using its IBM for data entry but requires its scientists to do their own data entry and management, largely on an ad hoc basis for discrete applications. IRF uses a relational data base package for its annotated bibliography of territorial and regional natural resource references. The usefulness of these data systems is limited by lack of knowledge about the existence of the data, and lack of access to report systems for extracting information from the data. In addition, the utility of the individual data sets could be enhanced if it were possible, for example, to readily compare the fisheries data with data collected in VINP studies.

Regional Biosphere Reserve Concept Will Require Expanded Communications and Information Sharing Strategies

Many individuals, often speaking for institutions, were also interested in expanding the information sharing concept beyond the Virgin Islands Biosphere Reserve to include other islands and organizations with parks and protected areas and focused resource management data and activities. This objective is clearly part of the role of an expanded VIBR that would include other important ecosystems in the region to form a multi-site, multi-country (international) Eastern Caribbean or Lesser Antillean Biosphere Reserve. Several current or planned activities (see Table 2) are designed to improve communication and information sharing among Caribbean scientists and institutions. A new network of Parks and Protected Areas Managers is currently in the development stages under the aegis of the Eastern Caribbean Natural Area Management Program (ECNAMP), a member of VIRMC.

Many Local VIRMC Institutions Have Information Management Problems

There is no apparent unwillingness to address the issue at the policy making level, but limited resources, crisis-oriented management, "island" decentralization and system center/periphery problems, and frequent changes in technically competent staff limit the effectiveness of many corrective strategies and well-meaning attempts at regularizing information exchange, data dissemination, and institutional dialogue regarding database sharing.

The lack of appropriate repositories of natural resource or environmental information is evident. A recent Information Resources

Table 2. Information sharing networks in the Caribbean.

NAME	FUNCTION	CONTACT
CARISPLAN Economic Commission for Latin America and the Caribbean (ECLAC)	Network for providing a broad range of Caribbean planning and development literature, linked to INFOPLAN (South American counterpart)	Wilma Primus ECLAC Port-of-Spain Trinidad (809) 623-5595
SIGNET Sea Grant Program	Network of Sea Grant institutions in the U.S., Puerto Rico and U.S.V.I.	Shirly Fisk NOAA/Sea Grant 202-443-8886
CEPNET UNEP/Caribbean Environment Programme	Clearinghouse for Caribbean environmental information	Salvano Briceno UNEP, Regional Coordinating Unit 809-922-9267
CARICOMP (Caribbean Coastal Marine Productivity)	Network of Caribbean Association of Island Marine Laboratories linked to central repository	Director West Indies Lab St. Croix, USVI 809-773-9339
CARDI (Caribbean Agricultural Research and Development Institute) Eastern Caribbean Farming Systems Research and Development Network	Link of CARDI countries via microcompter network to provide access to several software packages	CARDI U. of West Indies St. Augustine Campus Trinidad 809-663-2007/1678
CBIN (Caribbean Basin Information Network) Caribbean Central American Action (C/CCA)	Data base of business information maintained on mainframe with electronic mail capability throughout the Caribbean	Indira Jhappan C/CAA Washington, D.C. 202-466-7464
CEIN (Caribbean Energy Information System)	Coordinate collections of energy data and statistics for Caribbean	Dr. G. V. Taylor, Executive Director Scientific Research Council Box 350 Hope Gardens, Kingston, JAMAICA
CARSTIN (Caribbean Network for Scientific and Technical Information)	Established by UNESCO in response to requests from Caribbean Ministers of Science and Technology	UNESCO Geneva

Study prepared for the Commissioner of Planning and Natural Resources (DPNR) emphasized that information needs are not being presently met by either DPNR or the Virgin Islands Public Library System. Professional and technical staff cannot acquire basic handbooks and manuals needed for daily use. Although this study primarily focused on DPNR staff, its conclusions are similar to this study.

It is unrealistic to expect major new initiatives in natural resources information management to be implemented by agencies of the local government in the near future, due to budget restrictions and staffing problems. Nevertheless, the community of Government of the Virgin Islands (GVI) users represented in VIRMC is strongly in favor of developing a center to provide services such as archiving documents and reports, providing copying services, providing hard copy reports detailing acquisitions, establishing an electronic bulletin board, and distributing standard computer disk products. Some non-government institutions and many researchers remain skeptical about any truly centralized Virgin Islands documentation initiative -- for routine government data, yes; but not for the VINP/VIBR/VIRMC coalition of data users whose more holistic focus is the St. John ecosystem and whose mindset is driven by a more private than public sector work ethic.

GVI Bibliographic Models. Within the Government of the Virgin Islands, previous measures to develop up-to-date bibliographic services have met with limited success. For example, the Caribbean Research Institute (CRI) of the University of the Virgin Islands (UVI) attempted within the last two years to catalogue its library holdings. A reference librarian used the commercial database package, Enable, with an IBM PC with hard disk, to build a catalogue of library holdings. Unfortunately, this endeavor has been temporarily suspended pending additional support.

Another example is the Virgin Islands Bibliography Project (VIBIB) being conducted by Arnold Highfield and Walter Knausenberger at the UVI Kingshill campus. The goal of this long-term project is to produce and publish a comprehensive, annotated bibliography of the printed literature on the Danish West Indies and the U.S. Virgin Islands for the period 1493-1984. Ultimately, the sponsors of this project envision the creation of a computerized data bank. This is not likely to be realized before the end of the decade and perhaps the end of the century.

The most impressive archiving program encountered in the Virgin Islands is that of the Central Territorial Library. The Library, part of the Division of Libraries, Archives, and Museums in the DPNR, has acquired a Honeywell mainframe computer, housed in St. Thomas, that supports the library's computerized catalogue service. This computer is linked to all three islands via modem and also supports an electronic mail service. The system, named "Ultimate," is maintained by a

contractor from Provo, Utah. Discussions are presently underway to expand this network to UVI campus libraries.

The Island Resources Foundation (IRF) has just completed two years of work developing a computerized database of its reference library holdings on resource and environmental management for: St. John/VINP/VIBR, St. Thomas, St. Croix, British Virgin Islands, other Eastern Caribbean islands, and regional resource management issues, including fisheries, forestry, parks and protected areas, pesticides, etc. This catalogue (with a key word index) is done in dBase III+ using Ref Menu, a University of California public domain software package, and an IBM XT with a math coprocessing chip.

Although these various, local efforts will eventually provide better access to information in the Territory, they are not designed to meet the specific needs of natural resource or environmental information users. In fact, a major limitation of the Ultimate catalogue(s) is that critical collections are excluded, such as the Virgin Islands historical collection overseen by June Lindquist at the Enid M. Baa Library in St. Thomas, the collections and publications of the Caribbean Research Institute and its affiliate, the Water Resources Research Council, publications by staff at UVI, and reports by GVI and VINP groups. And, obviously, Enable, Ultimate, and Ref Menu systems are a long way from being compatible.

Space Constraints. Another problem connected to this topic is the general lack of space for archiving material. The new Biosphere Reserve facilities in St. John are already crowded, accommodating National Park administrative and scientific staff and associated equipment. The DPNR is functioning in unsatisfactory offices with wholly inadequate computer, museum, archival, and library facilities and insufficient personnel in each of these specialties. The UVI library is operating under space constraints, and a visit to the Enid M. Baa Central Public Library in Charlotte Amalie clearly showed that available space for its acquisitions was exceeded several years ago. The CRI library is not so acutely handicapped, but it has also reached its capacity to absorb any further significant numbers of acquisitions. One of the best reference libraries in the Eastern Caribbean for natural resource information is located at the rather cramped offices of the Island Resources Foundation in Red Hook. Not only is this facility overloaded with its present collection of materials, but its location is inconvenient for many "in town" professional and government personnel.

Local Equipment and Staff Capabilities for Database Management. Use of PCs in the natural resource/ environmental community has increased over the past couple of years. IBM compatible computers are relatively common, and users report adequate service. We also found, however, that most professional users do not have sufficient time to become proficient in using complicated programs such as database managers or even the advanced features of word processing systems. On

the other hand, junior level staff competencies in application programs are limited strictly to routine data entry, and they are not being trained to acquire skills in these systems.

Telecommunications. Local telecommunications networking among nearly all PC users is more or less a hobby and, at present, cannot support multiuser, frequent operations. Unlike the telecommunication industry on the U.S. mainland, commercial time-sharing services are not locally available. Unfortunately, telecommunication technology in the Virgin Islands has a checkered history, and we were told of frequent problems associated with suboptimal telephone lines, excessive surcharges to link to ITT long distance services and inadequate technical support by the local telephone company (VITELCO). Nevertheless, in an isolated island location with little direct PC user interaction, network experimentation and a telecommunication bulletin board initiative for VIRMC member researchers and other park and protected area managers in the region should be encouraged and supported, however premature the effort may seem. Even if it fails, the lessons learned will be useful steps toward computer competence, literacy and power.

Little Help from Overseas

The National Park Service, the Department of Interior, MAB administrators, various institutions affiliated with the Government and University of Puerto Rico, and such independent groups as IRF, individually and collectively, represent a substantial reservoir of talent and experience at the cutting edge of natural resource information management systems. Unfortunately, it is hard to focus this expertise on the particular needs of the VIBR for several reasons:

- There are substantial real costs involved in sustaining a long-term dialogue on information management issues.

- Within these various groups, the specific expertise to address problems faced by the VIBR is not widely dispersed. In other words, in spite of their relative size, there still are not a lot of people in the Department of Interior, for example, who can help to solve the VIBR information management needs.

- Solving the information management needs of the VIBR is not necessarily a high priority for program funders. As an indication of the importance attached to the subject, less than three percent of the VIBR baseline study grants was devoted directly to information management, and if one includes the two policy documents (VIRMC Technical Report Nos. 15 and 16), the figure is still only about seven percent of the total.

- Solving VIBR information management needs tends to be costly because it requires both technical skill and special management insight. Power outages are common, the risk of data losses and system crashes is high, itinerant visiting investigators (unfamiliar with local hardware and software) invite problems, and systems redundancy is low and therefore breakdowns are costly vis a vis personnel time.

CONCLUSIONS

(1) Standardize on a Geographic Reference System

Especially because of the small size, critical resource constraints, and relatively high environmental stress from intensive human use of the VIBR, management of the Reserve needs geographically referenced data at the highest appropriate resolution. This conclusion holds without regard to the eventual implementation of any GIS system (see below).

(2) Standardize on a Database Management System

All available source data should be published in a consistent format compatible with electronic access. Provision of this data to the VIBR (or its designated Information Clearinghouse, see below) should be a condition of future commissioned VIBR studies and permitted research in the VINP.

Monitoring agencies may need to be assisted to produce the appropriate datasets. Conversion programs can be routinely developed over time.

(3) Apply GIS Technology

GIS is a new, rapidly evolving technology, born in the 1960's from the use of satellites and other remote sensing systems. Appendix 3 is a short general introduction to GIS concepts. Recent advances in microcomputer processing, storage and imaging systems have made it possible to implement substantial GIS systems on micros. In addition, there are dozens of GIS systems operating on small mini-computer systems.

Conceptually GIS applications are very different from conventional resource mapping systems. Most practical GIS systems are based on a "raster" model, with each thematic map (e.g., "elevation" or "soils") assigning a value to each cell or pixel in the map. Decreasing computer memory prices permit these systems to employ data cells (i.e., pixel resolution) of a size that corresponds to reasonable resource management needs. Efficient database systems manage this mass of data.

The advantages of these systems for resource managers include the ability to handle vastly increased amounts of data and to display it in output "maps" which are generally comprehensible to the public and

other stakeholders in the resource management decision making process. The major disadvantage of implementing a GIS system is the cost of data input, which is usually estimated at 80 percent of the total cost of operating a GIS.

VIBR Information Management Strategy Needs a GIS

There are numerous advantages to the use of a GIS for analysis and planning of natural resource management activities. Many of these are self-evident, and all of them (and more) are expounded ad nauseam by the sellers of these systems. In addition to these general advantages, however, there are special reasons a GIS should receive attention and a high priority in the allocation of future resources for the VI Biosphere Reserve:

Useful Analyzing Complex Systems. The marginal costs of examining additional factors in the GIS analysis of a natural resource process is very small. In general, GIS systems encourage the examination of a variety of input and output scenarios. The energetic tropical marine and terrestrial ecosystems of the VIBR, and their various interactions including social and economic factors, provide an opportunity to exercise this ability to the fullest.

Especially Useful in Highly Variable Systems. One of the principal virtues of GIS systems is the ability to identify unique geographic loci which have special characteristics which would ordinarily be swamped by routine, non-geographic analysis systems. High variability within remarkably small geographic bounds is one of the dominant characteristics of the VIBR. In order to manage it effectively, it is vital to be able to recognize and plan for the unique character of small areas. The GIS is uniquely suited to this task.

Output Displays Encourage and Support Public Involvement. The maps and other graphical GIS representations of the area under VIBR management are good instruments for informing and educating the public about the sources and objectives of the overall management strategy. They also serve to focus attention and to narrow areas of actual or potential conflict. In an area with high public sensitivity to NPS acquisition policies, and with high potential for conflict between users with interests ranging from subsistence farming to world-class intercontinental tourism, the GIS display capabilities are very useful.

GIS Identification

It is not within the feasible scope of this report to recommend a specific GIS for the VIBR. As indicated previously, the National Park personnel assigned to the VIBR and associate members in VIRMC still

lack personnel and technical resources to implement any given GIS. The process of accumulating the necessary skills and equipment should include, in that process, the identification and selection of a specific GIS application program. In the meantime, any GIS system will require data linked to a standard geographic reference system, which can be incorporated within the other information management tactics of the VIBR.

Training and long-term equipment acquisition processes should be coordinated to provide the necessary skills by-a given date.

(4) Centralize Information in a VIBR Clearinghouse

An appropriate natural resource database or environmental information Clearinghouse should be developed to meet three major objectives:

(1) Support the Decision Making Needs of VIRMC Users.

First among these are the managers of the V.I. National Park and the Biosphere Reserve, followed closely by GVI natural resource managers and permitting authorities for coastal zone and other development activity.

(2) Incorporate Existing Information Sources into the System.

(3) Bring Local Institutions and Professionals into the Planning Process.

A basic premise associated with these conclusions is that the V.I. National Park, as administrator of the Biosphere Reserve, acting in collaboration with VIRMC, will be the lead organizer and sponsor of the clearinghouse function. This is not meant to discourage the participation of other interested parties.

Institutional Bases

There is general agreement that the success of a natural resource information Clearinghouse in the Virgin Islands is tied to finding an appropriate local institution to house and manage it. This Clearinghouse needs to serve the Biosphere Reserve, the Virgin Islands National Park, relevant agencies of the Government of the Virgin Islands, and the private sector. The institutions suggested as possible locations for housing this facility include the Enid M. Baa Central Library, the main library of the University of the Virgin Islands, the Caribbean Research Institute (at UVI), the VINP, the West Indies Lab-

oratory (WIL) on St. Croix, and the Center for Energy and Environment Research (CEER) of the University of Puerto Rico. Suggested sponsors of this operation include: the National Park Service, Island Resources Foundation, West Indies Lab, Sea Grant, Department of Science and Mathematics at UVI, CRI, DPNR, and VIRMC.

The most important issue associated with developing a Clearinghouse is funding to support staff and to provide adequate services to users. Plans for the financing of the Clearinghouse should consider establishment of a consortium with funding from a variety of sources, including user fees, to diversify the risk and support for the program.

The shortage of professional resources at most agencies and the lack of technical knowledge in database management requires recruitment and support of properly skilled staff to operate and manage the Clearinghouse. These individuals will need to combine experience in information management with professional knowledge of resource management issues. Professionals in the Virgin Islands indicate this is a rare combination of skills and not likely available in the Territory. Attracting this expertise to the Biosphere Reserve will require demonstrating the availability of adequate resources to support staff professionals as well as the Clearinghouse operations. Such support will require funding commitments of several years duration, rather than a limited short-term start-up budget.

Ultimately, the participation and cooperation of all agencies, organizations, and professionals involved in natural resource management in the Virgin Islands is critical to the success of the Clearinghouse. This undertaking will require maintaining the avenues of interaction among these parties established by the VIRMC concept and program to date.

RECOMMENDATIONS

(1) Select and Support a Standard Geographic Reference System

There are a great number of potential geographic reference systems which could be adopted for the VIBR by the V.I. National Park. The alternatives should be reviewed by VIRMC members, but this study recommends unequivocally the use of latitude and longitude, expressed in degrees, minutes and decimals. Precision of the geographic reference should be keyed to the size of the unit being reported -- for example, 18 degrees, 20.7' could refer to the latitude of Government Hill in St. Thomas, while 20.70 would refer to the latitude of Blackbeard's Castle on the top of Government Hill.

Latitude and longitude is an especially appropriate reference system for the Virgin Islands because of the area's maritime orientation and the high volume of recently surveyed areas which establish easily verified "ground truth" points along the coasts of the VIBR. Precise location of virtually all marine resources in the VIBR can be easily derived by triangulation and interpolation from known coastal and offshore features. In addition, the use of latitude and longitude facilitates data exchange with other areas of the Eastern Caribbean which may not share township or state grid-type reference systems.

However, all land development, planning, permitting and land use mapping and most project feasibility studies, as well as all land survey work, make use of the Universal Transverse Mercator (UTM) grid (1,000 feet U.S., 1,000 meter U.K.). It is suggested that all coastal and marine or marine-focused investigations utilize a latitude/longitude system and all terrestrial work use the UTM grid for spatial geopositioning and, in addition, indicate and lable one latitude/longitude coordinate tick mark to facilitate computer conversions (for which software is now readily available).

The Park should maintain a display of a large scale map of St. John and adjacent areas with a detailed overlay grid calibrated to the reference standard. This should be used to assist researchers to identify and convert geographic references of their studies. Previous studies and long term monitoring sites should be recalibrated to the reference standard, as necessary and as intern and other casual personnel assistance permits. The reference standard should be required for all environmental studies which the VINP permits.

The promulgation and enforcement of a geographic reference standard for the information resources of the VIBR is the single most significant step that can be taken to improve the long-term effectiveness of the Reserve's information management strategy. Among other

advantages, the consistent, universal application of a single geographic reference system will greatly reduce the costs of implementation and data entry for any subsequent Geographic Information System.

(2) Support DBASE as Standard Database System for All Automated Files

It is important to identify a single database format which will form the basis for all automated data files generated out of VIBR monitoring and research activities. The VIRMC group can provide valuable input into this process. The fine points in the debate over the selection of a common database system can approach something like theological fervor. Nonetheless, it is the position of this report that there is really only one satisfactory system, and that is the dBASE III+ (or, eventually, IV) database management system published by Ashton Tate.

This recommendation can be debated forever, but the major reasons for selecting the dBASE program seem overwhelming:

- Most large database systems on microcomputers are written in dBASE.
- Throughout the U.S. and the Caribbean, there are more dBASE trained database programmers than all other systems combined.
- There are many times more database support resources (ranging from Users Groups to magazines to reference and textbooks) for dBASE than for all other database management systems.
- There are more available data conversion routines for moving data into and out of dBASE than for any other application data except for plain ASCII or LOTUS 1-2-3.
- There are more functionally equivalent, cheap clones of the dBASE standard than of any other database system.

There are a series of recommendations which should be implemented to support this general policy:

(1) Automate conversion of standard monitoring reports to DBASE;

(2) Establish standard data file naming conventions;

(3) Establish standard record formats, especially for geo-referenced data.

(3) Promote GIS Capability and Applications Development

Appendix 3 provides a general introduction to Geographic Information Systems. At the present time there are only two -- somewhat dated -- textbooks on GIS. The best sources of information are the publications and proceedings of ASPRS (the American Society of Photogrammetry and Remote Sensing), the new GIS WORLD magazine, and training courses offered by various purveyors, including the new GIS for Natural Resource Management Center established by Colorado State University. Contacts for this Center include Denny Parker and Joe Berry, who has just returned to CSU from the Yale Forestry School. Dr. Berry is known to the Territory as a consequence of his experimentation with pMAP at Botany Bay on the western end of St. Thomas.

Use NPS Resources to Evaluate VIBR GIS Needs and Costs

The National Park Service has an established record in using GIS both at the National Service Center in Denver and in specific parks. SAGIS is the GIS software being officially promoted in the Park Service and the development of an application with this software in close association with VINP would be a useful learning experience. The costs of installing and operating the SAGIS system, which runs under the UNIX operating system on mini-computers, is substantial. Initially, however, the VINP staff could work with experienced Park Service technicians to thoroughly evaluate their GIS needs. At minimum this needs-analysis would generate answers to the following kinds of questions:

- What resource management decision-making needs, by which VIBR stakeholders, can be supported by GIS applications (e.g., coastal zone permitting, resource mapping, development planning)?

- What existing data sources currently exist that can be incorporated into a GIS, and what new data needs to be acquired? What are the costs of these data entry and acquisition exercises?

- How will the GIS change basic data acquisition and processing activities? And, more precisely, how can existing and future data generating exercises be managed to minimize the costs of converting the data to GIS input?

- How will these GIS program activities be supported over the longer term (e.g., through a cooperative agreement with USGS or a demonstration project for VINP by the U.S. National Park Service)?

- What are the anticipated benefits of such GIS activities (e.g., improved knowledge about regional natural resources, better capabilities to portray important resource issues, improved display technology for public education and policy making, more reliable data storage and retrieval systems)?

- How can this technology be made available to (and costs shared by) other interested parties in the Territory?

Channel VINP Training and Support to Build GIS Capability. An immediate concern for the Virgin Islands natural resource community is developing a better understanding of the benefits and limitations of GIS technology and associated management and technical concerns. Senior officials at both the DPNR and VINP have expressed their interest and reservations about this technology and need knowledgeable advice independent of agency or vendor interests. At present this input is not available, in considerable degree because GIS technology is so new that channels for providing the necessary support are only now being established.

To keep abreast of developments in this technology, the VINP personnel with Biosphere Reserve responsibility should invest in such services as membership in ASPRS (American Society for Photogrammetry and Remote Sensing) and a subscription to GIS World magazine.

Establish Prototype GIS Applications. There are a number of low cost, IBM PC-based GIS systems distributed by universities or affiliates. Many of these have been developed primarily as teaching systems and probably lack the capabilities desired in a full-fledged GIS system (e.g., the aMAP implementation of pMAP used by Professor Joe Berry and mentioned above). Nevertheless, they may provide a low-cost means of experimenting with GIS applications and concepts for specific, well defined, experimental projects.

(4) Develop VIRMC Information Clearinghouse

We recommend the establishment of an information clearinghouse to archive and distribute data and information useful in the management of and research about the VIBR. Specifically, we recommend that this clearinghouse be established as a membership organization, built on the positive experience of the Virgin Islands Resource Management Cooperative.

Plan the Clearinghouse

Given the diverse nature of institutional responsibilities and interests, it is apparent that all needs of all potential users of the proposed Clearinghouse cannot be fulfilled equally at the same time. A principal objective of the planning phase is to establish the

priorities and timetable for overall Clearinghouse capabilities and services

Acquire Seed Funds for VIRMC to Plan Clearinghouse. VIRMC has demonstrated its ability to function effectively during the last several years as sponsor and manager of numerous studies for the Virgin Islands Biosphere Reserve. Since the function of the proposed Clearinghouse is closely associated with the goals of the Cooperative, it is assumed that the preliminary planning of the Clearinghouse could be easily incorporated as another task of VIRMC. We recommend the major players at this early stage be representatives from the VINP, the Department of Planning and Natural Resources, the University of the Virgin Islands, Island Resources Foundation, West Indies Lab, and ECNAMP.

This early task requires modest funding to develop detailed plans of the functions of the Clearinghouse (see discussion below). This activity should be fully implemented within a period of approximately six months.

Establish an Advisory Board. The existence of an Advisory Board during the early stages of Clearinghouse development would provide VIRMC with outside guidance. The selection of board members should be based on:

(a) knowledge of the local institutional environment;

(b) knowledge of natural resource activities in the Eastern Caribbean;

(c) experience dealing with public and private sector natural resource management activities; or

(d) information management experience.

It is recommended that the Advisory Board be used to provide a combination of political, technical and financial advice, with only incidental overlap with the user community represented in VIRMC. In other words, as managers of the planning process VIRMC would have the direct responsibility for surveying and articulating end user needs, including the provision of open participation in the planning process for all manner of potential users, including representatives of other Eastern Caribbean governments or private contractors and engineering consultants. The Advisory Board would be a source of information about hardware and software technical resources and alternative options for funding the Clearinghouse.

Establish a Strategic Plan for Clearinghouse Collections. From the start, the Clearinghouse, with input from both the VIRMC users and the technical Advisory Board, needs to identify and assign priorities

to the specific datasets and reports which are critical to its function.

The priorities assigned to various inputs to the Clearinghouse will help to define the Interagency Agreements that would be negotiated with various data providers. For example, an agency such as the DPNR, which might provide 20 percent of the on-going monitoring data to be archived by the Clearinghouse, could logically expect to receive considerably greater services from the Clearinghouse in return for its cooperation than an individual academic researcher. In addition, the strategic importance accorded to various sources of input data will determine the allocation of Clearinghouse funds. For example, if most high priority data for the Clearinghouse can be efficiently generated by remote sensing and aerial photogrammetry, expenditures will be very different from a Clearinghouse in which the highest priority data will be derived from manual interpretation and entry of data from historic sources and previously published works (including the VIRMC studies).

Finally, the definition of strategic priorities for various datasets and information sources sets a range of success measures for the long-term operation of the Clearinghouse. If, at the end of two years, the Clearinghouse has been able to archive only 10 percent of the high priority data identified in the strategic plan, this becomes an indicator on which to base future decisions. Furthermore, if the Clearinghouse is unable to conclude satisfactory agreements with a substantial portion of the most important data providers, the project's long-term viability will be seriously jeopardized.

Develop Interagency Membership Agreements. An early step in the VIRMC planning process should be the design of agreements for potential member agencies of the Clearinghouse. These agreements would indicate how each institution would participate in terms of:

(1) providing current data from new publications and on-going report and monitoring series;

(2) responsibilities for providing historical datasets and reports;

(3) free services to be received by the agency and fee schedules for additional services;

(4) cash and other support to be provided to the Clearinghouse; and

(5) the designation of an institutional contact.

Identify a site for the Clearinghouse. As indicated in the findings above, simply finding an institution with sufficient space to house the Clearinghouse may be a significant problem. A major responsibility of the Advisory Board during its early activities will be

recommending a feasible location for housing and operating the Clearinghouse.

Evaluate Systems to Provide Required Services

An examination of existing and potential methods of cataloguing the Clearinghouse collections and delivering services to users is important because of the investment proposed. Since the Central Library has demonstrated effective use of the Ultimate system, a thorough evaluation of its capabilities is recommended. This system is targeted because it already exists, has established computer links to all three islands, and operates on a local mainframe. Furthermore, the Director of Libraries has indicated that she would be interested in providing support in return for a modest investment (in comparison to the costs already incurred by that government agency) to acquire and implement this operation. A second serious candidate for this service is the RITS software used by the NPS. Several specific issues are listed below:

- Evaluate the Ultimate and RITS Systems for Database and Telecommunication Capabilities.
- Determine Start-up, Fixed and Recurring Costs.
- Design and Implement a Prototype Link to the Designated System.

Define Staffing and Training Requirements

Staff skill needs will depend on the strategic plan, and the system identified as the basic model for Clearinghouse operation. The challenge faced by the planners will be to develop realistic staffing guidelines. The Clearinghouse will require staff possessing skills in information management, natural resources or environmental studies, and basic administration.

This study acknowledges the concern expressed by several professionals with regard to the difficulty of recruiting skilled staff. Salaries must be sufficient to attract the right individual(s). Long-term contracts (12 or 24 months) plus relocation expenses may be incentives worth more than their cost in attracting the right candidates. Another option which should be carefully considered is the use of relatively extensive training in information management for a candidate with good natural resource management skills and appropriate aptitude.

An administrator for the Clearinghouse should have strong local knowledge.

Implement Clearinghouse Functions in Deliberate Sequence

The functions of the Clearinghouse fall into eight broad activities. It is recommended that these actions be implemented in a phased, sequential manner, avoiding the impact of trying to accomplish too much too fast. In this context, we believe that starting slow and developing a solid repository to be the most judicious way to proceed.

1. Develop repositories for both paper and electronic storage of data and information.

The primary function of the Clearinghouse is the development of a central archive of natural resource and environmental information. Clearinghouse staff must rely on institutional contacts to provide copies of essential material. This process will consume the bulk of the Clearinghouse effort. From the outset this task requires a strategic plan for the compilation of data of various priorities.

2. Collect new reports and datasets as published.

To be effective, the contents of the Clearinghouse must (at least) be comprehensive and complete from its date of inception for all high priority data. It is critical to assure that all new reports and information are provided to the Clearinghouse on a regular basis. Agreement to provide this information should have been established during the planning phase discussed previously. Experience has demonstrated that Clearinghouse staff will have to maintain regular contact with their institutional contacts to ensure that this process does not disintegrate.

3. Institute a hard copy loan and copying program.

A mechanism needs to be created so that copies of reference material can be borrowed for a limited period of time. The shortcoming of this service is that lending material of this nature sometimes results in its disappearance. Clearinghouse staff will have to institute procedures to avoid having this occur and under such circumstances to invoke serious penalties.

Another essential service is providing copies of materials to the user community. Early consideration must be given to determining whether or not this function should be undertaken directly by the Clearinghouse, provided by another institution or contracted out.

4. Produce semi-annual reports.

Direct mailing of a semi-annual report on the progress and plans of the Clearinghouse is considered very important. This product should also include a summary of new acquisitions, reports on the repository, notification of services and fees of the Clearinghouse, and other news items of interest to the user community. Even if an electronic bulletin board is implemented, this report will probably continue to serve as the primary means of communication among the user community, especially for those who are remote from the Virgin Islands.

5. Develop an electronic mail and bulletin board system.

It was noted in the findings presented above that several parties were interested in establishing an electronic mail-bulletin board service. We see this as a potentially valuable function of the Clearinghouse but express concern that this not be initiated until there has been a full evaluation of the Ultimate system currently in use at the Central Library. If Ultimate does not prove to be useful for the VIBR user community, further consideration of how to provide this service will be needed.

6. Develop a computerized bibliographic data base.

In terms of scheduling the activities in this recommendation area, we propose implementing this particular function in the second year of operations of the Clearinghouse. This should probably be done by the Island Resources Foundation on behalf of or under the aegis of VIRMC since the Foundation's existing bibliography, referred to previously, is compatible (dBase III+/Ref Menu) and more than half completed.

7. Provide methods for wide distribution of electronic data and information maintained by the Clearinghouse.

Most of the user community have IBM compatible PCs. Consequently, during the first years of Clearinghouse operation, distribution of basic datasets on 360K, 5.25 inch floppy disks will probably be feasible. As the collection matures, however, it is likely that the floppy disk will be too small for efficient distribution. Decisions on the next step or mode of electronic data distribution are very important but must await the further development of the Clearinghouse concept and the on-going development of micro-based computer technology. Options might range from putting the Clearinghouse databases on a Bulletin Board System, such as the existing NPS BBS (202-343-1080), to high speed telecommunications links, to high density floppies or micro-floppies, to compact (laser) disk technology.

8. Establish regional coordinating unit.

One of the key roles of the Clearinghouse is coordinating with similar centers throughout the region. The Biosphere Reserve and GVI user community can benefit from links to other information centers. It is recommended that this activity be undertaken during the second year. The operational networking projected for the VIRMC Clearinghouse should be extended to these other centers.

Secure Funding

The Clearinghouse requires funding independent of any existing program budget in the Territory.

Estimate implementation and operational costs. These costs will include:

- equipment (microcomputer, terminal, copier)
- maintenance contracts
- installation and shipping charges
- site preparation
- supplies
- space leasing
- information gathering
- communications fees and equipment
- staffing
- consultant support.

Devise alternative funding strategies. Based on the estimated costs of the Clearinghouse and the various mix of services which the identified systems are capable of supporting, a series of alternative operating scenarios should be developed to permit analysis of trade-offs between the various funding alternatives. The four obvious sources are: sales of Clearinghouse products, fees for Clearinghouse services, membership charges, and contributions and appropriations.

A major task of the management of the Clearinghouse will be designing a funding strategy that combines these potential sources in the most reasonable fashion. Before actually testing the waters, the Clearinghouse should have a general model in mind as to what elements of its overall program should be dependent on what sources of funding. For example, it might be reasonable to charge a nominal fee for services to local agencies, to levy a higher fee for inquiries from the continental U.S., and to seek grants to support information services provided to other countries in the Eastern Caribbean -- all of which would represent only one part of the total funding for the Clearinghouse.

Identify funding sources and submit funding requests. The prospect for acquiring initial funds for planning has been discussed

above. During the early planning process there will also be a significant level of effort required to identify potential funding sources and key staff contacts, initiate dialogue, prepare funding proposals, and acquire funds. The active assistance of members of the Advisory Board in this activity is considered essential. Potential funding organizations include the federal sector (e.g., NPS, EPA) and the private sector (e.g., foundations, non-government organizations). Most probably -- and most desirably -- the funding for the Clearinghouse will be acquired from a combination of monies from several different sources.

APPENDIX 1

LIST OF INTERVIEWEES

NATIONAL PARK SERVICE

William Gregg	MAB Program, WASO
Anne Frondorf	WASO
Maury Nyquist	National Service Center, Denver
Caroline Rogers	Research Biologist, VINP
John Miller	Resources Management Specialist, VINP
Larry McLain	Research Biological Technician, VINP
Roland Wauer	Resource Specialist

V.I. DEPARTMENT OF PLANNING AND NATURAL RESOURCES

Alan Smith	Commissioner
Clara Lewis	Executive Assistant to the Commissioner

Office of Technical Review

Benjamin Nazario	Chief

Division of Fish and Wildlife

James Beets	Chief, Fisheries
Allen Berg	Fisheries Biologist
David Nellis	Chief, Wildlife
Ann Swanback	Office Manager

Division of Environmental Protection

Marsha Gilnack	Supervisor of Ambient Monitoring
Mark Pacifico	Environmental Specialist II

Division of Libraries, Archives and Museums

Jeanette Allis	Director of Libraries
June Lindquist	Professional Librarian IV

Division of Comprehensive and Coastal Zone Planning

Brian Turnbull	Assistant Commissioner of Planning
Dale Berry	Assistant Director
Sue Higgins	Senior Functioning Areas Planner
Robert Teytaud	Senior Resources Ecologist
Helmutt Giebon	Senior Planner
Charlotte Linville	Program Analyst
Nora Santana	Environmental Specialist II

Eastern Caribbean Natural Areas Management Program

Allen Putney	Director

WEST INDIES LAB-FARLEIGH DICKINSON UNIVERSITY

John Ogden	Director

UNIVERSITY OF THE VIRGIN ISLANDS

St. Thomas Campus

Theresa Turner	Assistant Professor, Marine Biology
Helen Gjessing	Professor, Life Sciences
John Lucas	Computer Sciences
Laverne Ragster	Associate Professor, Marine Biology
Natalie Peters	Marine Advisor (Sea Grant Program)

St. Croix Campus

Walter Knausenberger	Natural Resources Program Leader Cooperative Extension Service

Caribbean Research Institute

Kim Emmons	Research Technician
Kirsten Canoy	Manager VI Environmental Research Station

V.I. DEPARTMENT OF EDUCATION

Michael Canoy	Science and Math Coordinator

Donald Hamlin Engineering

Werner Wernicke	Engineer

McComb Engineering

William McComb	Engineer

OTHER CONTACTS

Rob Norton	Ornithologist, BVI Parks Trust
George Tyson	Historian, St. Thomas
Allan Zack	USGS District Office, Puerto Rico
Jan Voordouw	UNEP, Regional Coordinating Unit, Jamaica
Shirly Fisk	NOAA, National Sea Grant Program
Victor Omelczenko	NOAA, National Sea Grant Program
Nancy Huang	NOAA, National Sea Grant Program
Anne Reilly	New York Botanical Garden

MEMBERSHIP OF THE V.I. RESOURCE MANAGEMENT COOPERATIVE

The Virgin Islands Resource Management Cooperative (VIRMC) was formed in 1982 by a Memorandum of Understanding between the following institutions:

- Virgin Islands National Park
- Department of Planning and Natural Resources of the U.S. Virgin Islands Government (Division of Fish and Wildlife and Division of Natural Resources Management)
- University of the Virgin Islands
- West Indies Laboratory
- Island Resources Foundation
- Eastern Caribbean Natural Area Management Program
- U.S. Geological Survey
- U.S. Fish and Wildlife Service
- Southern Forest Experiment Station
- University of Puerto Rico (Sea Grant Program and the Center for Energy and Environment Research)
- Caribbean Fishery Management Council
- Ministry of Natural Resources and Labor of the British Virgin Islands Government
- British Virgin Islands National Parks Trust.

APPENDIX 2

DATA MANAGEMENT GUIDELINES

INTRODUCTION

Establishing guidelines for data management is important for facilitating data use and exchange. Presently, the VIBR has sponsored environmental research on diverse topics and initiated on-going monitoring programs. These endeavors are being undertaken by numerous individuals at several different institutions. Many scientists involved in these studies, and others interested in the results, are concerned about access to these data in the future. The feasibility of sharing data with several international organizations such as UNEP and the IUCN is also being explored.

The guidelines discussed in this section are intended to assist in development of practical data management initiatives. Experience has shown that overly ambitious data management plans lead to disappointment and frustration. These guidelines are also based on the premise that everything cannot be accomplished at once and that it is best to start small and expand as time and resources permit.

The guidelines discussed here are presented as an illustration of a way to establish protocols for describing data sets and developing a raw data repository in conjunction with the Clearinghouse.

(1) Develop Standard Data Set Descriptors

There are presently numerous existing data sets pertaining to natural resources of the Virgin Islands National Park and Biosphere Reserve. VIRMC has also initiated several long-term monitoring studies, and other researchers will also be conducting field studies in the future both in the Park and in the Virgin Islands. It is imperative to develop a standardized method to describe all these data sets. Exhibit 1 contains preliminary data set descriptors.

This information should be collected by the Clearinghouse and become part of the archive information base. The V.I. National Park issues permits for all research carried out in the Park. As part of the permitting system, the VINP Chief Scientist should require all researchers to provide a completed data set descriptor. The Clearinghouse staff will have to urge other researchers to provide this information for historical data sets or fill out these forms themselves.

(2) Establish Standards For Geographic Point Location Data

There are many systems in use for indicating point locations, with three widely used in the United States: Latitude and Longitude, Universal Transverse Mercator (UTM), and State Plane Coordinate System. It is necessary to establish a standard that all parties follow. It is specifically recommended that the VINP should require geographic location to be referenced by latitude and longitude to degrees, minutes, and decimals. There are existing federal cartographic standards issued by the National Bureau of Standards (U.S. Department of Commerce FIPS Publication #70) and the Federal Interagency Coordinating Committee for Digital Cartography (FICCDC) Cartographic Exchange Standards. The NPS Denver Service Center staff have participated in these activities and can provide more details and assistance.

(3) Develop Methods to Facilitate Transfer of Spatial Data From Researchers to The Clearinghouse

The exchange of raw data can be accommodated if certain guidelines are developed. The simplest mechanism is to request copies of data sets (e.g., floppy disk) with detailed documentation about file structure. Unfortunately, researchers tend to omit critical information in documentation, and it requires skilled programmers to even read tape headers. Second, the research community will always have a collection of diverse hardware and software that prohibits uniform data exchange. Invoking a requirement for providing data sets in ASCII format will not always work, and it imposes demands on time and staff that the Clearinghouse may be unable to meet. Resistance to this request could be overcome by providing certain financial incentives or reimbursing the researcher or institution for such activities. Another mechanism for accomplishing this task is to secure special funding to develop and provide such services as part of the Clearinghouse function.

(4) Establish a Central Computerized Data Repository

One solution is to have the Clearinghouse assume the additional role of maintaining a computerized data repository. This would require services such as acquiring data sets and corresponding documentation, modifying or acquiring software to read, manipulate and store the data sets, maintaining sufficient data storage capacity (hard disk or laser disks) to store the various data sets and hiring staff with appropriate skills to operate the computer system. This activity will become a major task requiring additional management oversight to prioritize work loads and deal with assorted frustrating technical problems.

An alternative solution is to contract these services out to an independent company or institution. The decision to proceed with this option would require developing realistic estimates of the overall cost of such an endeavor and the associated benefits to the user community.

The creation of linkages to other organizations such as UNEP and IUCN should also proceed with caution. These activities do not need to be established immediately and do not require real-time data exchange capabilities. It would be prudent to maintain frequent communication between the Biosphere Reserve Clearing-house, providing updates on progress and on a sporadic basis pro-viding samples of information products. It would be judicious to incorporate their data standards when possible.

The decision to use additional computer software -- such as Ultimate or RITS -- must await the outcome of the planning recom-mendations proposed for the Clearinghouse. It would be premature to establish any guidelines for this function at the present time.

EXHIBIT 1

DATASET DESCRIPTOR

CONTACT NAME

Data Base Name:

Responsible Agency:

Contact Person: Phone:

Address:

DATA CHARACTERISTICS

Subject Coverage:

Hydrology	Land Use
Surface Water	Living Resource
Marine/Estuary	Air
Groundwater	Demography
Geology	Health Effects
Soils	Regulated Entities
Vegetation	Archaeology
Climate/Weather	Socio-Economic

Comments:

Time Period:

Geographic Coverage:

VINP
St. Johns
VIBR
St. Thomas
St. Croix
BVI
Virgin Islands
Other

Comments:

Spatial Data Type:

Point
Line
Grid
Polygon
Other

Comments:

Scale:

AVAILABILITY AND STATUS

Availability:

Digital Spatial
Computerized Data Base (nonspatial)
Maps
Hardcopy Reports
Other

Comments:

Status:

Operational
Under Development
Other

Size of Records
Update Frequency

Comments:

Hardware:

Software:

Major Reports Generated:

General Comments:

APPENDIX 3

GIS GUIDELINES

INTRODUCTION

This Appendix discusses Geographic Information Systems (GIS) in relation to the Virgin Islands Biosphere Reserve and serves as a general introduction to the topic for management and technical considerations. GIS is a technology for linking attribute information to spatial data to support complex analysis with unique data integration and display functions. The use of GISs in natural resource applications has grown considerably during the last several years.

The advent of computers with mass storage devices has facilitated the integration of spatial data analysis, statistics, and computer graphics into comprehensive "turnkey" geographic information systems. GIS technology bridges the disciplines of computer science, information management, cartography, remote sensing, and environmental management.

One significant change during the last several years has been the availability of microcomputer-based GISs. These systems, although limited in terms of algorithm capabilities and processing speed, offer viable alternatives to the more expensive mini-computer and mainframe systems. Selection of an appropriate GIS or other software tools must be linked to spatial analysis needs and other requirements discussed below.

The GIS is distinguished from other automated information systems by its ability to perform extensive spatial data manipulation and analysis. Additional features include printing hard copy maps, displaying and manipulating maps and similar outputs interactively on computer screens with "zoom in" capabilities and overlaying different data types.

GISs provide entry, storage, manipulation, analysis, and display of geographic, political, environmental, and other data in a common spatial framework. The data consist of spatial information (points, lines and polygons) and their associated attributes. Point data might be used to represent the location of monitoring sites or historic landmarks. Lines are commonly used to represent rivers, contours, coastal boundaries or transects. Drainage basins, coral reefs, and seagrass beds would be represented as polygons. Sources of GIS data can include a diverse collection of information including maps, aerial photographs, censuses, field data, and meteorological records.

The potential user of GIS tools must also evaluate less expensive digitizing and mapping software packages. Business graphics packages for the personal computer that create and present full color maps are

numerous and varied (e.g., MAPIT, Rand map, Atlas MAP). As in all information technology investments, selection of an appropriate system or collection of software tools must be based on users' specific requirements for data processing, analysis, and output.

OVERVIEW OF GIS CAPABILITIES

For convenience, a GIS can be discussed in terms of spatial data characteristics and four major functions: data input, database management and storage, data manipulation and analysis, and information display. These major GIS functions are discussed below.

Spatial Data Characteristics

The geographic location of each data record is a key identifier used to describe and organize data in a GIS. The concept of data analysis in relation to geographic position is commonly encountered in map reading. Conventional maps are used in natural resource management for numerous purposes. The GIS facilitates automated storage and analysis of spatial data which previously existed as hard copy maps, in combination with many forms of derived statistical information.

For example, a map of coral reef locations may be digitized using an "x, y" coordinate system. In addition to geographic location, attribute information such as species of coral, reef depth or age may be attached to each GIS record. Each attribute is recorded on a separate map, or "theme." All source data for the GIS is based on single attribute themes; standard maps often display a multitude of themes at the same time, such as elevation, vegetation, water bodies, road type, buildings, etc. The GIS can generate maps and associated tabular reports for unique supersets of the attribute data (e.g., shallow reefs less than fifty years old).

Another important feature of geographic data is the representation by either of two formats -- raster/grid or vector/polygon data structures:

(1) Raster/grid structures store spatial references and attributes as specific x, y intersections (e.g., latitude, longitude) representing a given area in two-dimensional space (e.g., an acre, square meter, or quarter section) The choice of an appropriate scale or cell size resolution is critical to the success of raster-based GIS.

(2) Vector/polygon structures define geographic features in terms of points, straight or curved lines, and polygons. A bay, for example, would be described by the polygon defining its outer boundaries.

The advantages of raster/grid data structures over vector/polygon structures include greatly simplified computations. The disadvantage of raster-based systems is the question of whether the system is able to track information at a reasonable level of discrimination, considering the decision-making needs of the situation. For example, a raster-based GIS of the V.I. National Park on St. John which tracked information at the quarter section (160 acres) level would be ineffective because most management decisions are made on parcels considerably smaller than 160 acres. On the other hand, a similar level of discrimination applied to the 9 million acres of federal forest land in Montana might well represent data overkill.

Features represented by vector/polygon data structures are more closely aligned with actual map features and more easily understood since the computer information is compatible with traditional paper map products. A major factor in developing GIS software applications is the complexity associated with providing data manipulation algorithms. Current GIS technology provides the user with ample choices for selecting one or the other format, and several commercial GISs handle both data structures -- using vector based representations for display and raster based systems for data manipulation. As computer memory becomes cheaper, raster-based technologies will become more practical on micro-computers.

Data Input

Data entered into GIS most often come from maps, remote sensing products, and environmental monitoring. Any data record entered into a GIS requires two distinct fields: geographic reference and attribute characteristics. The location of the record entry, or geographic reference, is the coordinates which are generally entered by a process known as digitization. Attribute data is often entered by key-entry at a terminal or transferred from a separate computer system.

Perhaps the most important issue associated with GIS implementation and operation is the need to establish a quality assurance and quality control process for data entry. Since data which forms the GIS database comes from different sources, and requires digitization by staff with varying levels of skill, the end-product needs to be subject to a rigorous quality control system if users are to have confidence in the GIS products. The rule-of-thumb is that data entry costs are 80 percent of the cost of implementing a GIS system.

Database Management and Data Storage

The distinguishing characteristic of GISs from other spatial software packages is the way GIS stores the data and provides flexible access and analysis capabilities to the user. The GIS stores the spa-

tial data in a format which permits rapid and accurate entry, modification, and manipulation of both the spatial data and related attributes.

Data Manipulation and Analysis

Most GISs allow the user to query, manipulate and extract both the geographic and attribute features of any combination of records. Some GISs also provide data analysis tools such as statistical packages, report generators, and graphic packages. The greatest power of the GIS is its unique spatial data analytical techniques. One of the pioneers in this field, Professor Joe Berry of Colorado State University, refers to this as the ability to perform "spatial algebra." Another GIS analytical capability includes the ability to print or map data that meet multiple criteria -- such as all bays without seagrass for the last five years, number of fish landings per marine sector, number of dwellings per watershed.

Information Display

The second most important characteristic of GIS technology is the ability to tailor the display of stored data and analytical information products of the system in a variety of ways. GIS outputs include maps, charts, graphs, 3-D drawings, tables and listings. This display capability includes the association of variable colors or patterns with multiple map themes on display on a computer screen to reveal spatial relationships. The media on which outputs are presented also varies and can include CRT images, color slides, film plots, video disk images, floppy disks, microfilm, multi-color plotter output, and printed graphics and computer reports.

It is important to stress that outputs as described above are distinct from spatial analysis. The analysis usually precedes data display, although displays of raw data can serve as useful tools for identifying patterns and testing hypotheses for further analysis.

TECHNICAL CONSIDERATIONS

A number of technical issues must be considered while planning for GIS implementation and are discussed below.

Data Acquisition

Data selected for incorporation into the GIS may come from a multitude of sources. Appropriate data sets will need to be identified and acquired. This effort can consume considerable time, manpower, and resources. Sometimes specific data sets will be purchased because

they are essential or in the long run cheaper than collecting anew or manually digitizing information already available on hard copy. Usually, new data will be collected as part of a monitoring program because historical data is not complete or further analysis is necessary.

Decision rules are required at an early stage in GIS implementation to set acceptable quality assurance standards. The data used in the GIS program can include raw data values, indices, published maps, printed tables, or other automated data sets. Definition of appropriate data attributes must be established at this early point.

Data Input

Data input can be accomplished by downloading, digitizing, scanning and keyboard entry. The type of input process selected will be dependent on factors such as volume of data, peripherals available, and manpower and time constraints. Realistic estimates of data format conversion needs must be defined to determine programming and technical staff requirements. When data are acquired from manual files and then automated in-house, the data input process is generally less complicated because data formats are well understood.

Additional factors that need consideration include development of a data dictionary, types of tabular and graphic displays and computational capacity and speed. A less important need for the beginning or small-scale GIS is the ease of incorporating models into the GIS. Associated with this issue is the availability and expense of vendor assistance for developing unique or modified routines.

Data Validation and Quality Assurance

To ensure that the GIS operation contains reputable data, the data incorporated into the GIS must meet acceptable data quality standards and quality assurance. Managers and GIS staff must determine what level of QA is needed for acceptable data quality. In addition, thought must be given to establishing data quality standards throughout data retrieval, display, and analysis functions.

Data Updates, Security and Maintenance

The GIS is a dynamic system that requires data up-dating and revision to maintain the currency and utility of the data base. Changes to existing GIS data records should only be permitted by authorized staff. In a small operation, this can usually be accomplished with minimal rules. In contrast, a larger multi-user GIS operation will require well defined protocols.

Storage Requirements

A realistic assessment of data storage requirements is important to the long-term success of the GIS operation. On-line disk storage or Bernoulli boxes are desirable because they provide the user with quick access to the data. Tape storage is a viable alternative for backup, but problems may be encountered with physical storage demands.

MANAGEMENT CONSIDERATIONS

During the planning stages of GIS some important managerial issues need to be considered. These issues are highlighted below.

Clear Definition of Objectives

Initially, a thorough evaluation of GIS needs by the V.I. National Park and the Biosphere Reserve is needed before attempting to acquire a system. (Given the costs and management support needs of GIS, it would be pointless for one entity to employ the technology without the participation of the other.) This includes being able to identify what activities will be supported, how these activities will be funded, and the anticipated benefits.

The Denver Service Center of the NPS would be an ideal center to assist the VINP/BR in this task. Furthermore, development of a NPS sponsored GIS application would provide valuable VINP/BR exposure to the GIS technology that would be useful for future applications. However, existing GIS demonstration commitments and limited finances and staff might delay this technical assistance unreasonably. Several GIS proposals, on the other hand, have been submitted to the VINP/BR. If the Denver Service Center cannot provide assistance, the Park staff in conjunction with Regional managers, need to determine how an outside GIS application can aid Park/Biosphere management.

This phase can also show that in fact full-blown GIS technology is not needed or remains impractical because of staffing, policy or financial barriers. Consequently, a viable data analysis alternative may be defined that incorporates less expensive commercial products.

Determine The Scope Of The GIS Applications

Another important initial planning consideration is the scope of GIS needs in relation to the number of anticipated users, types of management decisions to be supported, boundaries of the targeted geographic region, and types of data required. If properly identified and accommodated, these decisions will lay the foundation of the GIS operation and will result in flexibility that will reward such careful early planning.

Identify Existing Data Sources

The types of data that will be used to develop the GIS database need to be detailed. Some of the data already exists in computerized formats, while other data will be manual files in a variety of conditions. The VINP/BR will need to develop a detailed description of appropriate information and this task can be assisted by the previously discussed Clearinghouse. At this time, identification of new data requirements should also occur. A strategy will need to be devised to schedule the digitization of the data. In addition, a protocol should be established to review data files and records to assure they represent desired information.

Determine Staffing Requirements

In a small GIS operation using a micro-based system, there needs to be a least one dedicated staff person for day-to-day operations. This person will obviously need to be computer literate with special training in GIS applications. Most commercial vendors provide orientation programs for the novice and more advanced technical training. Sufficient funds to support such training must be allocated during the implementation process.

A present constraint of the VINP/BR is that this staff slot does not exist. If the staffing problem is solved, it is doubtful that adequate space exists in current offices to house the necessary equipment and hardcopy storage. Also, the implementation of a GIS at the Park would have an impact on other existing administrative and management resources.

Establish Data Validation Measures

The issue of data validation must be addressed in the early stages of GIS data base planning. Existing historic data for the Virgin Islands that are considered for incorporation into the GIS should be reviewed to determine if the data quality is acceptable. Data quality may vary depending on the applications which the GIS will support. It would be useful to provide quality indicators in the GIS data base or fields which identify data sources.

Establish GIS Standards

Another strategic step is the development of GIS standards. In the case of the VINP/BR, the Denver Service Center can assist in this process. Standards are considered strict requirements, and although this might be a long-term goal, it is probably more realistic in the early stages to provide guidelines to the data generators. This subject is discussed in more detail in Appendix 2.

Estimate Program Costs

The implementation of a GIS includes numerous costs associated with equipment purchase, installation, and database development. In estimating the GIS implementation and operational costs, consideration must also be given to software and hardware prices, shipping of equipment, site preparation and installation, training, data gathering and updating, regular maintenance to both hardware and software and system upgrades. A realistic estimate of staff resources is also necessary.