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ENVIRONMENTAL DATA

Major Effort Is Needed to Improve NOAA's Data Management and Archiving

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The Honorable Ernest F. Hollings
Chairman, Committee on Commerce,
Science, and Transportation
United States Senate

Dear Mr. Chairman:

This report assesses how well NOAA and USGS are managing, storing and archiving environmental data collected by space and ground data collection systems. The report identifies a number of problems and challenges both agencies face in ensuring that the massive volumes of irreplaceable environmental data is preserved and accessible to scientists engaged in global change research.

As arranged with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the date of this letter. We will then give copies to appropriate congressional committees; the Secretary of Commerce; the Administrator, NOAA; the Secretary of Interior; the Director, USGS; the Administrator, NASA; and other interested parties upon request.

This work was performed under the direction of Samuel W. Bowlin, Director for Defense and Security Information Systems, who can be reached at (202) 275-4649. Other major contributors are listed in appendix IX.

Sincerely yours,

Ralph V. Carlone

Ralph V. Carlone
Assistant Comptroller General

Executive Summary

Purpose

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is responsible for operating the nation's environmental satellite systems, and managing, archiving, and disseminating environmental data. Since 1970, it has spent about $3.5 billion on environmental data programs, launched over 40 environmental satellites, and managed extensive ground data collection systems. The Department of Interior's Geological Survey (USGS), through its Earth Resources Observation Systems (EROS) Data Center, is working with NOAA to manage and archive earth observation data from the Landsat spacecraft. NOAA's environmental data, stored on over 440,000 magnetic tapes, 374 million film records, and 89 million paper records, have expanded our understanding of earth's surface, oceans, atmosphere, and solar conditions. The nation's ability to monitor and understand global changes in the earth's environment, such as the depletion of ozone and global climatic changes, will depend on these data.

Given the importance of environmental data to the global change program, and the nation's investment in acquiring these data, the Senate Committee on Commerce, Science and Transportation asked GAO to assess how well NOAA and its contractors are protecting the tapes, film, and paper containing this information from loss and deterioration.

Background

Because much of the environmental data are irreplaceable, they should be managed as a valuable national resource. NOAA stores most of these data on magnetic tapes, film, and paper records in 35 storage vaults at NOAA data centers, academic institutions, and other federal agencies. Federal regulations, established by the National Archives and Records Administration (NARA), require government agencies to follow specific regulations in managing, maintaining, and storing magnetic tapes and film records. Paper records, while not covered by specific regulations, should be protected from fire and water damage. These regulations were adopted to ensure the long-term preservation of data stored on these media, the prompt disposal of unneeded records, and the efficient management of storage resources.

Future spaceborne and ground data collection systems are expected to produce a massive increase in the volume of data, an increase unparalleled in NOAA's history. Several systems—the new geostationary and polar orbiting satellites, the next generation radar, and the National Aeronautics and Space Administration's (NASA) Earth Observing System spacecraft—are expected to generate more data each year than NOAA

collected during the past 10 years. This increase will require considerable management attention and resources, as well as the use of advanced data storage technologies.

Results in Brief

Currently, over 230,000 tapes, more than 370 million film records, and 76 million paper records containing environmental data are stored under poor conditions. Some irreplaceable data have already been lost. Further, NOAA has not (1) adequately managed and maintained its archives, (2) performed an agencywide inventory of its data holdings, and (3) promulgated agencywide standards for minimum acceptable storage, maintenance, quality control, and inventory practices.

NOAA and USGS are working or plan to address certain aspects of the problems noted. However, they have not allocated adequate resources to improve the management and storage of environmental data. Moreover, since the volume of data to be handled in the future will increase at tremendous rates, data storage and management issues need immediate attention.

Principal Findings

Many NOAA Tapes and Film Records Are Stored Under Substandard Conditions

Twenty-two of the 35 vaults, which store over 230,000 of the 440,000 tapes and over 370 million film records, did not comply with more than one half of the combined federal regulations and industry tape management guidelines. These vaults, operated by 10 data centers, did not have adequate temperature and humidity control, fire protection, water protection, security, or tape maintenance. In some instances, GAO found tapes stored in basements, dusty warehouses, and offices not designed for tape storage.

A general lack of security is also a serious threat to NOAA's computer resources and data holdings. Some facilities GAO visited lacked even rudimentary access control to guard against unauthorized entry into computer rooms and tape storage areas. Only six vaults maintained backup tapes of original data so they could be restored if they were accidentally lost or destroyed.

In contrast, a good storage environment is possible. All three of NOAA's major data centers operated at least one storage vault that partially met

most of the federal regulations and industry tape storage guidelines. The USGS's EROS Data Center clearly demonstrates that it is possible to meet federal and industry standards. Its main tape and film vaults met, with a single exception, all federal regulations and industry standards.

NOAA Has Not Performed an Agencywide Inventory of Data Holdings

NOAA does not know how much data has been retained or archived on paper, film, or magnetic tapes since it was created in 1970. At the facilities it visited, GAO identified 89 million paper records, over 440,000 magnetic tapes, and over 374 million film records which were stored and managed by NOAA data centers, academic institutions, USGS's EROS Data Center, NASA's Tape Staging and Storage Facility, and NARA's federal records centers. Although every facility GAO visited maintained an inventory of data holdings, these varied in completeness and format.

Data May Soon Be Lost

NOAA officials noted that some early satellite data are lost, and that over half of the archived environmental data are suspect, damaged, or otherwise at risk. EROS is storing over 30,000 tapes containing images from Landsat 1, 2, and 3 spacecraft. These tapes as well as inoperable computer equipment needed for processing, were shipped to EROS in 1988 from another federal agency. Sampled tapes show that the entire shipment is deteriorating and that unless EROS acquires new computer hardware needed to process and recover them, the entire holding may be lost.

Data Archiving Was Treated as a Low Priority Activity

Neither Commerce nor NOAA have provided adequate management leadership or resources for its archival efforts. Instead, most of the attention and resources were spent on managing and operating the data collection systems. During the 1980s, the lack of management emphasis in this area resulted in a decrease in data management funding, from $27 million in 1983 to $21 million in 1989. This decrease occurred despite massive growth in the volume of archived data.

In 1988, NOAA proposed a major data management program, known as the NOAANET project, to improve its data management and archiving. However, according to officials involved in archiving environmental data, Commerce has shown little interest in NOAA's attempt to enhance its data management and archiving capabilities, and has in fact reduced data management resources below minimum levels required to adequately maintain data holdings. This assessment was echoed by the National Research Council's Committee on Geophysical Data, which

noted that the decline of funding had a severe impact on NOAA's data centers, data management technologies, and capabilities.

NOAA and USGS Are Seeking to Correct Identified Deficiencies

NOAA and USGS recognize that significant efforts will be needed to correct the problems noted. NOAA is taking immediate steps to correct minor deficiencies, and is planning to address the remaining problems in the future. USGS is also planning a 5-year effort to convert all of its tapes to advanced storage media, process all Landsat data, and provide an off-site backup for its tape holdings.

Recommendations

GAO is making a series of recommendations to the Secretary of Commerce which should be incorporated in NOAA's plans to help ensure that its valuable environmental data are adequately stored, maintained, and preserved. These include recommendations that NOAA (1) conduct a thorough inventory of its tapes, film, and paper records; (2) assess their scientific value and the condition of the storage media; (3) copy valuable data to archival quality media; and (4) archive data in facilities that meet NARA regulations. GAO is also recommending that NOAA strengthen its data management capabilities by (1) developing and implementing appropriate tape and film management standards, and (2) allocating adequate resources to data management and archiving. GAO is not making any recommendations to USGS because its plan to process and convert its Landsat data holdings, if approved and funded, will address all of the identified deficiencies. Details on GAO's recommendations to Commerce are in chapter 4.

Agency Comments

In commenting on a draft of this report, Commerce and NOAA agreed that NOAA's data management and archiving program needs to be strengthened. NOAA noted that it shares GAO's concerns, and said that it has programs underway to implement GAO's recommendations. Commerce said that it supports NOAA's effort to strengthen its environmental data management and archival program. Commerce's and NOAA's comments are included in appendix III.

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Abbreviations

EOSAT	Earth Observation Satellite Company
EROS	Earth Resources Observing Satellite
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NCDC	National Climatic Data Center
NESDIS	National Environmental Satellite, Data, and Information Service
NGDC	National Geophysical Data Center
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NSIDC	National Snow and Ice Data Center
SDSD	Satellite Data Services Division
SSEC	Space Sciences and Engineering Center
TSSF	Tape Staging and Storage Facility
USGS	United States Geological Survey
WDC	World Data Center
WNRC	Washington National Records Center

Introduction

Since 1970, the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) has spent about $3.5 billion collecting data in atmospheric, marine, solid earth, and solar-terrestrial sciences. NOAA and its predecessor, the Environmental Science Services Administration, launched over 40 spacecraft, and collected, processed, stored, and distributed massive volumes of environmental data. It has helped to expand our understanding of earth's environment, and is providing critical environmental data to thousands of researchers worldwide. These data, stored on over 440,000 tapes, 374 million film and 89 million paper records, represent significant national resources needed for global climate change research and other scientific investigations of earth's environment.

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) operates the environmental satellite program, and collects, processes, archives, and distributes environmental data and information to support the needs of users in commerce, industry, agriculture, science and engineering, the general public, and federal, state, and local agencies. It relies on space and ground platforms, including spacecraft, aircraft, balloons, ships, buoys, and ground observation stations to collect environmental data. NOAA also receives data from many other sources including National Aeronautics and Space Administration (NASA), Department of Defense, and foreign spacecraft. NOAA is also designated as one of the key federal agencies participating in the Global Change Research Program.[1]

The Department of Interior's Geological Survey (USGS), and its EROS Data Center works with NOAA to manage its earth observation data. Under an agreement with NOAA, EROS processes and archives data and images from Landsat spacecraft.[2] In addition to the EROS Landsat archive, Landsat data are also managed by the Earth Observation Satellite Company (EOSAT)[3] which stores over 17,000 Landsat 4 and 5 tapes at NASA's Tape Staging and Storage Facility (TSSF) in Landover, Maryland.

[1]NOAA is one of seven agencies with budget initiatives focusing on specific Global Change Research Program objectives. Other agencies include the Department of Energy, Department ofthe Interior, the Environmental Protection Agency, NASA, National Science Foundation, and the Department of Agriculture.

[2]According to USGS officials, the Administration budget request for fiscal year 1990 included a directive to transfer the responsibility for the Landsat archive from the Secretary of Commerce to the Secretary of Interior. Legislation addressing this transfer was pending as of September 14, 1990.

[3]EOSAT was assigned exclusive rights to market all Landsat data.

Numerous Facilities Manage NOAA's Data

NESDIS manages environmental spacecraft and related activities, including processing, archiving, and distributing climatological, geophysical, oceanographic, and environmental data. It operates three major data centers responsible for climatic, geophysical, and oceanic data:

- the National Climatic Data Center,
- the National Geophysical Data Center, and
- the National Oceanographic Data Center.

NOAA also contracts with other centers to provide management and archival services for its data, including:

- the University of Wisconsin Space Science and Engineering Center,
- National Snow and Ice Data Center,
- USGS's EROS Data Center, and
- NARA's Federal Records Centers in Washington, D.C, and Atlanta, Georgia.

See appendix I for a brief description of the activities of each of these centers.

National Archives and Records Administration Provide Governmentwide Guidance and Oversight

The National Archives and Records Administration (NARA) is responsible for establishing records management requirements, and for periodic reviews of NOAA's and other federal agencies' activities in managing and archiving their data.

Magnetic Tapes and Film Require Controlled Storage Environment

Computer magnetic tape, various types of film,[4] and to some extent paper are the most common storage media for scientific data and images gathered by spacecraft, aircraft, balloons, ships, and ground observation stations. They are durable, portable, and relatively inexpensive but must be properly managed, maintained, and stored to prevent deterioration. Federal regulations and guidelines require government agencies to follow specific standards in managing, maintaining, and storing magnetic tapes and film. These standards were adopted to ensure long-term preservation of valuable data and efficient management of storage resources.

[4]Includes microfilm, microfiche, negatives, positives, and other types of film.

According to computer industry guidelines, a magnetic tape that has been properly stored and maintained may last about 10 years. General industry practices require that all tapes 10 years old be copied. Data deterioration or losses are mainly due to physical damage to tape caused by mishandling, contamination, and a poor storage environment. Properly stored film, on the other hand, is expected to last between 10-100 years. While film is more durable than tape, it too may be damaged if not properly maintained. As with magnetic tape, the loss of data stored on film may occur due to contamination, poor storage environment, and physical abuse. Paper records should be protected from fire and water damage.

NOAA's Environmental Data Are a Valuable National Resource

Many of NOAA's environmental data represent a significant national and international resource that must be safeguarded and preserved. These data, which cost billions of dollars to collect, are distributed to and used by thousands of researchers in commerce, industry, science and engineering, national defense, and government agencies in applications ranging from estimating world food supplies to the understanding and intelligent use of the environment. More importantly, these data are increasingly important to understanding the environmental changes on our planet. They will help scientists answer questions on the extent and the potential impact of global changes in earth's environment, and on the well-being and the quality of life of future generations. These data are critical to research of ozone depletion, global climate warming, sea level change, drought, deforestation, desertification, and the reduction in the diversity of living organisms.

Managing Environmental Data Will Pose Significant Challenges in the Future

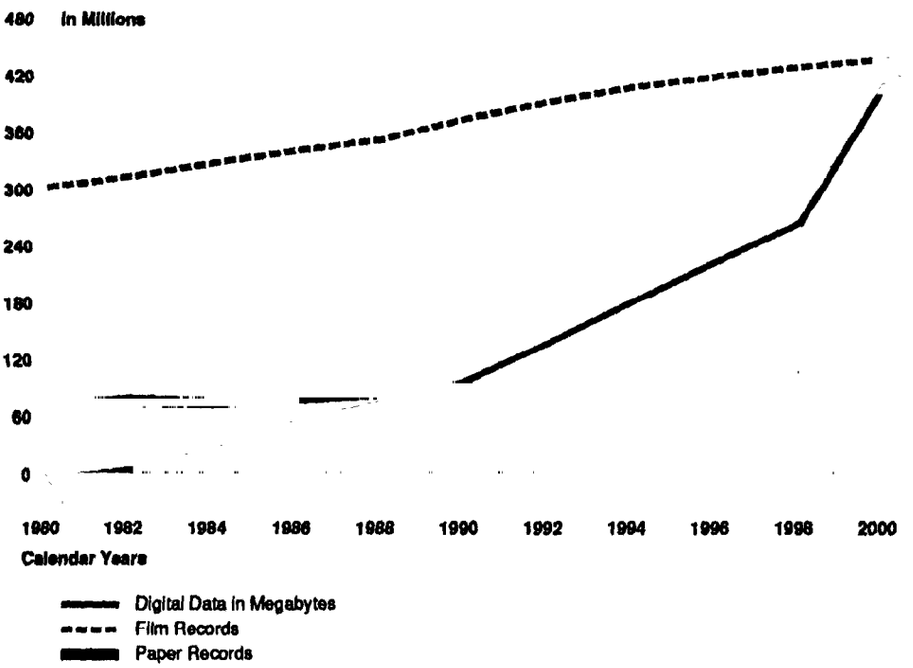
During the 1990s, NOAA will face significant challenges in managing, processing, and archiving its data. It expects a hundredfold increase[5] in the annual volume of environmental data flowing to its data centers, and a fourfold increase, from 96 terabytes[6] in 1990 to 410 terabytes in 2000, in the volume of its digital data archives. A less dramatic increase is expected in the volume of archived film and paper records, with film records increasing from 374 to 438 million, and paper records from 89 to 103 million. During this period, NOAA is expected to handle data from its

[5]The annual data volume is expected to increase from about 2 terabytes in 1990 to 200 terabytes in 2000.

[6]One terabyte of data equals 10^{12} bytes (1,000,000,000,000 or 1 trillion bytes).

advanced polar and geostationary satellites,[7] its Next Generation Radar system, two NASA Earth Observing System satellite platforms, as well as from other national and international sources. Figure 1.1 presents NOAA's estimates of actual and projected data volumes between 1980-2000.

Figure 1.1: Actual and Projected Archival Data Volumes, 1980-2000



Objectives, Scope, and Methodology

On September 13, 1989, the Senate Committee on Commerce, Science and Transportation asked us to report on how well NOAA and USGS are managing and archiving environmental data stored on film and magnetic tapes. The Committee asked us to use evaluation methodology and a tape management checklist we developed for our assessment of NASA's tape management and archiving practices. To obtain information on NOAA and USGS film and tape management practices, we:

[7]Between 1990-98, NOAA is planning to launch 7 polar orbiting, NOAA-series satellites, and 4 geostationary, GOES-series spacecraft.

- identified federal and private sector film management regulations and guidelines, and revised our tape management checklist;
- reviewed NOAA's policies and guidelines governing data management;
- reviewed reports and documents related to management of data, including reports prepared by NOAA and scientific groups and committees;
- interviewed NOAA, USGS, and NASA officials responsible for managing NOAA's data;
- identified and reviewed film and tape management practices at 10 data processing and storage facilities operating 35 film and tapes storage vaults (see table 2.1); and
- discussed NOAA's tape management practices with NARA officials.

We used NARA regulations and NIST guidelines as the primary guide in developing film and tape management criteria, and we supplemented our checklist with guidance provided by major manufacturers of magnetic computer tapes. Although our review focused on magnetic tapes and film records, in one major facility we also reviewed the management and storage of large volumes of paper records. When we noted an absence of an agencywide inventory or central listing of film and tapes holdings, we relied on other information to estimate NOAA's tape and film holdings, including estimates provided by NESDIS and federal records centers' officials. On the basis of this information, we identified all major facilities we believe manage the bulk of NOAA's environmental data.

To determine the extent to which each facility complied with the regulations and guidelines, we:

- used our checklist to discuss, observe, and document the storage conditions found at each location, always in the presence of facility representatives;
- photographed and videotaped examples of the conditions noted; and
- modified, where appropriate, the results of our visits, based on written comments provided by each facility (discussed in app. II).

Our audit work was performed in accordance with generally accepted government auditing standards, between January 1990 and August 1990 at various locations, including:

- Commerce and NOAA headquarters, Washington, D.C.;
- NESDIS headquarters and the Satellite Data Services Division's (SDSD) vaults in Suitland, Maryland;

- the National Climatic Data Center (NCDC) in Asheville, North Carolina;
- the National Geophysical Data Center (NGDC) and the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado;
- National Oceanographic Data Center (NODC) in Washington, D.C.;
- Goddard's TSSF in Greenbelt, Maryland;
- NARA headquarters, Washington, D.C., and its Washington and Atlanta federal records centers;
- USGS headquarters in Reston, Virginia;
- EROS Data Center in Sioux Falls, South Dakota; and
- Space Science and Engineering Center (SSEC) at the University of Wisconsin, Madison, Wisconsin.

NOAA's Tape Management Practices Place Environmental Data at Risk

NOAA has not properly managed, stored, and maintained its magnetic tapes, film, and paper records containing valuable environmental data. It has begun to develop an agencywide master directory of environmental data sets, but it does not have a central inventory of its tapes, film, and paper records. Therefore, NOAA neither knows what or how much data have been collected since 1970, nor can it easily identify data that have been lost.

Some Irreplaceable Data Are Deteriorating

NOAA has no film or tape management standards of its own, and most of its centers operate one or more film and tape storage vaults that do not meet many critical federal storage requirements and industry guidelines. As a result, many of NOAA's valuable and often irreplaceable data may be at risk. In our March 1990 report on NASA's tape storage and archiving practices[1] we noted that NASA's data stored on magnetic tapes are deteriorating because of aging, lack of maintenance, and poor storage conditions, and that some important data may have been irretrievably lost. We have similar concerns about NOAA's tape holdings.

Officials involved in data management and archiving admitted that all of NOAA's tapes are deteriorating and that some tapes are already unreadable. More disturbing are actual data losses. A recent draft of NOAA's data management program[2] highlighted a loss of early satellite scanning radiometer data, and noted that over half of the archived environmental data are suspect, damaged, or otherwise at risk. The deterioration of NOAA tapes was confirmed by NCDC's 1988 attempt to read over 18,000 inactive tapes. This effort was aborted because over 1,600 older tapes were in such bad condition that tape drives were being damaged. We found similar problems at EROS, where a recent test of older Landsat tapes showed the tapes to be deteriorating.

EROS officials noted that much of the Landsat data were only partially processed with much of the original data remaining on aging and deteriorating tapes. For example, only about 10 percent of the 400,000 images of the earth's surface acquired between 1972-78 were converted from video to computer tapes. The bulk of these data remain stored on aging and deteriorating video tapes. Similarly, only 5 percent of the 150,000 Landsat images acquired since 1982 were processed and transferred to

[1]Space Operations: NASA Is Not Properly Safeguarding Valuable Data from Past Missions, (GAO/IMTEC-90-1, Mar. 2, 1990).

[2]Environmental Data Management Program (Draft), NOAA, August 10, 1990.

computer tapes. About half of the Landsat tapes containing about 950,000 images are over 10 years old and rapidly deteriorating.

NOAA Has No Agencywide Inventory of Its Environmental Data

NOAA stores its data in 35 storage vaults operated by NOAA's data centers, academic institutions, and other federal agencies, including NARA and USGS. In general these data are stored on magnetic tapes, film, and paper. NOAA has not performed an agencywide census or inventory of its data and thus does not know what data it has and where the data are located. Although every center we visited maintained data inventories of their own data holdings, these inventories varied in quality and completeness. For example, while every center maintained automated inventories of tapes kept in its storage vaults, tapes stored at the federal records centers were usually inventoried by storage boxes rather than by individual tapes. Furthermore, some centers kept only manual inventories of their non-digital data, and were unable to accurately estimate the volume of their film and paper records.

Notwithstanding NOAA's lack of an agencywide data inventory, we identified over 463 million archival tape, film, and paper records. Specifically, over 440,000 NOAA tapes are stored by NESDIS' centers, EROS Data Center, and by the federal records centers in Washington, D.C., and East Point, Georgia. Over 25,000 videocassette tapes, equivalent to over 3.7 million standard tapes, are stored by the Space Sciences and Engineering Center at the University of Wisconsin.[3] Although there could be more, these facilities collectively store or manage over 440,000 NOAA tapes, 384 million film records, and more than 89 million paper records. We visited 10 facilities, which store NOAA's environmental data in the 35 film and tape storage vaults listed below.

[3]The videocassette archival system, developed by SSEC under a grant from the National Science Foundation, uses standard U-MATIC videocassette and modified videocassette recorders to store over 8 billion bytes of data on a single cassette. The storage capacity of one 75-minute cassette is equivalent to 150 standard (6,250 bits per inch) computer tapes.

Table 2.1: Selected Data Processing and Storage Facilities Managing NOAA's Environmental Data

Facility	Number of Storage Vaults	Location
National Climatic Data Center	7	Asheville, North Carolina
Satellite Data Services Division	2	Suitland, Maryland
National Geophysical Data Center	10	Boulder, Colorado
National Snow and Ice Data Center	3	Boulder, Colorado
National Oceanographic Data Center	1	Washington, District of Columbia
Tape Staging and Storage Facility	1	Landover, Maryland
Atlanta Federal Records Center	2	East Point, Georgia
Washington National Records Center	3	Washington, District of Columbia
EROS Data Center	3	Sioux Falls, South Dakota
Space Science and Engineering Center	3	Madison, Wisconsin

The Federal Government and Industry Prescribe Tape and Film Management Standards

Poor management of magnetic tapes and film may cause partial or total loss of recorded data. Although both storage media are sturdy, research and empirical evidence have shown that both will deteriorate unless properly stored and maintained. Concerns in government and industry about the preservation of magnetic tapes and film led NARA, the National Institute of Standards and Technology (NIST), and the industry to develop comprehensive tape and film management standards. These standards fall into two groups: federal regulations established by NARA,[4] and NIST[5] and industry[6] guidelines. Together, they constitute a set of safeguards and practices that are designed to reduce the potential loss of valuable data stored on magnetic tapes and film.

According to NARA and NIST, loss of data stored on magnetic tapes and film stem from contamination and physical or chemical deterioration of the recording media due to poor housekeeping techniques such as lack of cleanliness, inadequate temperature and humidity control, the absence of maintenance, and improper handling. Data stored on damaged, contaminated, or deteriorated tapes and film can sometimes be partially or fully recovered through costly restoration and recovery procedures.

[4]Code of Federal Regulations, Title 36, Part 1232, 1234.

[5]Care and Handling of Computer Magnetic Storage Media, NBS Special Publication 500-101, National Bureau of Standards, June 1983. (NBS is now called NIST).

[6]We contacted eight manufacturers of magnetic tapes or peripherals, one tape management consulting firm, and the International Council on Archives, and obtained their tape management guidelines.

Because NOAA had not adopted the federal tape and film management requirements as agency policy, or developed its own tape and film management guidelines, we used a tape management checklist developed for our review of NASA's archiving practices and NARA's film management requirements to assess each facility's tape and film management practices. The checklist focused on crucial factors in preserving stored data:

Covered by Federal Regulations

- temperature and humidity control;
- test and certification of tapes designed for long-term storage;
- backup and storage of tapes containing valuable data at another location;
- adequate security and internal controls to safeguard equipment, software, and tapes from theft, tampering, or destruction;
- quality control, through sampling, to detect deterioration of stored tapes;
- readability of tapes and film by ensuring the availability of hardware required to read the stored data; and
- data inventory.

Covered by Federal and Industry Guidelines

- clean environment and handling to prevent tape and film contamination and damage;
- fire protection;
- water protection; and
- a routine, scheduled tape maintenance program.

Many Facilities Do Not Comply With Federal and Industry Standards

Twenty-two of the 35 vaults, which store over 230,000 of the 440,000 tapes and about 370 million film records, did not comply with more than one half of the combined federal regulations and industry tape management guidelines. These vaults failed to meet such criteria as adequate temperature and humidity control, fire protection, water protection, or tape maintenance. We found tapes and film records stored in a dusty warehouse, basements, and office spaces not designed for tape or film storage.

Although we noted numerous facilities with several deficiencies, a good storage environment is possible. Most of the centers we visited, including NCDC, NGDC, and NODC, had at least one storage vault in full or partial compliance with most federal regulations and industry guidelines. The EROS main tape and film vaults were, with a single exception, in full compliance with all regulations and guidelines.

The following table lists individual regulations and guidelines and the level of compliance we found during our review. In noting the compliance level, we assigned:

- a full compliance rating where total compliance with all regulations or guidelines was observed or documented;
- a partial compliance rating where the facility did not comply with one or more regulations or guidelines;
- a non-compliance rating where compliance with none of the regulations or guidelines was observed or documented; and
- a non-applicable rating where the facility was not responsible for certain aspects of media management such as quality control.

Figure 2.1: Compliance with NARA's and Industry Tape and Film Management Standards

Tape or Film Storage Facility	Number of Records Tapes	Number of Records Films[a]	NARA Regulations: Environmental Controls Temperature	NARA Regulations: Environmental Controls Humidity	NARA Regulations: Test/ Certify Media	NARA Regulations: Off-site Backup	NARA Regulations: Security	NARA Regulations: Sample 3% of tapes	NARA Regulations: Changing Technology	NARA Regulations: Inventory	NIST/Industry Guidelines: Media Handling	NIST/Industry Guidelines: Protection Fire	NIST/Industry Guidelines: Protection Water	NIST/Industry Guidelines: Media Maintenance
National Climatic Data Center														
Main Tape Vault	33,493	•	●	●	●	●	△	△	●	●	●	●	△	△
Backup Tape Vault	22,712	•	○	○	●	●	△	○	●	●	●	○	△	○
Satellite Data Storage	16,666	•	○	○	○	○	△	○	●	○	●	○	△	○
Coastal Zone Color Scanner Tape Storage	25,000	•	○	○	○	NA	○	○	●	○	○	○	△	○
Computer Room Tape Storage	22,392	•	●	●	NA	NA	●	NA	●	●	●	●	△	NA
Film Vault	•	236,034,000	○	○	NA	●	●	NA	NA	○	●	○	△	NA
Basement Paper & Film Storage	•	•	○	○	NA	○	○	NA	NA	○	○	○	○	NA
Satellite Data Services Division														
Tape Vault	90,000	•	△	△	○	○	○	△	●	●	●	●	△	○
Film Storage	•	250,000	△	△	NA	△	●	NA	●	●	●	○	○	NA
National Geophysical Data Center														
Main Tape Vault	6,000	•	○	○	○	●	●	△	●	●	△	○	○	△
Valmont Warehouse Tape Storage	15,000	•	○	○	NA	NA	○	○	●	●	○	○	○	○
Space Environment Laboratory "B" Tape Library	2,534	•	○	○	△	NA	●	○	●	●	●	○	○	○
Space Environment Laboratory "C" Tape Library	12,541	•	●	●	△	NA	●	△	●	●	●	●	●	△
Solar-Terrestrial Physics 12" Film Storage	•	•	○	○	NA	NA	●	NA	NA	△	△	○	○	NA
Solar-Terrestrial Physics Microfilm Storage	•	•	○	○	NA	NA	○	NA	NA	△	●	○	○	NA
Solar-Terrestrial Physics Microfiche Storage	•	130,600,000	○	○	NA	NA	△	NA	NA	△	●	○	○	NA
Marine Geology and Geophysics Microfilm Storage	•	•	○	○	NA	NA	○	NA	NA	△	●	○	○	NA
Solid Earth Geophysics Microfilm Storage	•	•	○	○	NA	NA	○	NA	NA	△	●	○	○	NA
Valmont Warehouse Film Storage	•	•	○	○	NA	NA	○	NA	NA	△	○	○	○	NA

Tape or Film Storage Facility	Number of Records Tapes	Films[a]	NARA Regulations: Environmental Controls Temperature	Humidity	Test/ Certify Media	Off-site Backup	Security	Sample 3% of tapes	Changing Technology	Inventory	NIST/Industry Guidelines: Media Handling	Protection Fire	Water	Media Maintenance
National Snow and Ice Data Center														
Tape Storage	1,575	•	○	○	○	●	○	△	●	●	△	●	○	△
2nd Floor Film Storage	•	1,400,000	○	○	NA	NA	○	NA	NA	●	●	○	○	NA
3rd Floor Film Storage	•	•	○	○	NA	NA	○	NA	NA	●	●	○	○	NA
National Oceanographic Data Center	3,900	1,800,000	△	△	●	●	△	●	●	●	●	●	△	●
Space Sciences and Engineering Center														
Tape Vault	11,659	•	○	○	NA	○	●	●	●	●	●	△	●	NA
State Records Center "L" Storage	13,000	•	○	○	NA	NA	●	NA	NA	●	●	○	○	NA
State Records Center "E" Storage	650	•	○	○	NA	NA	●	NA	NA	●	●	○	○	NA
EROS Data Center														
Main Tape Vault	99,592	•	●	●	●	○	●	●	●	●	●	●	●	●
Basement Tape Storage	30,969	•	●	●	NA	○	●	●	○	●	NA	●	△	NA
Film Vault	•	9,401,167	●	●	NA	NA	●	NA	NA	●	●	●	●	NA
Tape Staging and Storage Facility	17,517	•	●	●	NA	NA	●	NA	NA	●	●	●	△	NA
Atlanta Federal Records Center														
Vault 1	5,044	15,000	●	●	NA	NA	●	NA	NA	●	●	△	△	NA
Vault 2	•	•	●	●	NA	NA	●	NA	NA	●	●	△	△	NA
Washington National Records Center														
Vault 1	14,937	4,750,000	△	△	NA	NA	●	NA	NA	●	NA	△	△	NA
Vault 2	•	•	△	△	NA	NA	●	NA	NA	●	NA	△	△	NA
Vault 3	•	•	△	△	NA	NA	●	NA	NA	●	NA	△	△	NA
Total	445,181	384,050,167												

● Full Compliance
△ Partial Compliance
○ Noncompliance
NA Not Applicable

[a] Estimated

Most facility managers generally agreed with our findings, and in most instances are planning to correct the deficiencies. Asked to name what, in their opinion, caused these deficiencies, the managers listed budgetary constraints and the high cost of complying with every regulation. Appendix II presents their detailed responses to our findings.

The following section contains our summary assessment of how well the 10 centers implemented procedures and safeguards related to the critical factors in their 35 tape and film storage vaults.

Temperature and Humidity Control

To avoid environmental damage to stored records, NARA requires that tape storage vaults be kept at 60 to 72 degrees Fahrenheit and between 40 to 50 percent relative humidity, with film storage vaults below 70 degrees Fahrenheit and between 40 to 60 percent relative humidity. Extreme temperature and humidity levels or repeated temperature and humidity changes cause permanent tape and film damage and loss of data.

Only nine of the 35 tape and film storage vaults store film and tapes in full compliance with NARA's temperature and humidity requirements. The majority of tape and film storage vaults we visited are not equipped with hygrothermographs for monitoring temperature and humidity in their storage vaults, and in several instances, the centers were storing tapes and film in poorly air-conditioned basements or office spaces.

Figure 2.2 shows two portable humidifiers in a backup storage vault cooled by a portable wall-mounted air-conditioning unit. The vault was not equipped with hygrothermographs.

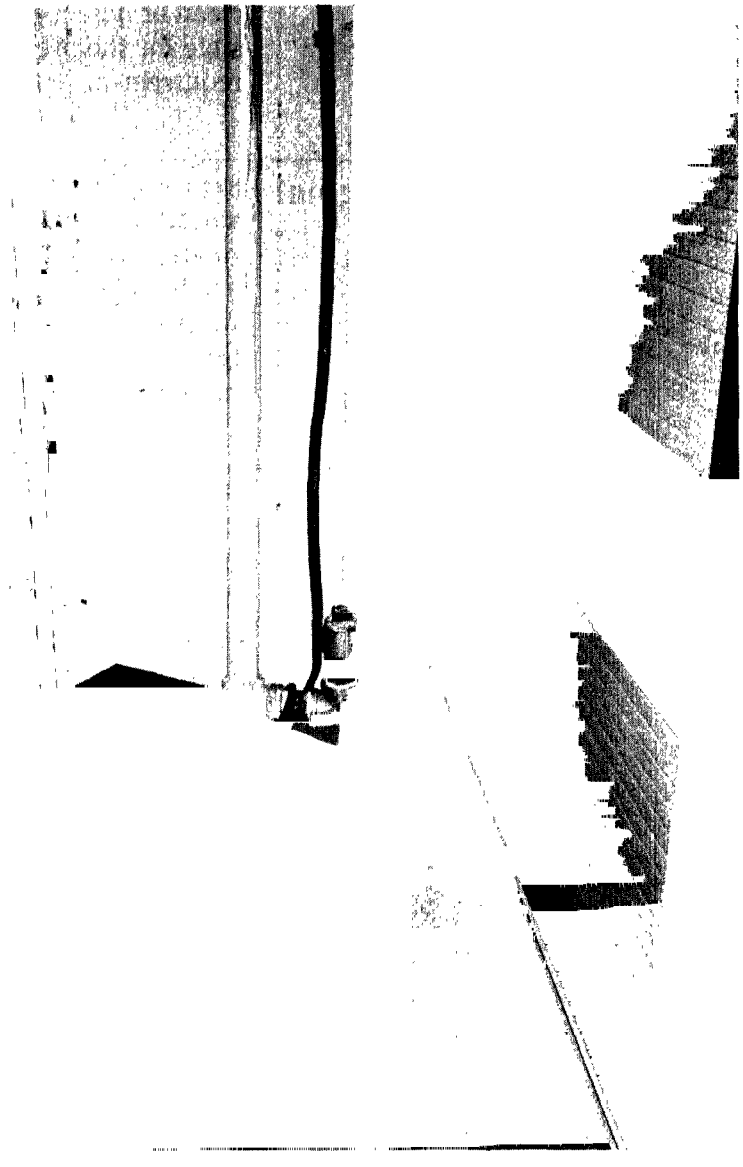


Figure 2.2: Portable Humidifiers in a Tape Vault Not Equipped With Hygrothermographs

Preparation of Archival Tapes

NARA requires that all tapes designated for permanent retention be tested and certified no more than 6 months before they are used for long-term storage. This regulation is designed to assure the long-term preservation of the recorded data by removing contaminants and ensuring that the tape is free of manufacturing defects. Although most manufacturers test tapes before shipment, that does not guarantee a

clean or defect-free tape. Only five of the 11 tape storage vaults responsible for the preparation of archival tapes complied with this requirement.

Off-Site Backup of Original Tapes

NARA requires that a duplicate of tapes containing valuable data be stored at an off-site location. This regulation intends that a full set of tapes is available should the originals be destroyed through vandalism, earthquake, flood, or fire. Only six of the 13 storage vaults responsible for providing backup for their tape holdings did so. Moreover, three centers—SDSD, EROS, and SSEC—which store irreplaceable satellite data did not have any backup for their archival tapes.

Security and Internal Controls

Poor security and access control may result in theft, tampering, or destruction of computer equipment, software, and data. Sixteen of the 35 storage vaults did not provide adequate security for their data holdings. In some instances, the effort and cost to correct the most significant deficiencies is minimal, and may require only a modest expenditure for a card access lock for the storage vaults, or changes in facility operating procedures. In other instances, improving security is more difficult and costly. For example, the federal building housing NCDC's vaults is classified as a historic landmark and is accessible to the general public through 13 separate entrances.

Quality Control

NARA requires that each federal facility storing magnetic tapes annually sample 3 percent of all holdings to detect deterioration. Only four of 14 tape storage vaults responsible for the monitoring of their tapes performed quality control—through sampling—of stored tapes. We considered six additional vaults to be in partial compliance because they monitored the conditions of their active tape holdings through routine processing, rather than statistical sampling as required by NARA.

Changing Technology

NARA requires that federal agencies storing tapes ensure that they have the equipment needed to read and process the stored data. This may be accomplished either by copying the older tapes to a new, widely supported tape format, or by maintaining hardware required for their processing. One tape storage vault, EROS' auxiliary vault, lacked equipment for reading older tapes. It does not have the tape drives and other

computer hardware capable of reading more than 30,000 tapes containing images from Landsat 1, 2, and 3 spacecraft. These tapes, originally stored by another federal agency, were transferred to EROS in 1988. Although the agency also transferred all of the necessary hardware, including tape drives, this hardware is obsolete, and according to EROS officials, inoperable. The problems with obsolete tapes are illustrated in the following photographs. Figure 2.3 shows over 20,000 deteriorating video tapes containing Landsat images, while Figure 2.4 shows the hardware, now obsolete and inoperable.

Figure 2.3: Landsat Tapes Stored on Pallets in a Partially Finished Auxiliary Vault

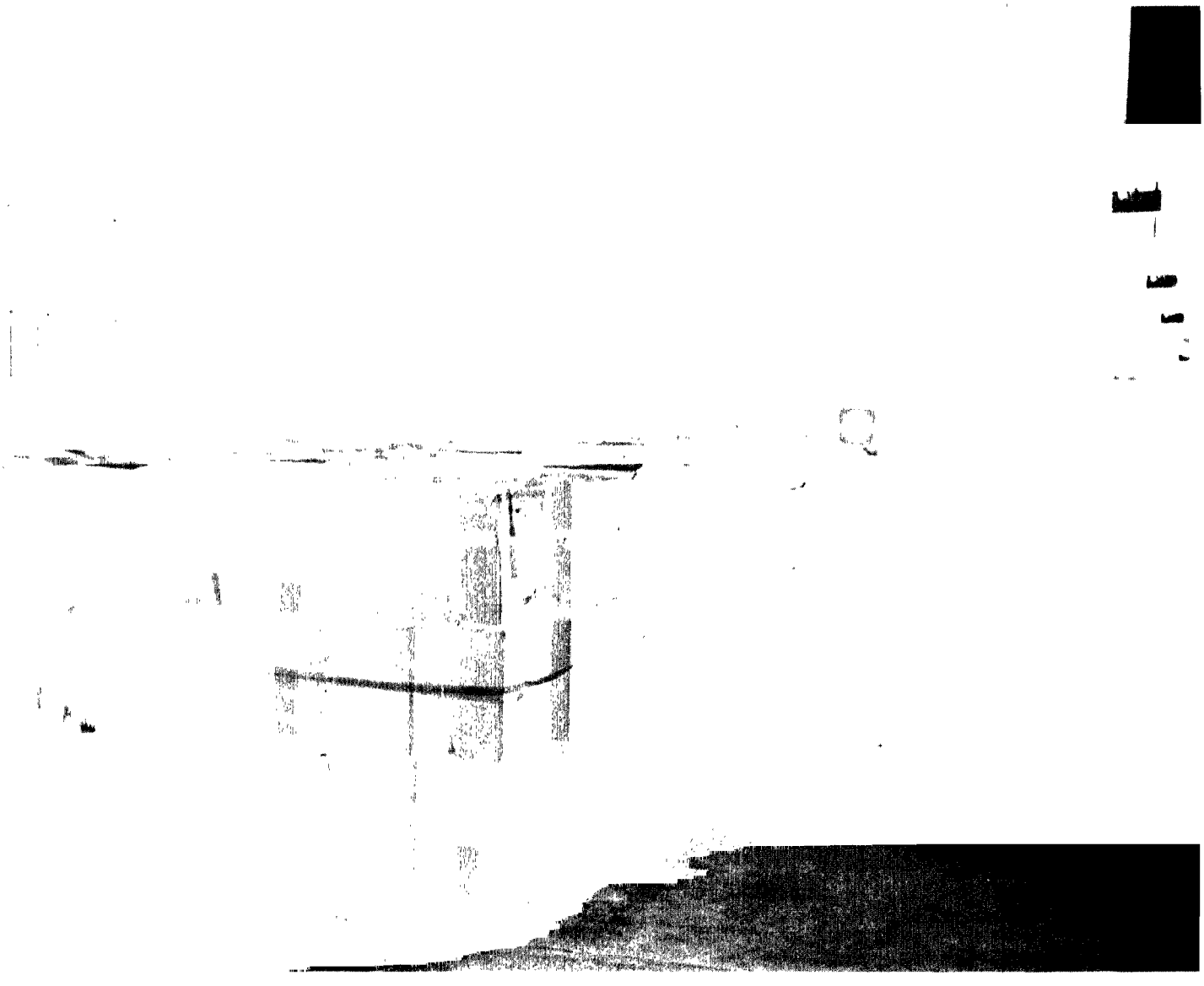
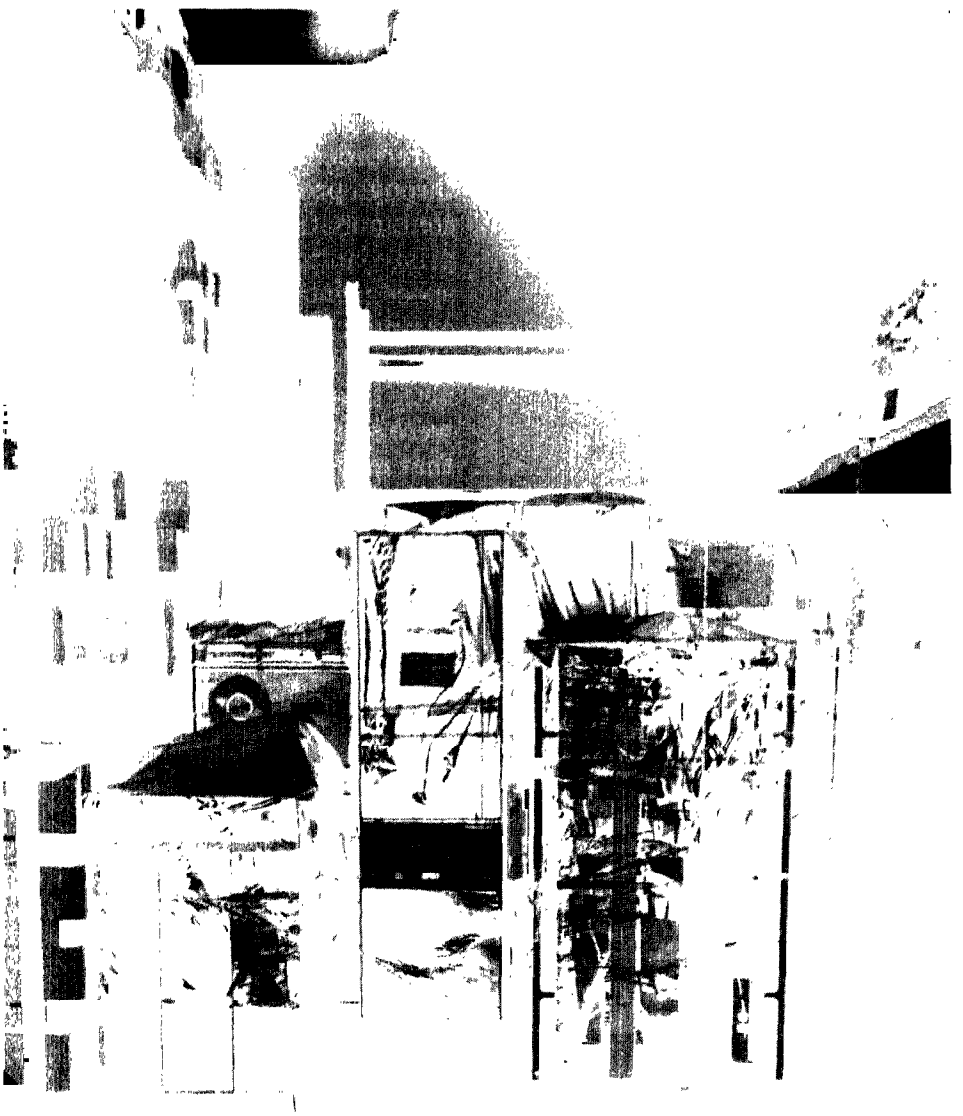


Figure 2.4: Inoperable Landsat Hardware



Inventory

NARA requires that federal agencies maintain accurate inventories of their film records and magnetic tapes. Accurate inventories are needed to identify record location and to facilitate the disposition of obsolete records. Ten of the 15 film storage vaults failed to maintain adequate inventories of millions of their film records.

Clean Environment and Media Handling

Clean environment and handling standards cover a broad range of recommendations ranging from clean processing and clean storage vaults to guidelines on physically handling the storage media. Poor film and tape handling may cause tape contamination or physical damage and the loss of recorded data. For example, film and tapes may be contaminated through proximity to smoking, eating, and drinking. Other sources of contamination are dust and debris from stored paper products, inappropriate janitorial techniques, or dust-producing equipment such as high speed printers. Tapes may be physically damaged by horizontal stacking or rough handling. Seven vaults did not provide an environment meeting all standards for the cleanliness and handling of film records and magnetic tapes. As shown in the following figures, several storage vaults were storing NOAA's film and tapes in a manner and in an environment that may damage them. For example, Figure 2.5 shows one facility where we found thousands of tapes, some covered with cobwebs, in a dusty warehouse, while Figure 2.6 shows the same facility where we found rolls of film stored without protection on an office chair. Finally, Figure 2.7 shows tapes stored in an office space also used to store discarded equipment and paper.

Figure 2.5: Tapes Stored Near Discarded Equipment in a Warehouse

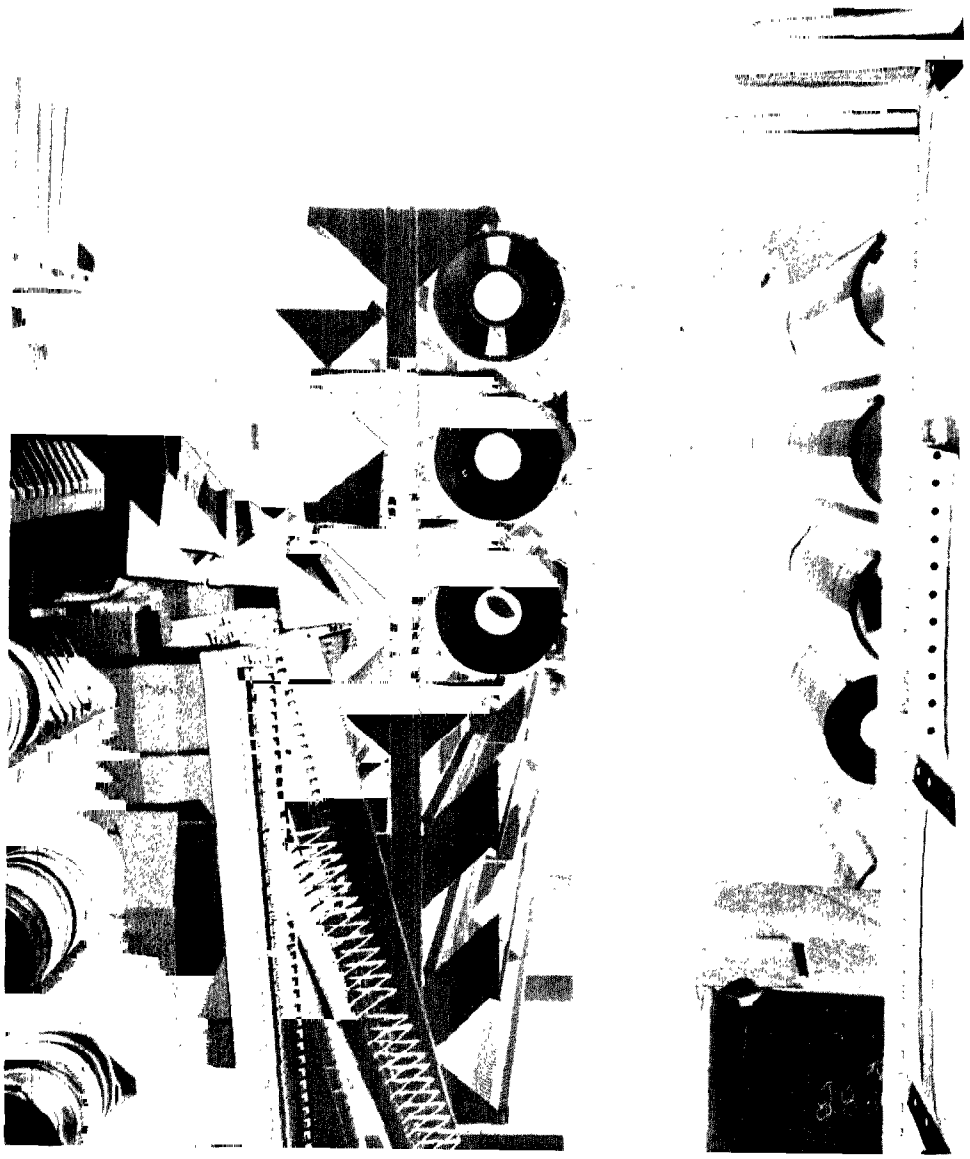


Figure 2.6: Archival Film Stored on a Chair

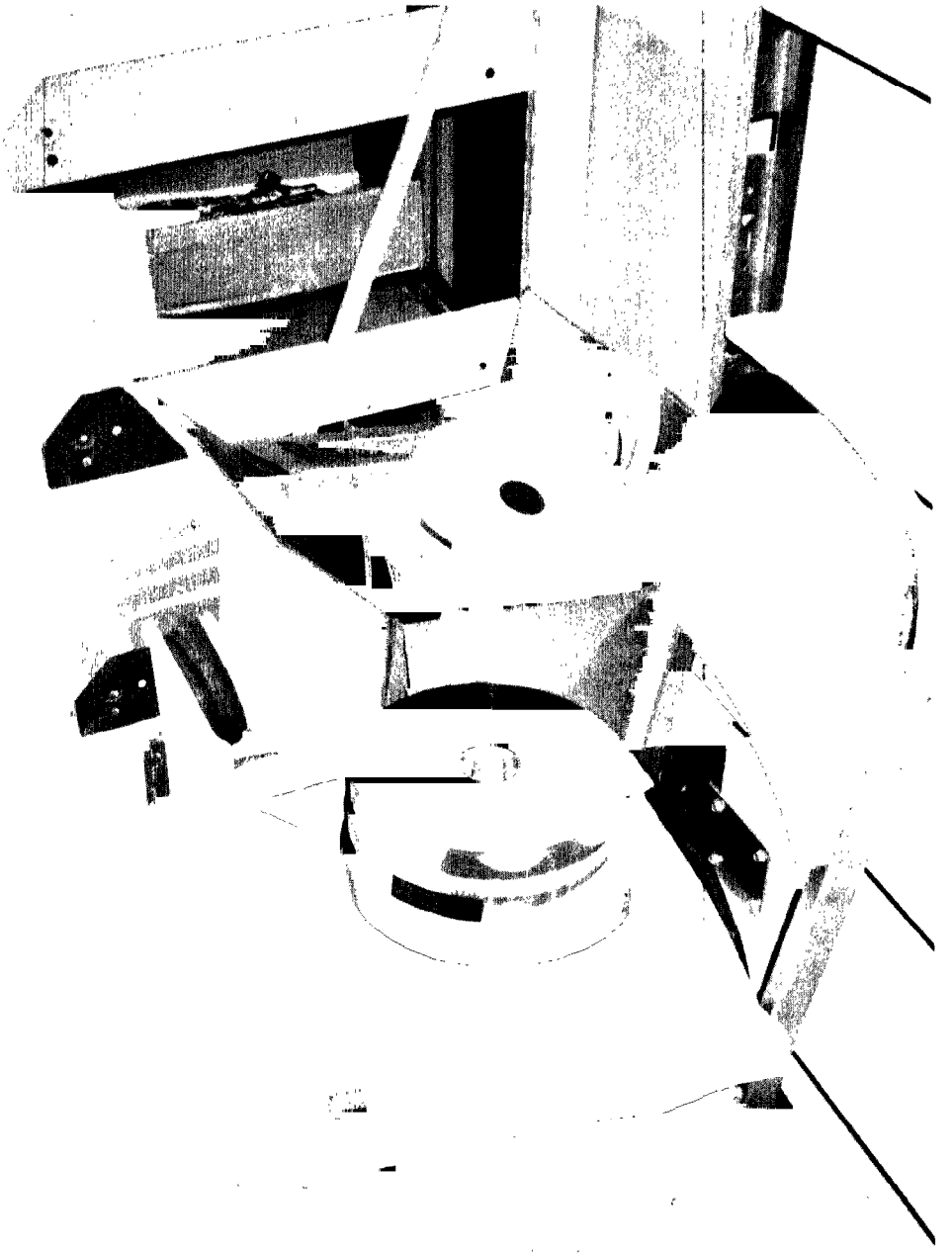
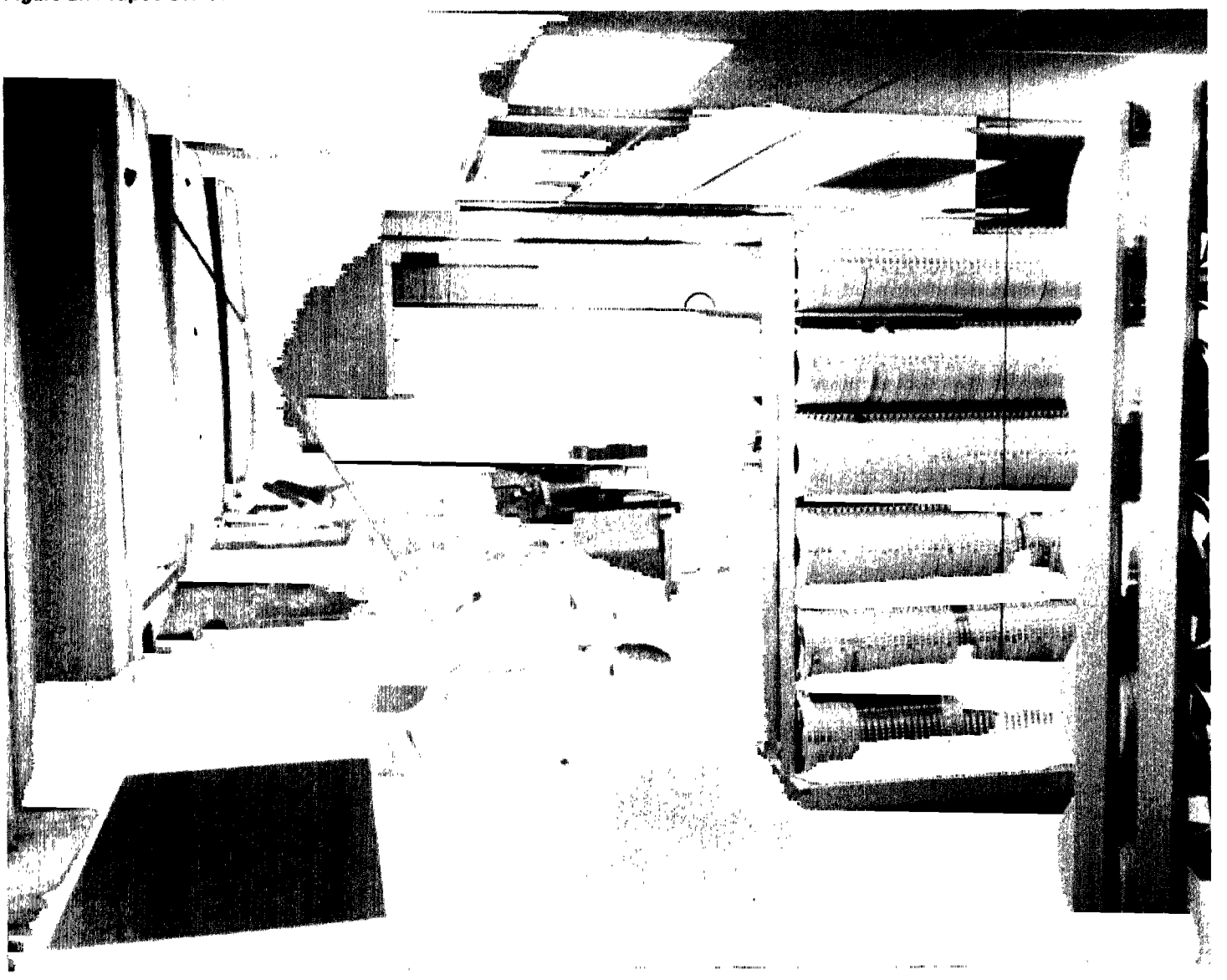


Figure 2.7: Tapes Stored in an Unconverted Office

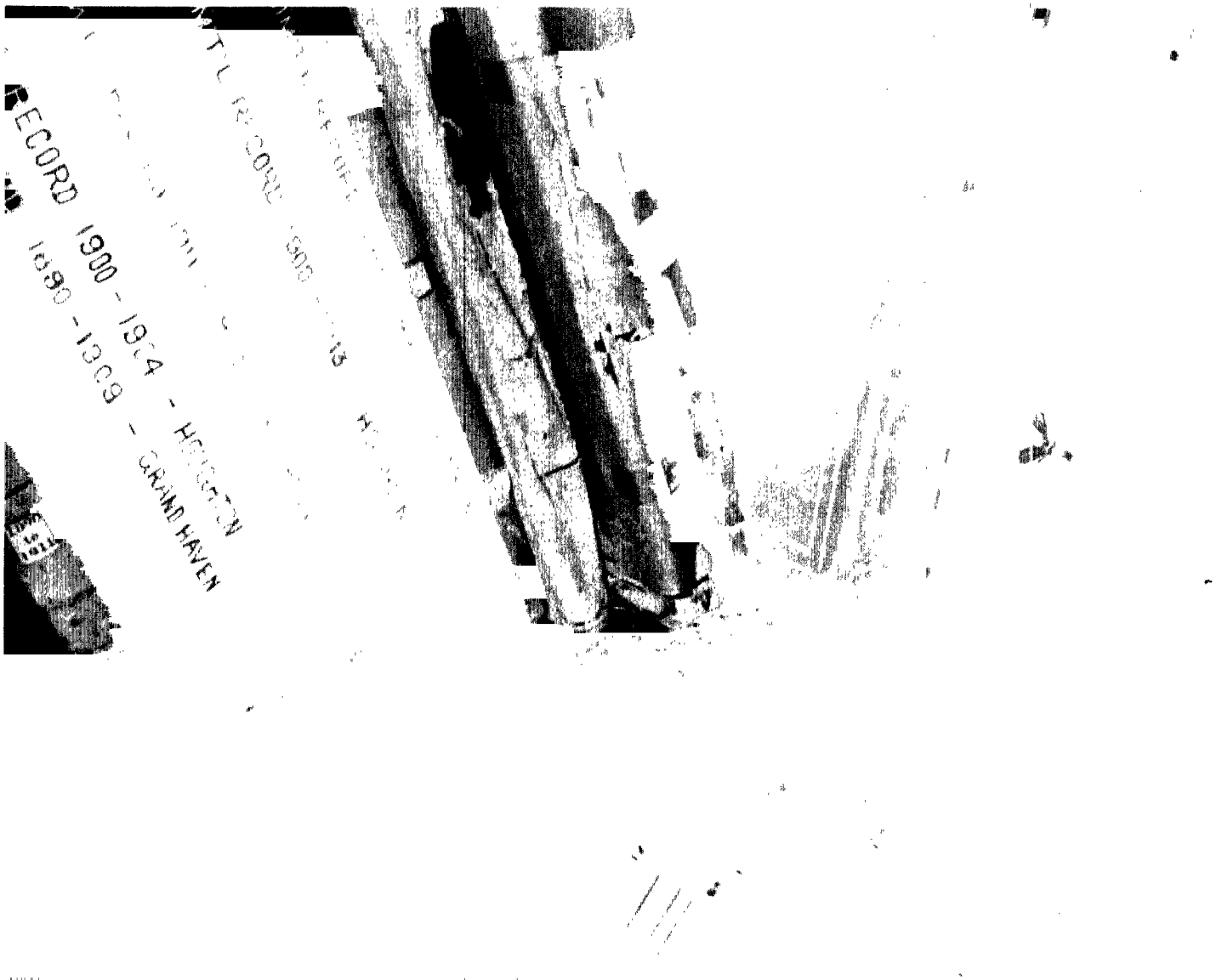


Fire Protection

According to National Fire Protection Association guidelines, film and tape storage vaults may minimize fire danger by: (1) installing fire and smoke detectors, (2) having a fire suppression system, (3) keeping records in non-combustible containers, (4) being free of combustible materials, and (5) not being located below ground level. Twenty-seven of the 35 storage vaults lacked adequate fire protection or were keeping combustible materials near stored records.

Figure 2.8 shows a few of the 240 million original paper records stored in a basement storage facility. This vault is not equipped with an automatic sprinkler system. It also contains large volumes of film processing chemicals as well as a silver recovery plant. Located in a building containing five film and tape storage vaults, the basement storage is, according to NOAA's own assessment, "a safety hazard and a fire trap."

Figure 2.8: Deteriorating Paper Records Stored Without Fire or Water Protection in a Basement



Water Protection

NIST and industry guidelines recommend (1) the installation of floor-based water detectors, and (2) the availability of plastic sheets to protect stored tapes from overhead leaks. Only four of the 35 storage vaults provided adequate safeguards against water damage. In several instances we noted evidence of past water leaks.

Routine Tape Maintenance

NIST suggests that tapes be periodically cleaned, rewound, and, if required, recopied. Only two of the 12 vaults responsible for maintaining archival tapes implemented a scheduled tape maintenance program. Tape maintenance is critical, especially for tapes stored in vaults with poor environmental controls.

A Good Storage Environment Is Achievable

Each facility we visited operated at least one film or tape storage vault that met some NARA requirements and industry guidelines. For the most part, it appears that the centers allocated most of their storage resources to vaults containing the most valuable film records and tapes. One center, the USGS's EROS, was providing an exceptional storage environment for its permanent film and tape holdings. We found the center's main tape and film vaults, as shown in figures 2.9 and 2.10, to be, with a single exception, in full compliance with all of the applicable federal regulations and industry guidelines. It clearly demonstrates that a good film and tape storage environment is achievable.

Figure 2.9: EROS' Main Tape Vault

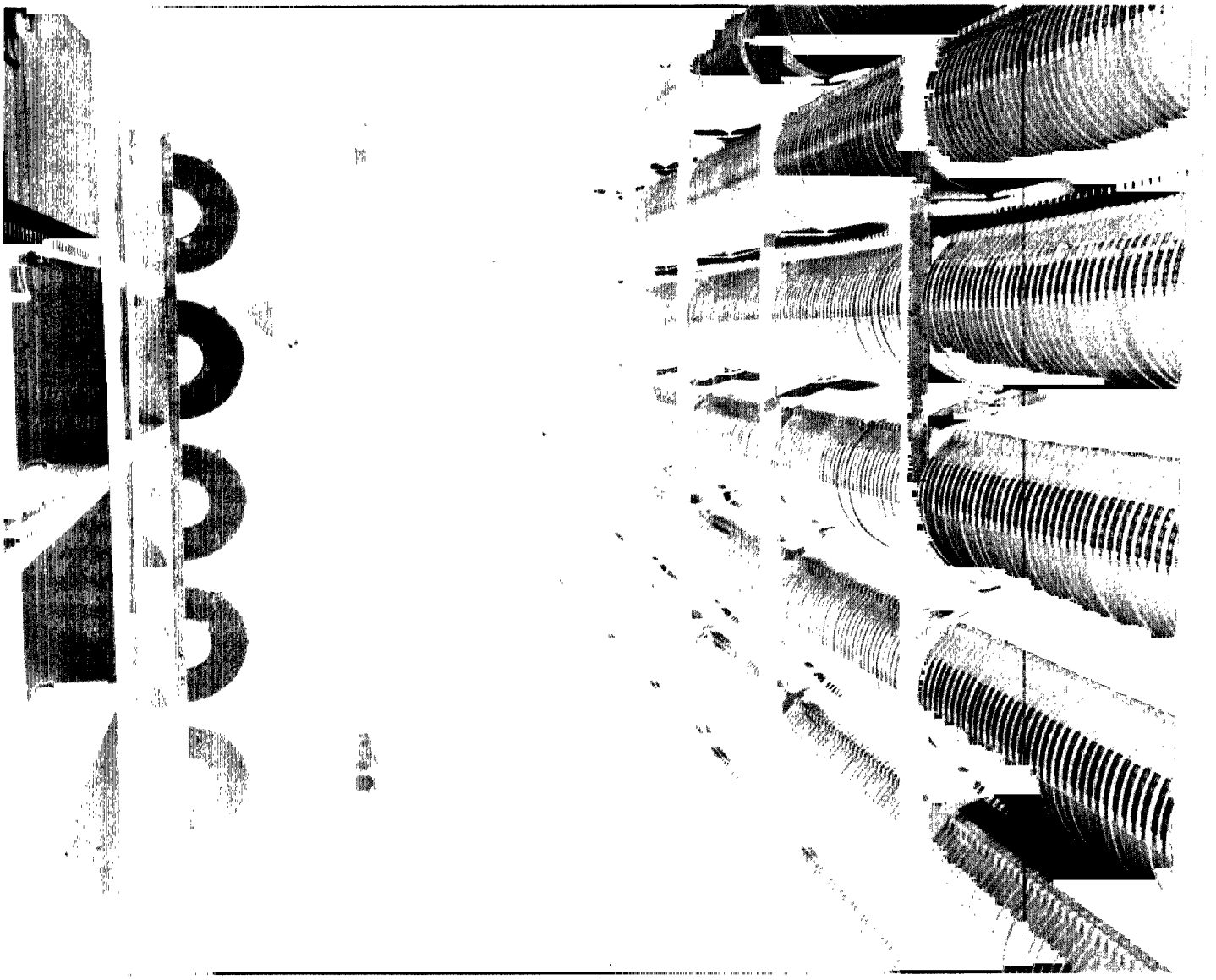
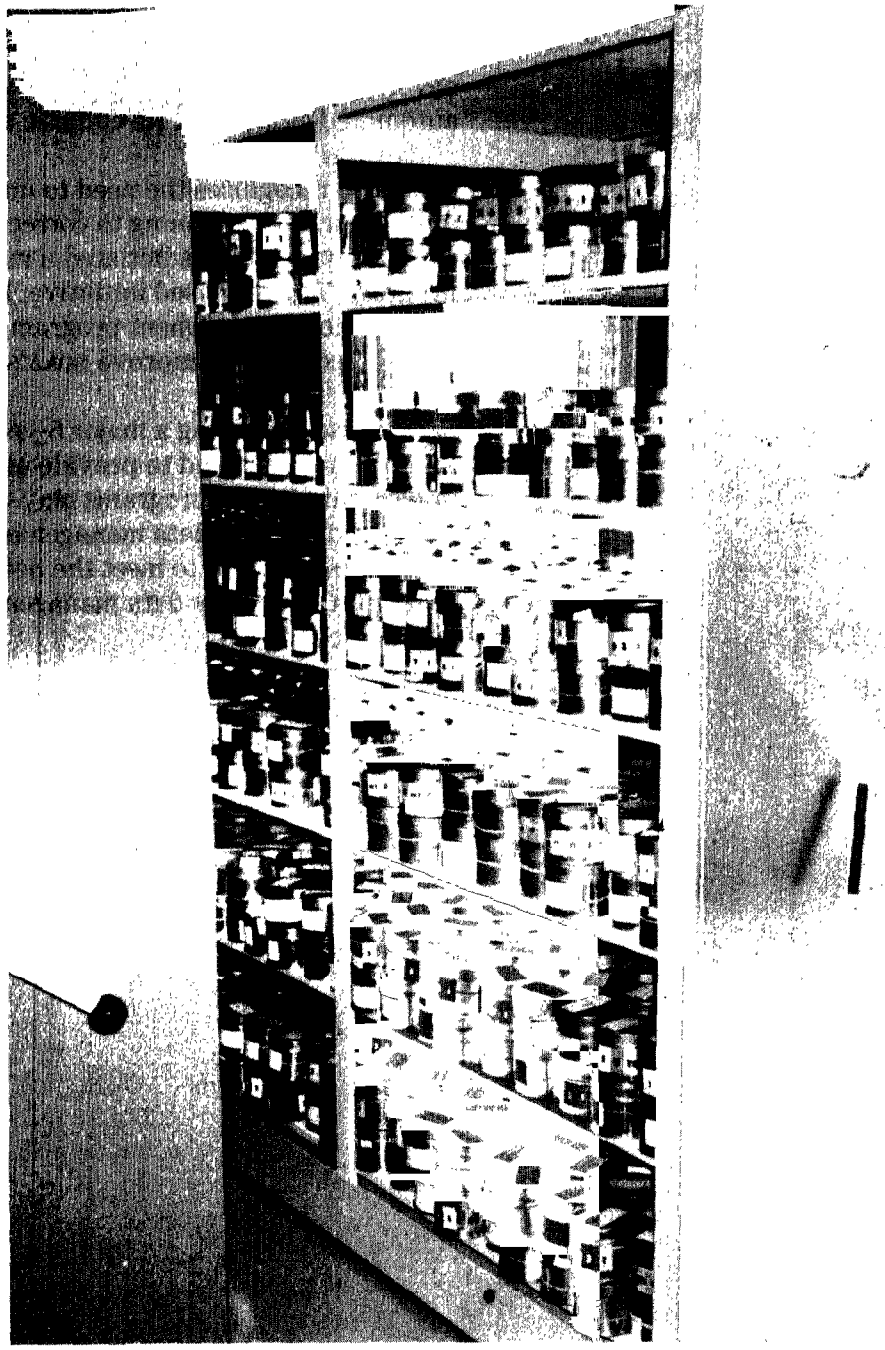


Figure 2.10: Mobile Film Storage Cabinets in EROS' Main Film Vault



NOAA and USGS Are Planning Several Improvements

NOAA and USGS have efforts underway or plan to address the noted deficiencies. For example, NOAA is addressing the inventory problems by developing an agencywide master directory as well as a comprehensive automated catalog for its climatic and atmospheric data.

NOAA also recognizes the need to improve the management and archiving of its data; it is beginning to correct deficiencies requiring modest expenditures and has initiated a major data management improvement program. The proposed initiative, known as the Earth System Data and Information Management program, includes proposals to restore deteriorating tapes and to improve NOAA's tape and film storage facilities.

EROS is also proposing a major 5-year program to restore its entire Landsat holdings and to provide an off-site backup for all of its tapes. If implemented, both programs may not only correct existing deficiencies, but would provide data management and archiving capabilities and structures required to meet the needs of the global change research program. NOAA and USGS data management initiatives are discussed in more detail in chapter 3.

Lack of Resources Is the Principal Cause of Data Management Deficiencies

During the past decade, Commerce and NOAA did not give adequate attention and support to managing and archiving environmental data. Until the mid-1980s, NOAA also showed little interest in improving the management of its data archives, and as the volumes of archived data increased, so have data management and storage problems.

Data Management Was Viewed as a Low Priority Activity

In the past, Commerce, and to a certain extent NOAA, viewed data management and archiving as a low priority. Traditionally, they perceived NESDIS' primary mission to be focused on the operations of its geostationary and polar orbiting satellites, and the acquisition, processing, and rapid dissemination of real-time satellite data to support severe weather forecasts. The management and maintenance of archival data bases for scientific research was relegated to a secondary status. NESDIS' attempts to strengthen its data management and archiving were frustrated by Commerce's belief that responsibility for managing environmental data should be transferred to the private sector. Because of this, Commerce was reluctant to provide the required resources.

Funding for Data Management and Archiving Is Inadequate

During the past decade, Commerce has not allocated adequate resources for data management and archiving. We first noted in our 1988 report[1] that inadequate data management budgets may affect NOAA's and USGS's ability to adequately manage the increasing volumes of environmental data. NESDIS officials in data management and archiving told us that despite the dramatic increase in the volume of environmental data during this period, data management resources decreased. This assessment was also echoed by the Committee on Geophysical Data in its 1989 report,[2] which singled out the low level of support allocated by federal agencies to data management activities as one of the biggest challenges facing the proposed Global Change Research Program. It also stated that funds allocated by the agencies for data storage often represent the lowest priority in the research budgets, and noted that scientists in general show only tepid support for data management. In addressing the impact of inadequate funding on NOAA's data management, the report noted that

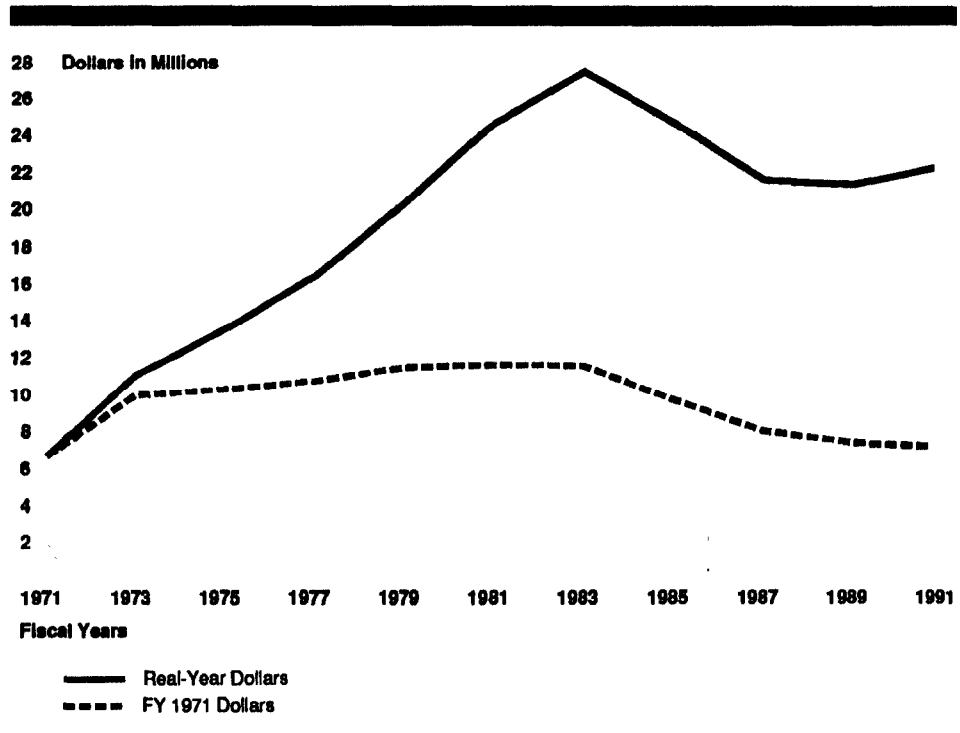
[1]Satellite Data Archiving: U.S. and Foreign Activities and Plans for Environmental Information, (GAO/RCED-88-201, Sept. 29, 1988).

[2]A U.S. Strategy For Global Change Data And Information Management (Draft), Committee on Geophysical Data, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, September 1989.

Partly because of the lack of a policy for the handling of geophysical data, the broad range of geophysical data facilities in the federal government has suffered a general decline in funding. The result is decreased efficiency of data processing and decreased data availability. Some centers are decades behind technologically. (For this reason, large volumes of satellite and hard-copy data have been effectively lost during the past several decades). The impact of funding have been severe at the data centers operated by the National Oceanic and Atmospheric Administration.[3]

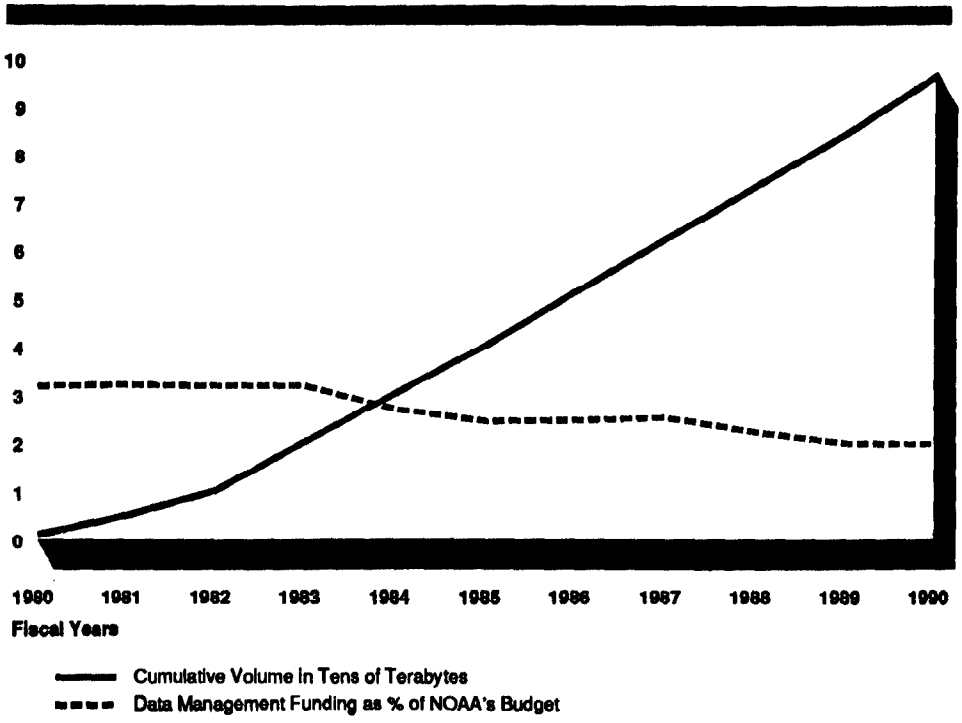
Our analysis, shown in figures 3.1 and 3.2, confirms the decline in resources allocated to NESDIS' data management and archiving. Figure 3.1 shows NESDIS' expenditures on data management in real-year and deflated (FY 1971) dollars, while figure 3.2 shows NESDIS' expenditures on data management as a percent of NOAA's budget in relation to the cumulative volume of archived digital data.

Figure 3.1: NESDIS' Data Management Expenditures in Real-Year and FY 1971 Dollars



[3]U.S. Strategy, p. 10 (emphasis added).

Figure 3.2: NOAA's Data Management Budget as a Percent of its Total Budget and the Cumulative Volume of Archived Digital Data



As shown in figure 3.1, inflation eroded NESDIS' fiscal year 1990 data management funding to the FY 1971 level. Thus, between 1971-90, the resources available for data management increased only by $500,000, from $6.6 million in FY 1971 to 7.1 million in FY 1990. Figure 3.2 presents a similar picture. Although the cumulative volume of NESDIS' digital data holdings increased between 1980-90 by about 96 times,[4] the proportion of NOAA's budget allocated to data management activities decreased.

Savings From Privatization of Data Products and Dissemination Functions Never Realized

According to NOAA officials, Commerce believed that much of the environmental data management and archiving functions should be transferred to the private sector. During the late 1980s, Commerce directed NOAA and its data centers to perform extensive privatization reviews. While the reviews resulted in the privatization of some minor data management functions, their overall impact on data management and archiving was devastating. First, data management budgets were cut in

[4]According to NESDIS, its 1980 digital holdings increased from 1 terabyte in 1980 to 96 terabytes in 1990.

anticipation of savings that never materialized because the private sector had no interest in assuming responsibility for the management of NOAA's environmental data. Second, major data management initiatives, such as NOAANET, were cancelled or deferred in the hope that many data management and archiving functions would be transferred to the private sector. Third, the review process has caused serious morale problems among NOAA staff. For example, Commerce's Office of Inspector General found in its 1987 report that the privatization review conducted at NCDC resulted in a loss of about $1 million in possible savings. The report noted that because of the inordinate time spent on the privatization review, the center was forced to defer cost saving recommendations from earlier efficiency studies.

NOAA and USGS Have Made Efforts to Strengthen Data Management

NOAA and USGS recognize that a significant effort will be required to correct existing data management problems. NOAA officials told us that they are correcting deficiencies requiring modest expenditures, such as acquiring and installing temperature and humidity recorders. They noted that many of the deficiencies are due to the location of NOAA's storage facilities in aging buildings not suited to data archiving, and that they will be corrected when NCDC and NGDC move to new facilities. Both NOAA and USGS are planning to address other deficiencies, such as the lack of an off-site backup, quality control, and media maintenance in proposed data management plans. NOAA officials said that the agency has taken steps to strengthen its data management organization and is currently working with other agencies and organizations in improving its data management capabilities. These activities include (1) a joint effort with NARA to develop NOAA records disposition guidelines, (2) a joint effort with the National Institute of Standards and Technology to develop technical standards for NOAA, (3) a joint effort with the National Research Council's Committee on Geophysical Data and the scientific community to develop NOAA archival guidelines, and (4) participation in the Interagency Working Group on Data Management for Global Change.

NOAA has also established, under the Office of the Chief Scientist, the Data and Information and Management Program Office. The office is expected to provide agencywide oversight of data management practices, and is now drafting data management policies, organizational structures, and plans to support the agency's role and activities in the global change research program. It is also developing, with NESDIS and other organizations, NOAA's Earth System Data and Information Management program. According to NOAA officials, the program is designed to correct existing data management deficiencies, and integrate common

elements of data and information management through technology modernization and new organizational structures.

Several of the key features of the Earth System Data and Information Management program related to the correction of data management and archiving deficiencies include

- the immediate restoration of high demand data;
- the modernization of processing and storage vaults at NOAA's data centers;
- the review and restoration of all NOAA's environmental data stored on tapes with a goal of restoring 20,000 tapes annually; and
- the completion of a comprehensive master directory identifying all environmental data sets.

The EROS Data Center is also planning to correct several deficiencies in the management of its tapes. The center is proposing a project to restore its entire Landsat holdings and to provide an off-site backup for all of its tapes. This 5-year, $21 million project will also allow it to acquire hardware needed to read and restore the 30,000 deteriorating Landsat tapes received in 1988 from NASA. Since our 1989 visit conducted as a part of our review of NASA's archiving practices, the EROS Data Center corrected several tape management deficiencies. With one exception, its main tape and film vaults fully comply with all of the federal requirements and industry guidelines.

Conclusions and Recommendations

Conclusions

NOAA's management of its environmental, climatic, and geophysical data has resulted in improper storage and inadequate maintenance of thousands of magnetic tapes and millions of paper and film records containing irreplaceable data. Valuable data are stored on deteriorating media and some irreplaceable data have been lost. Since NOAA does not have an agencywide inventory of its data, it does not readily know what is being retained, where it is located, and what data were lost.

The EROS Data Center is also experiencing problems. Although its management of permanent film and tape holdings is exemplary, and its main tape and film vaults meet, with one exception, all federal requirements and industry guidelines, approximately half of its 130,000 Landsat tapes are over 10 years old and are deteriorating. EROS does not have the hardware to read, process, and maintain over 30,000 early Landsat tapes. Although EROS officials believe that some tapes may already have deteriorated beyond recovery and may be lost, they are planning to acquire the hardware needed to restore them.

During the last 20 years, data management and data archiving have not received priority attention from Commerce and NOAA officials. The global change research program and its data requirements are forcing Commerce and NOAA to reassess their past approach to data management and archiving. The potential scientific value of the environmental data holdings is unquestionable, and NOAA is planning to take steps to preserve these data holdings. However, Commerce and NOAA should do more.

NOAA must inventory all its data and determine their scientific value. Without an agencywide inventory, NOAA cannot adequately plan or budget for environmental data management. Commerce and NOAA also need to allocate sufficient resources to data management and archiving to ensure that data are adequately inventoried, stored, and maintained.

These steps will require considerable effort, different funding priorities, and a dramatic change in Commerce's view of NOAA's role, which in the past emphasized satellite operations and relegated data management and archiving to a secondary status. Without a major effort to strengthen the management and archiving of NOAA's data, and the allocation of necessary resources for their preservation, irreplaceable data will be lost. Furthermore, if Commerce and NOAA do not take the required steps to correct the existing deficiencies affecting data management and archival programs, several of which Commerce and NOAA have

known about for years, future data will also be placed at risk, particularly if stored on magnetic tapes, film, and paper.

Recommendations

We recommend that the Secretary of Commerce instruct NOAA officials responsible for the management of data to:

- conduct a thorough inventory of all NOAA's environmental data, including data on tapes, film, and paper, stored at NOAA centers and contractors, universities, research institutions, and other federal agencies;
- assess, in cooperation with the scientific community, the inventoried data for its scientific value and the integrity of its storage media;
- copy valuable data from deteriorating media to archival quality media suitable for long-term retention of digital data, and release unneeded tapes, film, and paper records for reuse or disposal;
- archive valuable scientific data in vaults that meet NARA regulations;
- develop and implement agencywide tape, film, and paper record management and maintenance standards which include all NARA regulations and appropriate NIST guidelines; and
- ensure that NOAA's data management and archiving are allocated adequate resources to properly store and maintain environmental data holdings.

Agency Comments and Our Evaluation

In commenting on a draft of this report, Commerce and NOAA agreed that NOAA's data management and archiving program needs to be strengthened. NOAA noted that it shares our concerns, and said that it has programs underway to implement our recommendations. Commerce said that it supports NOAA's effort to strengthen its environmental data management and archival program. Commerce's and NOAA's comments are included in appendix III.

Major Facilities Managing NOAA's Data

National Climatic Data Center (NCDC)

NCDC is the official archive for U.S. weather records and holds the largest collection of climatic data in the world. It collects, processes, archives, and distributes climate data from worldwide sources, and maintains meteorological data ranging from Thomas Jefferson's weather observations to data acquired by active spacecraft. NCDC annually archives over 30 million meteorological observations, 2.5 terabytes of digital data, and 60,000 photographic images. The center operates several storage facilities, including the Satellite Data Service Division (SDSD) archives, and provides archival services to other NESDIS data centers. It also operates the World Data Center A (WDC-A) for Meteorology. Figure I.1 shows a sample of a paper record produced in 1877 from NCDC's historical climatic data holdings that may play an important role in global climate research.

Figure I.1: 1877 Meteorological Record for Smithville, North Carolina, Compiled by a Sergeant of the U.S. Army Signal Service

[FORM 34.]

METEOROLOGICAL SUMMARY.

DATE.	Barometer: Mean	Barometer: Mean of A.M. observation	Barometer: Mean of P.M. observation	Barometer: Mean of Night observation	Barometer Range: Highest	Barometer Range: Lowest	Barometer Range: Difference	Thermometer: Mean	Thermometer: Mean of A.M. observation	Thermometer: Mean of P.M. observation	Thermometer: Mean of Night observation	Thermometer Range: Maximum	Thermometer Range: Minimum	Thermometer Range: Difference	Mean relative humidity	Prevailing direction (Wind)	Wind miles: Noon to 6 P.M.	Wind miles: 6 P.M. to midnight	Wind miles: Midnight to 6 A.M.	Wind miles: 6 A.M. to noon	Maximum velocity during month	Total	Rain and melted snow: Amount in inches	Number of days on which rain or snow fell	Number of auroras
1877.																									
January.	30.201	30.223	30.176	30.214	30.490	29.409	1.081	45.4	44.3	49.4	44.1	64	17	47	80.4	SW	1877	1443	1088	1287	36	5065	2.98	15	0
February.	30.118	30.144	30.088	30.125	30.496	29.583	0.912	47.8	42.0	53.1	48.8	65	30	35	69.9	NE	1682	1044	1160	1527	27	5383	2.77	5	0
March.	30.081	30.074	30.019	30.054	30.604	29.427	1.177	53.0	49.2	58.2	51.6	73	27	46	72.4	SW	2153	1763	1705	2125	49	7746	5.73	13	0
April.	29.964	29.989	29.934	29.960	30.393	29.371	1.022	59.7	57.7	63.9	58.1	79	36	43	78.3	SW	2565	1804	1450	2038	50	7857	5.18	10	0
May.	30.053	30.069	30.021	30.053	30.448	29.589	0.829	65.4	62.7	72.3	62.3	87	42	45	72.9	S	2074	1421	1158	1605	27	6258	2.55	6	0
June.	30.067	30.081	30.024	30.067	30.288	29.703	0.585	76.4	75.1	81.1	74.4	95	57	38	79.2	SW	2237	1857	1282	1633	28	7109	5.19	8	0
July.	30.021	30.047	30.005	30.024	30.313	29.810	0.503	80.9	79.1	85.6	79.2	98	64	34	76.7	SW	2344	2068	1580	1711	36	7703	4.51	11	0
August.	30.044	30.017	29.985	30.020	30.271	29.750	0.521	79.9	77.1	84.3	78.7	93	67	26	75.0	SW	2114	1770	1396	1638	24	6918	3.78	10	0
September.	30.029	30.035	29.999	30.031	30.282	29.690	0.592	74.3	72.0	77.8	72.1	91	60	31	78.9	N	1927	1740	1551	1720	31	6938	11.87	17	0
October.	30.089	30.108	30.058	30.092	30.407	29.393	1.014	66.2	63.5	71.1	64.4	82	46	36	79.4	N	1728	1400	1491	1692	51	6311	6.84	12	0
November.	30.112	30.137	30.089	30.116	30.454	29.706	0.748	57.7	53.7	61.7	56.2	78	28	50	77.9	N	1879	1758	1859	1806	36	7302	6.56	11	0
December.	30.198	30.223	30.179	30.199	30.871	29.571	1.300	50.5	46.6	54.3	49.8	66	24	42	80.9	N	1815	1614	1635	1762	50	6826	7.05	11	0
Sums.	360.927	361.151	360.587	360.908	364.962	354.702	10.284	757.2	721.0	812.8	740.7	971	498	473	921.9	–	24095	19322	17455	20544	445	81416	65.01	129	
Annual means.	30.077	30.096	30.049	30.080	30.445	29.559	0.887	63.1	60.1	67.7	61.7	80.9	41.5	39.4	76.8	SW.	2008	1610	1455	1712	37.1	6785	5.42	10.8	0

GENERAL REMARKS.

January. Middle of month remarkable for dense fog. Mean Bar. .070 lower than 1876; Mean Temp. 6°.3 lower than 1876
February. No unusual phenomena during month, Weather generally clear.
March. Rainfall above the average. Severe storm during the month.
April. Two severe storms, Wreck of vessel and loss of life occasioned by the one of 13th inst. No results of the other known.
May. Barometer lower than corresponding month of 1876, and rainfall less; No severe storms, Weather generally fair.
June. Small monthly range of barometer, no severe storms during month; Weather pleasant.
July. Excessively hot during last week. Gales on 3d, 18th, 19th-20th. Lunar Halo on 29th. Thunderstorm on 25th, 26th, 29th, 30th.
August. Temp. & Pressure very uniform. No Storms. Severe Rainsqualls from S & SE on 23d. Thunderstorms on 1st, 3d, 7th, 9th. Halos on 20, 22, 25, 26
September. Remarkable for preponderance of Northerly winds & cloudiness; Much rain during latter half of month, Gales 1st, 20th, 27th; Thunderstorms 4th, 7th, 12, 13-20th
October. Very fine during greater part of month; Severe gale on 4th. Lunar Halo on 14th, Lunar Halo 21st
November. Gales on 2d, 8th, 21st, 22d, 23d-26th. Thunderstorm on 20th; First Frost on 12th. Remarkably cold on 30th. Lunar Halo on 20th, Meteor on 20th, 4 P.M.
December. Mean Temp. 10° higher than 1876; Severe S & SW. Storm on 5th; NE & E. Gale on 29th. Frost on 1, 2, 7, 8, 9th. Lunar Halo on 18th.

Station Smithville N.C.

Robert Seyboth
Sergeant, Signal Service U. S. Army.

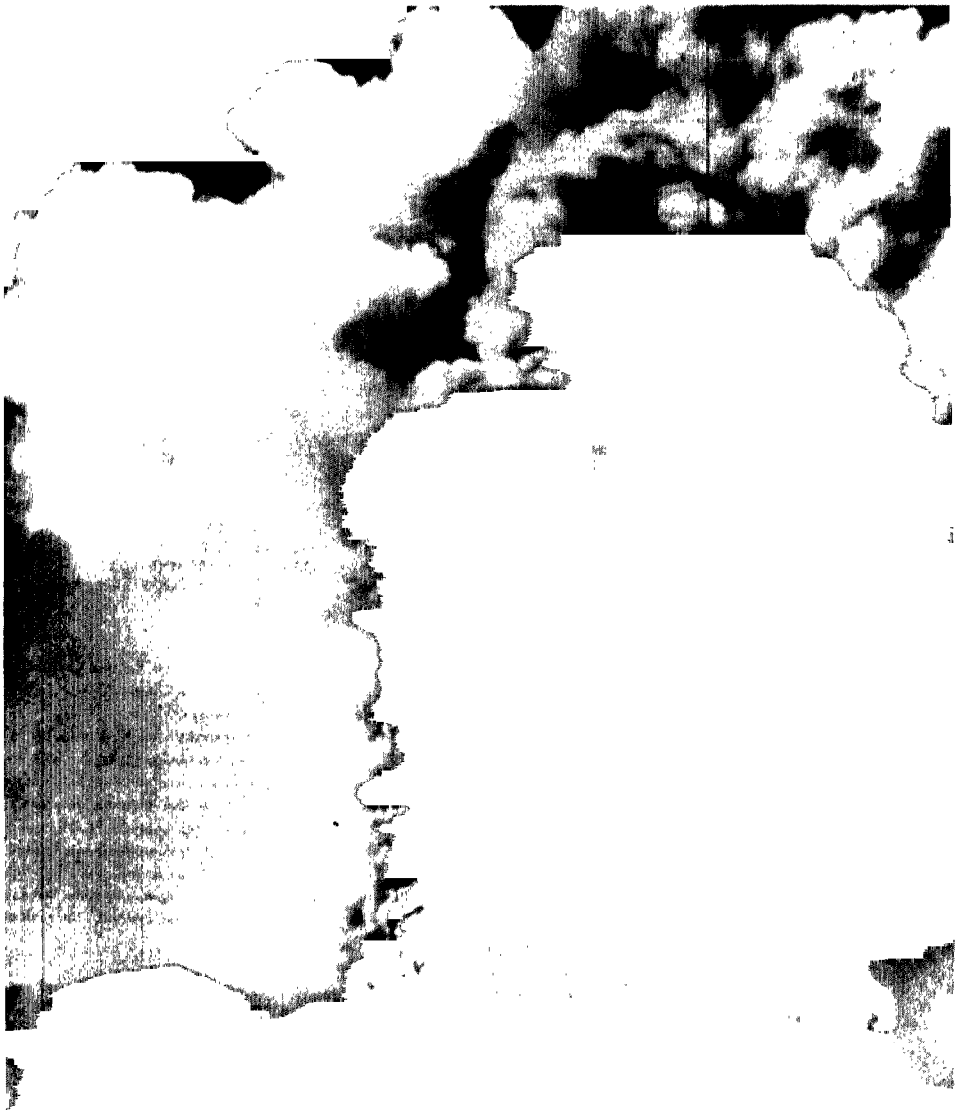
All entries previous to July were made by my predecessors.
R. S.

Source: NCDC

National Geophysical Data Center (NGDC)

NGDC collects, processes, archives, and distributes data related to the earth's interior, land surface, ocean floor, snow and ice coverage, upper atmosphere, space environment, and solar activity. It also operates the WDC-A for Solar-Terrestrial Physics, Solid Earth and Marine Geophysics, Marine Geology, and Glaciology. Figure I.2 shows a photograph of a volcano from NGDC's extensive film and photograph holdings.

Figure I.2: Volcanic Cinder Cone Surrounded by Lava Flows, Taricutin, Mexico, 1943



Source: NGDC

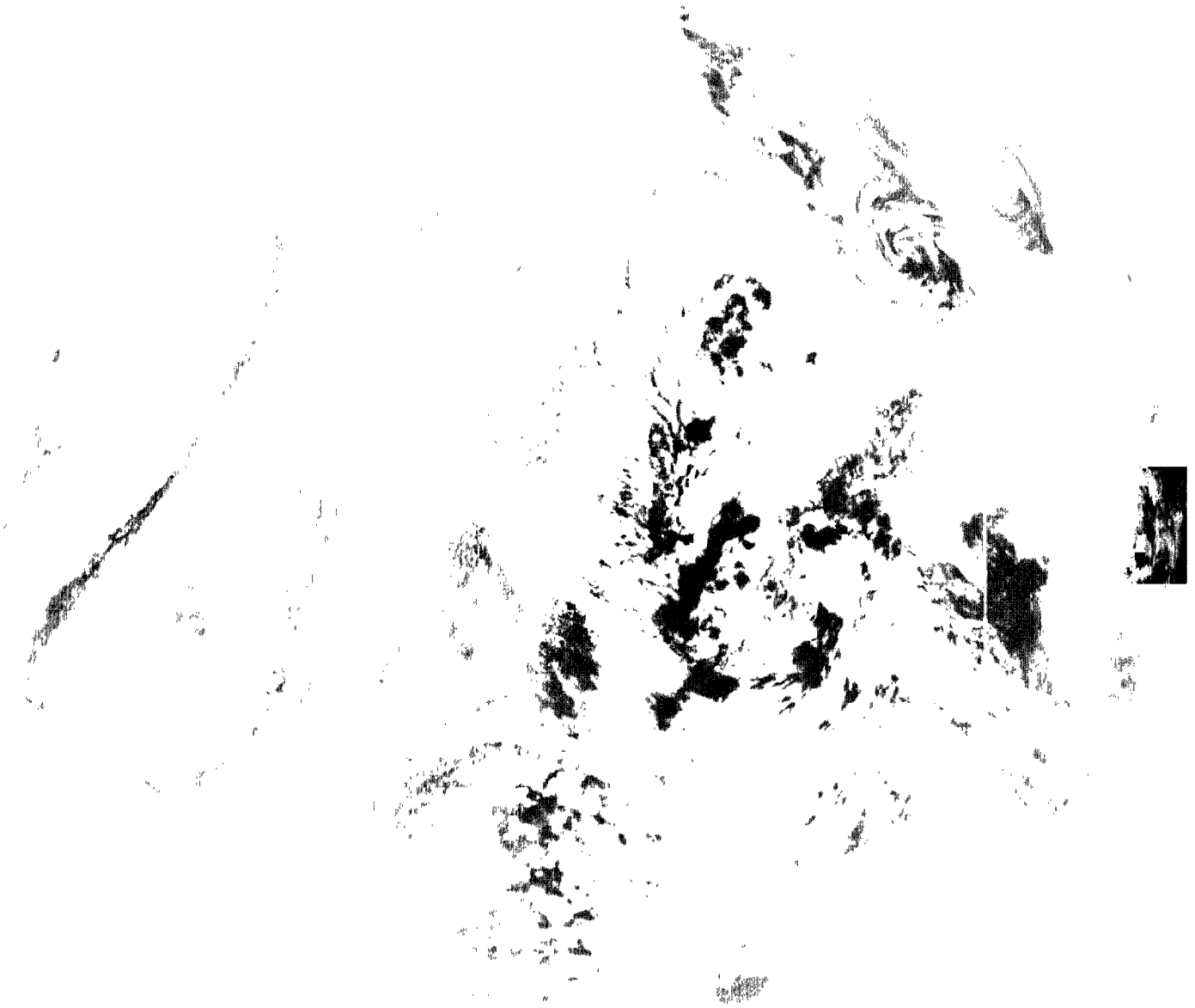
National Oceanographic Data Center (NODC)

NODC collects, processes, archives, and distributes global oceanographic data. It collects ocean related data from more than 860,000 stations around the world, as well as U.S. and foreign spacecraft. The Center maintains one of the world's largest oceanographic data bases, and provides facilities and support for the WDC-A for Oceanography.

Space Science and Engineering Center (SSEC)

SSEC is the principal archive for data collected by NOAA Geostationary Operational Environmental Satellites, and maintains global collection of satellite data from 1978 to the present. It also conducts atmospheric studies of earth and other planets, operates the Institute for Meteorological Satellite Studies, and NESDIS' Developmental Laboratory, which researches satellite applications. Figure I.3 shows a satellite image of 1980's Hurricane Allen.

Figure I.3: Image From NOAA's Geostationary Operational Environmental Satellite



Source: SDSD

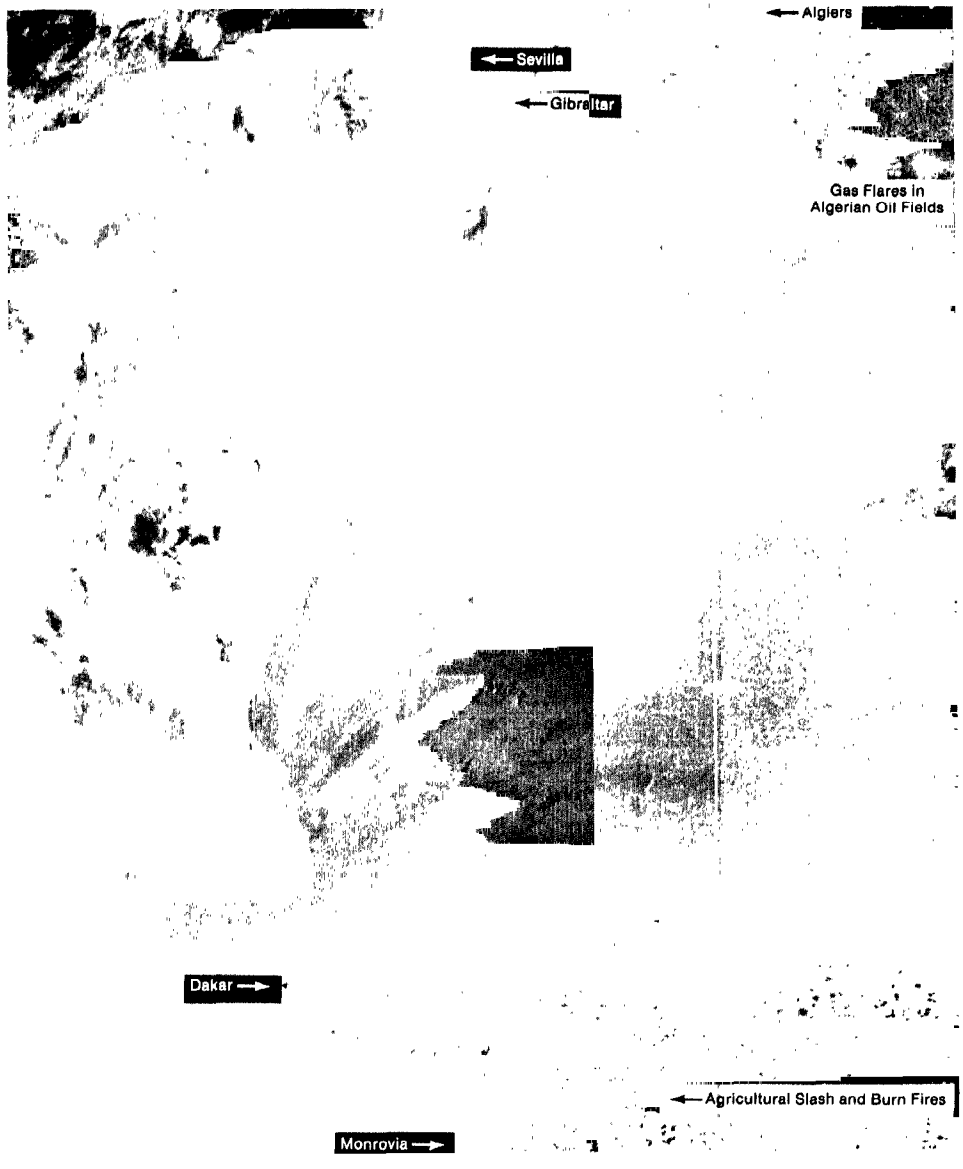
National Snow and Ice Data Center (NSIDC)

NSIDC, in association with NGDC, acquires, processes, archives, and distributes snow and ice data, including snow cover, sea ice, polar ice sheets, and glacier data. It also manages and archives a large data base of satellite film images acquired from the Air Force's Defense Meteorological Satellite Program.[1] Figure I.4 shows a visible-band image of West Africa taken by Defense spacecraft on a full-moon night. Apparent in the image are city lights along the Mediterranean, massive gas flares in the Algerian oil fields, and hundreds of small agricultural slash-and-burn[2] fires stretching from Senegal and Guinea through Ivory Coast to Burkina Faso and Ghana.

[1]This is a system of near-polar orbiting satellites providing visible- and infrared-band images of the earth's surface.

[2]A destructive farming method used in the tropics in which a forest is felled and burned, the cleared land is planted for a few years, and then abandoned. Image produced from Air Force's Defense Meteorological Satellite Program film transparencies archived for NOAA/NESDIS at the Cooperative Institute for Research in Environmental Sciences/NSIDC, University of Colorado.

Figure I.4: Nighttime Image of West Africa With Gas Flares and Small Agricultural Slash-And-Burn Fires



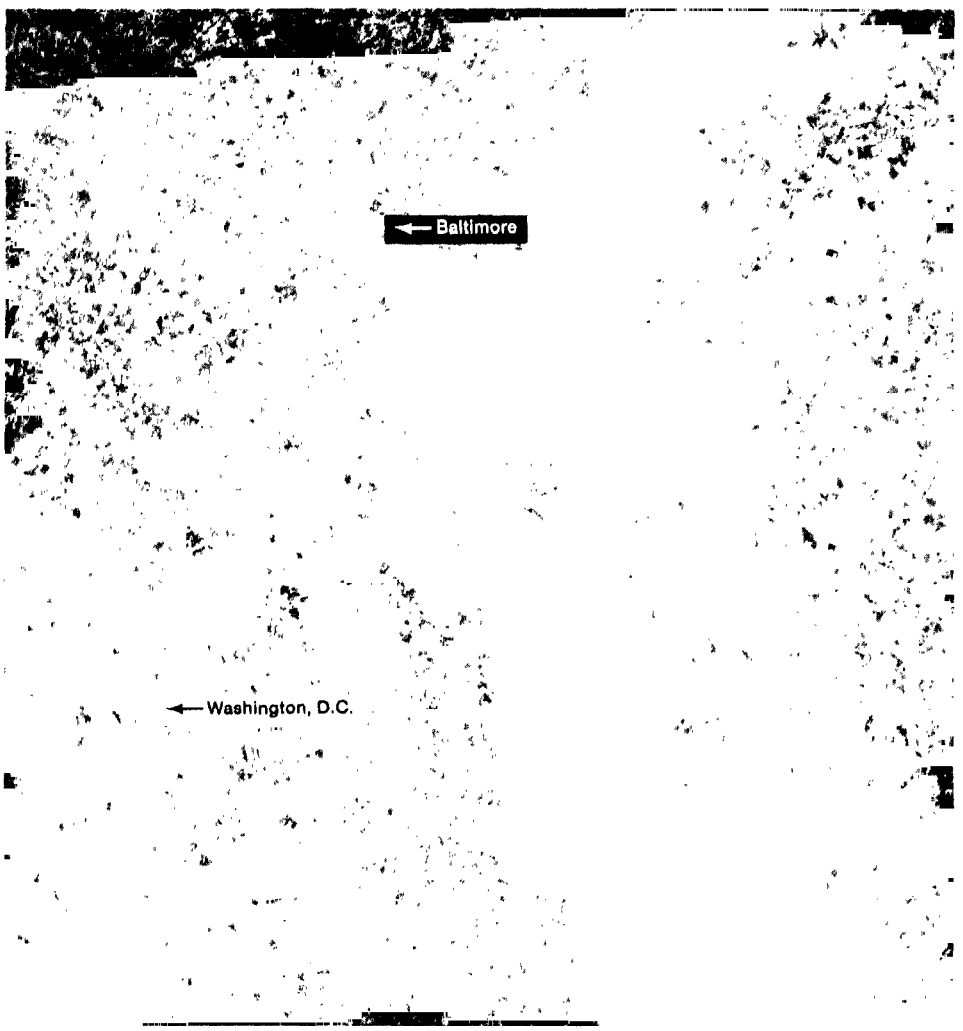
Source: NSIDC

USGS' EROS Data Center

The EROS Data Center, one of the five field centers of USGS' National Mapping Division, archives Landsat data and collects, processes, archives, and distributes data from other sources, including spaceborne remote sensing instruments. Its Landsat archives include images of the earth's surface collected without interruption during the last 18 years. These images, acquired at the cost of over $1.5 billion, provide a valuable data

base to monitor land masses and shallow seas from space, and will play an important role in the global change research program. Figure I.5 shows a Landsat image of the Washington-Baltimore region from EROS' film archives.

Figure I.5: Landsat Image of the Washington-Baltimore Region



Source: EROS

Facility Response to Our Findings

Our review of selected tape processing and storage facilities revealed significant deficiencies in most aspects of the tape management process. Our findings are grouped by two sets of standards—NARA's mandatory regulations and NIST's and industry guidelines, including recommendations provided by the International Council on Archives. Our rating of facility compliance with tape management regulations and guidelines is based on visits to each facility, discussions with facility staff, and a review of relevant documents. When appropriate, we photographed significant deficiencies in tape management practices and summarized our findings in a tape management checklist (see ch. 2).

Response to Our Findings

We asked each facility to review and comment on our findings. To facilitate this process, we gave them (1) a copy of our rating table, (2) our rationale for assigning partial or non-compliance with a specific NARA requirement or industry guideline, (3) a copy of NARA's tape management regulations, (4) copies of the American National Standards Institute's film storage standards, (4) a copy of NIST's tape management guidelines, and (5) a copy of the National Fire Protection Association's standards for the protection of records. We modified our rating in instances where the facility provided additional information or explanation. The following section summarizes their comments.

National Climatic Data Center

The center generally agreed with our findings and noted that the new NCDC facility will resolve many of the identified deficiencies such as the lack of fire and water protection, and security. In the interim, the center will install hygrothermographs and water detectors, provide off-site backup for selected holdings, and seek guidance on tape maintenance procedures for its cartridge tapes. It noted, however, that it currently does not have the resources needed to comply with the 3 percent sampling requirement, or for the development of an automated inventory of its film holdings.

NCDC Satellite Data Services Division

Main Tape Vault: The division generally agreed with our findings, has taken steps to improve security of its tape holdings, and plans to calibrate its hygrothermograph, install water detectors, and implement tape maintenance procedures. It disagreed with the partial compliance rating for media handling, fire protection, and the test and certification requirements. We agreed that the deficiencies noted in these categories were minor and changed the ratings to full compliance. The division

noted that it currently does not have the resources to fully comply with the 3 percent sampling requirement.

SDSD Film Storage Facility: the division agreed with our rating for off-site backup, and disagreed with the ratings for temperature and humidity control, and fire and water protection requirements. We reaffirm our ratings. Although the film archive is air conditioned, it lacks a hygrothermograph, and the division is unable to measure and record temperature and humidity fluctuations when the archive is unattended. Furthermore, while the facility is equipped with fire detectors connected to a nearby fire station, the lack of an automatic fire suppression system, water detectors, and plastic sheets place its film holding at risk. The division is planning to correct most deficiencies. It will install a hygrothermograph, provide plastic sheets to protect its film records from potential water damage, and as funds become available, will create a copy of its inventory for off-site storage.

National Geophysical Data Center

The center is planning to transfer its data holdings to a new facility with tape and film storage vaults equipped with automatic fire suppression system and environmental controls. It noted that it does not have the resources to fully comply with the 3 percent sampling requirement and the media maintenance guidelines. It disagreed with our non-compliance ratings for the film inventory requirement, noting that although it cannot provide a count of its film records, it maintains a comprehensive inventory of its film holdings. We agreed and changed our rating for the center's film storage vaults to partial compliance.

Main Tape Vault: the center generally agreed with our findings. It noted that it will install water detectors, provide plastic sheets, and improve its media handling practices. The center disagreed with our rating for the changing technology requirement, noting that the tapes for which it does not have tape drives do not contain archival data and will be discarded. We agreed and changed our ratings to full compliance.

Valmont Warehouse Film and Tape Storage: The center agreed with our findings and is planning to install hygrothermographs, intrusion and water detectors, and additional tape racks. It will also improve its media handling practices and may transfer some of its film records to a federal records center.

Space Environment Laboratory's B and C Tape Libraries: The center agreed with our findings and is planning to comply with the water protection guidelines.

Solar-Terrestrial Physics Division's Film Storage Vaults: the center agreed with our findings and is planning to install hygrothermographs and water detectors, and improve its media handling practices, and fire protection.

Marine Geology and Geophysics Division's Film Storage Facility: the center agreed with our findings and will move its film records to a facility in compliance with security and water protection requirements.

Solid Earth Geophysics Division's Film Storage Vaults: the center agreed with our findings and is planning to install hygrothermographs and water detectors, and improve the security of its film holdings.

National Snow and Ice Data Center

Computer Room and Tape Storage Vault: the center generally agreed with our ratings and stated that it is planning to correct most of the deficiencies related to its tape holding. It disagreed with the partial rating for the 3 percent sampling requirement since it processes over 30 percent of its tapes annually and thus more than satisfies the intent of this recommendation. We reaffirm our rating, since this approach is not statistically valid and does not allow the center to adequately monitor the condition of its entire tape holdings. The center also noted that it cannot correct deficiencies in the test and certification and tape maintenance requirements because of budget constraints.

Film Vaults: the center agreed with our rating but noted that it will transfer its entire film library to a federal records center.

National Oceanographic Data Center

The center's director agreed with our ratings for security and water protection and disagreed with our ratings for temperature and humidity control. He said that although the center did not have a hygrothermograph in the tape storage area, this area is air-conditioned by state-of-the-art air handling units equipped with an alarm system that will alert center's staff if the temperature or humidity in the storage area exceed the pre-set range. We agree, and changed our rating for the temperature and humidity control requirements to partial compliance. He further noted that the center is taking action to correct all deficiencies by

acquiring hygrothermographs, and installing intrusion alarms and water detectors in the tape storage area.

Tape Staging and Storage Facility

The facility official agreed with our rating and said that Goddard is installing water detectors in the tape storage area.

Atlanta Federal Records Center

The center agreed with our ratings and noted that NARA's Office of Federal Records Centers does have initiatives under way to provide for servicing and storage of magnetic tapes.

Washington National Records Center

No response received as of August 31, 1990.

EROS Data Center

The center disagreed with several compliance ratings and provided additional information on its tape management procedures implemented at its main and auxiliary tape vaults.

Main Tape Vault: the center disagreed with the partial compliance rating for test and certification of media, 3 percent sampling and tape maintenance, and provided additional information to show that the center is in full compliance. We agreed and changed our ratings to full compliance. In regard to the lack of off-site backup for its tapes, the center noted that within 5 years it plans to copy all of its tapes to a new mass storage media, and to store the original tapes in an off-site location.

Auxiliary Tape Vault: the center disagreed with our ratings for 3 percent media sampling, changing technology, media handling, and tape maintenance. It noted that the Landsat tapes stored by the center in its auxiliary tape vault represent a unique case. First, tests indicate that these tapes suffered serious deterioration and that much of these data will be unrecoverable. Second, the center cannot read and maintain these tapes since the hardware is inoperable. Third, given the conditions of these tapes, the center believes that their retention in the original shipping containers will not cause additional damage.

We agree that the Landsat tapes stored in the auxiliary vault represent an unusual case and changed our rating to full compliance for the 3 percent sampling requirement and not applicable for two other requirements (media handling and tape maintenance), while retaining a noncompliance rating for the changing technology requirement and off-site backup. A center official told us that EROS is seeking $21 million over the next five years to convert all of the Landsat tapes, including those stored in the auxiliary vault, to a next-generation long-term storage media, and to provide a full backup for all of its tapes.

Space Science and Engineering Center

SSEC Videocassette Library: the center agreed with our compliance ratings for temperature and humidity controls and noted that it is taking corrective action and will install a hygrothermograph in its tape storage area. In addressing the lack of off-site backup and the lack of automatic fire suppression equipment, the official noted that the center is not funded by NOAA to provide off-site backup, and that the center will continue to rely on manually operated fire extinguishers to provide fire protection in the tape storage area.

State Records Center Storage Vaults: the center disagreed with our noncompliance rating for temperature and humidity control, and for fire and water protection. It noted that the temperature and humidity gauges are monitored by its staff and that the temperature and humidity levels are adequate. In regard to fire and water protection, the center noted that when its facility was built in early 1960s it was believed that the potential damage caused by water sprinklers was more serious than fire damage. The center plans to investigate the cost effectiveness of installing hygrothermographs and will purchase plastic sheets to protect NOAA's tapes from overhead water leaks. There are no plans to install water sprinklers. We reaffirm our rating. Without hygrothermographs, the center is unable to adequately monitor the temperature and humidity levels in its tape storage vaults and thus ensure that NOAA's tapes are stored according to NARA's requirements. Furthermore, the lack of an automatic fire suppression system will continue to pose a risk to NOAA tapes.

Commerce's and NOAA's Comments

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

12 OCT 1990

Mr. Ralph Carlone
Assistant Comptroller General
Information Management and
Technology Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Carlone:

Thank you for your letter requesting comments on the draft report entitled, "Environmental Data: Major Effort is Needed to Improve NOAA's Data Management and Archiving Program."

We have reviewed the enclosed comments of the Under Secretary for Oceans and Atmosphere and believe they are responsive to the matters discussed in the report. The Department supports the strengthening of NOAA's environmental data management archival program and is committed in helping NOAA accomplish this task.

Sincerely,

Thomas J. Collamore
Assistant Secretary
for Administration

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

OCT 3 1990

Mr. Ralph V. Carlone
Assistant Comptroller General
Information Management and Technology Division
United States General Accounting Office
Washington, DC 20548

Dear Mr. Carlone:

Thank you for your letter requesting our comments on the draft General Accounting Office report entitled Environmental Data: Major Effort Is Needed to Improve NOAA's Data Management and Archiving Program (GAO/IMTEC-90-99, Code 510493).

NOAA recognizes that it must strengthen its data management and archiving program and is committed to doing so. Our comments on your recommendations follow.

Recommendation: Conduct a thorough inventory of all NOAA's environmental data, including data on tapes, film, and paper, stored at NOAA data centers and contractors, universities, research institutions, and other Federal agencies.

Comment: The report notes that NOAA's data centers each have inventory systems, with automated systems in place for data on magnetic tape and manual systems for nondigital data. NOAA is well under way in implementing a NOAA-wide Earth Systems Data Directory, which will provide a top level summary of NOAA's environmental data holdings. In addition, NOAA plans to review all of its detailed data inventories to assure that they are complete, of sufficiently high quality, and that they describe in adequate detail all environmental data for which NOAA is responsible. Existing inventory systems will be improved as necessary and inventories for new data established in such a way as to ensure the integrity and the accessibility of these data.

Recommendation: Assess, in cooperation with scientific community, the inventoried data for its scientific value and the integrity of its storage media.

THE ADMINISTRATOR

Comment: As recognized in the GAO report, NOAA began over 2 years ago to obtain scientific community involvement in evaluating its archived environmental data and to develop criteria to assist in prioritizing the allocation of resources given to current and future data. This assistance is being provided by the Committee on Geophysical Data of the National Academy of Sciences. Recently, NOAA has also established science advisory panels for each of NOAA's data centers to assure that science community input is factored into NOAA's management of environmental data. NOAA has also arranged to obtain assistance from the National Institute of Standards and Technology relative to the use of standards and guidelines to help assure the integrity of the archived data for which NOAA is responsible. As NOAA's inventories of data are extended and made more complete, these science community participants will continue to be involved in assessing the full complement of NOAA data.

Recommendation: Copy valuable data from deteriorating media to archival quality media suitable for long-term retention of digital data, and release unneeded tapes, film, and paper records for reuse or disposal.

Comment: NOAA is already under way in its effort to rescue valuable environmental data from older magnetic media that have the potential to deteriorate in the near future. NOAA is committed to identify the necessary resources to assure that all data for which it is responsible are placed on suitable long-term storage media, with off-site backup copies. NOAA has begun this data rescue effort using best available magnetic and optical media.

Recommendation: Archive valuable scientific data in vaults that meet NARA regulations.

Comment: Arrangements have already been made and initial funding obtained for two new, modern buildings, one in Asheville, North Carolina, and the other in Boulder, Colorado, which are being designed to correct the major storage facility deficiencies identified in the report. To the extent that certain of the identified problem areas can be corrected with minimal expenditure of resources, this has already been done, e.g., procuring and arranging for installation of hygrothemographs in

all media storage facilities. To the extent that some additional available resources can be justified for additional changes to facilities scheduled to be replaced by these new buildings, such changes will be made to mitigate the possibility of data loss prior to completion of the new facilities.

Recommendation: Develop and implement agency-wide tape, film, and paper record management and maintenance standards which include all NARA regulations and appropriate NIST guidelines.

Comment: An effort is well under way to identify and implement NOAA-wide data management standards and guidelines, including those necessary to assure the integrity of storage media. The National Institute of Standards and Technology is participating with NOAA in this process. To the extent that NARA regulations and NIST Government-wide guidelines are available and applicable, they will be included in these NOAA-wide standards and guidelines.

Recommendation: Ensure that NOAA's data management and archiving are allocated adequate resources to properly store and maintain environmental data holdings.

Comment: NOAA is committed to assuring that adequate resources are available to properly store and maintain the environmental data for which it is responsible. To the extent that the necessary resources are not available, NOAA will take appropriate steps to identify such resources. NOAA is pleased to note that this GAO report recognizes that the data perceived to be most valuable has been given the greatest attention by NOAA data center managers. NOAA will continue giving priority within available resources to the most valuable data, especially those data whose integrity may be threatened by storage on older storage media. NOAA's prioritization process for making such decisions has recently been strengthened through expanded involvement by the scientific community, with special attention given to involving experts in each of the environmental disciplinary areas for which NOAA has data holdings.

We appreciate this opportunity to comment on the draft report.

Sincerely,

John A. Knauss

Major Contributors to This Report

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