St. Thomas Electronic Records Disaster Recovery Effort

Technical Report RE0025

Dr. John W.C. Van Bogart
John Merz

National Media Laboratory
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EXECUTIVE SUMMARY

This report describes the recovery of electronic records by National Media Lab personnel on St. Thomas, U.S. Virgin Islands (USVI) during October 7 to October 11, 1995. At the request of NARA, NML participated in the recovery of electronic records and devices for the USVI government. Specifically, the NML recovery team assisted the USVI Legislature, the Department of Planning and Natural Resources, and the St. Thomas Hospital in the recovery and evaluation of compromised computer systems and media.

Specific NML accomplishments were as follows:

The optical discs used to store records of USVI legislative sessions were cleaned and restored to virtually original condition. The optical drives were cleaned and reconditioned with spare parts; however, an optical drive could not be restored to operational condition.

The index of records for USVI legislative sessions were successfully rescued from the hard drive of a damaged PC and transferred to tape.

Recommendations were made to the St. Thomas hospital regarding the services necessary to recondition their mainframe computer system, PC terminals, and associated hardware.

Library and USVI government staff were instructed with regard to the cleaning and reconditioning of PC's, optical discs, and floppy disks.

ST. THOMAS ELECTRONIC RECORDS DISASTER RECOVERY EFFORT

1 Objectives

The task was to assist in the recovery of storm-damaged electronic records for the Government of the Virgin Islands of the United States. NML participated in the Federal Emergency Management Agency (FEMA) sponsored recovery effort at the request the National Archives and Records Administration (NARA).

Specific tasks were as follows:

Recovery of USVI Legislature records stored on WORM optical discs and hard disk.

Repair/recovery of storm-damaged PC's for the Department of Planning and Natural Resources.

Review of a bid for the reconditioning of mainframe and desktop computer systems for the St. Thomas hospital.

2 Background

On September 15, 1995, Hurricane Marilyn struck the United States Virgin Islands (USVI). High winds (> 200 mph), rain, and swelling surf severely damaged buildings and disabled electrical power. On September 16, 1995, President Clinton declared that a major disaster existed in the U.S. Virgin Islands. The Federal Emergency Management Agency (FEMA) coordinated the disaster recovery effort. FEMA contacted the National Archives and Records Agency (NARA) to assist in the recovery of both paper and electronic records damaged by the hurricane. NARA contacted the National Media Lab (NML) to help specifically with the recovery of electronic records.

NML Disaster Recovery Team members John Merz and John Van Bogart arrived in Charlotte Amalie, St. Thomas on October 7, 1995. Recovery Team personnel were asked to examine and evaluate equipment from four areas: the Legislature Building, the Department of Planning and Natural Resources (DPNR), the St. Thomas Community Hospital, and the Department of Education. The Enid M. Baa Public Library was designated as the central recovery facility. Equipment from the USVI Legislature and DPNR offices was brought here for examination and recovery.

Figure 1: Condition of DPNR main offices in the wake of Hurricane Marilyn (after salvaging operations). Wall off to left of the photograph was literally blown away.

The USVI Legislature Building and the DPNR main offices were hardest hit by the storm. This was due, in part, to the fact that both were near the shore of St. Thomas Harbor and did not have the benefit of any natural protection from the winds (see Figure 1). Wind, rain, sand, and sea water entered USVI Legislature offices through a broken window and severely contaminated data storage systems. Sea water was the worst contaminant, causing appreciable corrosion of mechanical components and electrical connections. During and after a hurricane, even rain can contain salt-the violent winds pull sea spray into the atmosphere and deposit it in rain drops.

Image Unavailable

Figure 2: A map of Charlotte Amalie, St. Thomas, USVI detailing locations of government facilities housing electronic records damaged by Hurricane Marilyn. 1-Legislature Building; 2-Department of Planning and Natural Resources (DPNR); 3-St. Thomas Community Hospital; 4-Enid M. Baa Library.

Key persons involved in the FEMA sponsored disaster recovery effort were the following:

NML Disaster Recovery Team:

John Merz, Technician

Devora Molitor, Operations Support

John Van Bogart, Principal Investigator, Media Stability Studies

Key NARA Personnel:

Diana Alper, Team Leader

Alan Perry, Preservation Officer from Kansas City, Former Territorial Archivist for the USVI

USVI Agencies:

Jeanette Bastian, Director, Division of Libraries, Archives and Museums (Ms. Bastian originally contacted FEMA for assistance in the recovery of government records)

Christian Doute, Division of Libraries, Archives and Museums

Key customers and contacts for the NML electronic records recovery efforts were:

USVI Legislature:

Donald Cole, Archivist

Kerwin Woodley, Systems/Network Administrator

USVI Department of Planning and Natural Resources:

Christian Doute

St. Thomas Hospital:

Carol Jackson

3 Approach

The various data storage systems examined by NML while in St. Thomas included:

Three Laser Magnetic Storage International (LMSI) optical disc drives and 12-inch WORM media-used by the USVI Legislature for legislative session records.

An IBM AS400 310 mainframe-used by the St. Thomas Hospital for records storage.

Various IBM-compatible desktop PC's and network servers-from the USVI Legislature, DPNR offices, and the St. Thomas Hospital.

The condition of the systems varied from unrepairable and unplayable to undamaged and operational. System damage was solely the result of the storm and not as a result of negligence on the part of the system operators. Indications were that systems were properly maintained (cleaned, backed up, properly stored on desktops or in racks) and media were properly stored (in storage boxes provided) prior to the disaster. In most cases, systems had been protected by covering them with plastic sheets or plastic bags as Hurricane Marilyn approached. Media has also been enclosed in plastic bags, in some cases.

System hardware was reconditioned by cleaning system boards and/or replacing damaged components. Salt and water deposits on system boards were removed with compressed air, by wiping with a dry cotton cloth, and/or by wiping with a cotton cloth moistened with bottled water (tap water was unavailable).

Media was recovered by a very careful cleaning of the affected media. Optical disc media were removed from cartridge shells and carefully cleaned with water and cotton wipes. Diskettes were reconditioned by transferring the floppy disk from the damaged diskette housing to a new housing. The information on the diskettes was the copied to a new floppy disk.

4 Results

4.1 USVI Legislative Records

From a data recovery standpoint, the USVI optical disc storage system provided the greatest challenge to NML staff. The building in which the data storage system was housed was located at the shore of St. Thomas harbor (See Figure 2). During the storm, wind, rain, sand, and sea water entered offices through a broken window and severely contaminated the optical drive system. Sea water was the worst contaminant, causing appreciable corrosion of mechanical components and electrical connections.

As the storm approached, a tape backup of the hard drive contents was initiated, but was never completed. As received, the Gateway 2000 system still had the tape cassette in the badly corroded tape drive.

4.1.1 Hardware Recovery Efforts

The Legislature's archive system consists of a Fujitsu M3095 scanner, a Ricoh 4150 printer, and two LMSI LD1200 12-inch WORM optical disc drives. A Gateway 486DX-33V PC running MS-DOS 6.22 controls the drives via an Adaptec AHA-1542C SCSI host adapter. The display subsystem includes a Kofax 8400 display adapter, a Kofax 8202/8204 compression board, and a Moniterm 17-inch monitor. Paper-based records are scanned in, compressed, and stored on optical disc. The PC's hard drive stores the "Legislative Archive Application" software (from Genesys Information Systems Corporation) and an index of the information stored on the optical discs. As a backup, the paper records are also copied to microfiche.

Details on the LMSI optical drive system and media are provided in Appendix D where a spec sheet from product literature has been reproduced.

Archive System Recovery

Of greatest concern to USVI Legislature staff was the well-being of the index located on the Gateway PC's hard drive. If the worst case proved to be true-that the optical discs were unreadable-the index could still be used to locate records stored on microfiche.

The Gateway PC sustained sand and salt water damage to its power supply, 5 1/4-inch floppy drive, and Colorado Jumbo 250 (1/4-inch tape) drive. In fact, the head of the tape drive was completely corroded. Both drives were considered total losses and removed. The motherboard and 3 1/2-inch floppy drive escaped damage despite evidence of standing sea water inside the case. The hard drive, a Seagate Technologies Caviar 1210, showed no external signs of contamination. The hard drive was removed from the Gateway and installed in an undamaged PC containing a Colorado 350 tape drive. The Seagate 1210 had been partitioned into two logical drives. Drive "C" contained the operating system and Genesys application software. The "D" drive contained the index (a single, 185 MB file). Both partitions were backed-up to tape (twice).

The power supply was removed and cleaned. Measurements with a voltmeter showed it to be operational. The hard drive was then re-installed.

Recovery-LD1200 Optical Drive

Three LMSI LD1200 drives were recovered from the legislative building. Two of the drives were part of the working archive system, the third was used for spare parts. Unfortunately, documentation for the drives could not be located. In the following paragraphs, drive numbers 1 and 2 refer to serial numbers 4597 and 12214 respectively. Drive number 3 (the spares unit) refers to serial number 4397.

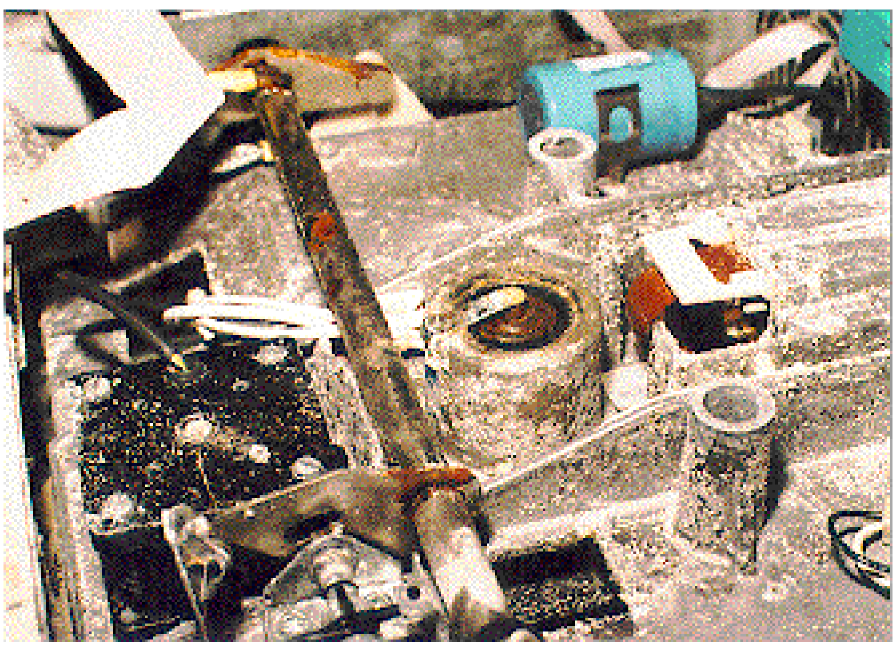

Figure 3: View inside one of the LMSI optical drives. The heavy whitish deposit contaminating the drive is a mixture of fine sand and salt.

Recovery-Initial Examination

Drives 1 and 2 showed signs of extensive sea water and sand contamination. Dried salt and sand were found throughout both units. Of the two, however, drive 1 was hardest hit. Metal parts were beginning to rust, notably the spindle motor bearings. Nearly every circuit board was caked with dried salt and sand. Drive 2 was in markedly better shape. Although salt and sand were found on most metal parts, circuit boards were not damaged. Drive 3 managed to escape contamination altogether. However, its "cartridge sensor" circuit board had already been tagged as defective. We decided to remove the tagged cartridge sensor board from drive 3 and replace it with drive 2's sensor board.

The system's Moniterm monitor was also recovered from the Legislature Building. The monitor was disassembled and inspected. It appeared to have sustained only superficial exposure to sea water.

Recovery-Drive 3

Drive 3 was attached to the Gateway PC with a shielded SCSI cable. A recovered cartridge was installed and the drive was powered on. The Gateway was then powered on. During boot-up, the drive was recognized as SCSI ID #6, but the SCSI BIOS was not loaded. The drive then went through a self test, illuminating the two-digit display with numbers from "00" to "FF." The "Start" button was pressed to initiate rotation of the disk. The spindle motor failed to rotate. The drive's display would then indicate "FA" (a fault condition) and lock up. At this time, we learned from legislature personnel that this drive had other problems in addition to its defective sensor board. We decided to concentrate on cleaning and repairing drive 2 since it was known to work before the storm.

Recovery-Drive 2

First, the cartridge sensor board was removed from drive 3 and re-installed in drive 2. We then removed as much sand and salt from the unit as possible using dampened swabs and compressed air.

The power supply and SCSI connectors were examined for signs of contamination, but appeared to be undamaged. The unit was then attached to the Gateway PC and a cartridge inserted. During boot-up, the drive was recognized as SCSI ID #3, but again the BIOS was not loaded. The drive went through its self-test, and displayed "BB" (the "ready" indication). The disk would not rotate after pressing the "Start" button. It appeared that the drive did not recognize the presence of a cartridge.

At this time, the SCSI terminator connected to the rear of the drive began to smoke. The drive was immediately powered down and the terminator removed. The terminator was disassembled and determined to be a total loss. An examination of the drive's terminator connector showed no damage. A second terminator was available to install, but we decided to hold off until the drive could be made operational. All internal connectors were then removed and reseated. The drive was powered on (SCSI BIOS did not load). During the self-test, the laser assembly solenoid unlocked, the laser assembly moved to its starting position and began to go through a positioning check. When the display indicated "BB," the start button was pressed and the disk began to spin.

Using the archive application software, an attempt was made to read the disk. The results were inconclusive, however, since the SCSI terminator was not installed. Given the late hour, we decided to try again in the morning.

The next day, we could not get the drive to spin up. Fortunately, the LD1200 is a very modular system making it easy to swap boards and other subsystems. However, every board in the unit (with the exception of the laser assembly) was swapped to no avail. The power supply was also swapped, but did not help.

4.1.2 Optical Disc Recovery

Twelve LM 1200-002-722T WORM optical disc cartridges were recovered from the legislature building. Most were protected during the storm by virtue of the fact that they were stored in split plastic cases inside of cardboard shipping boxes. The two disks that were contaminated most severely were the ones that were still inside of the optical disc drives at the time the storm hit St. Thomas. Only one other disk showed minor contamination with sea water residue as its storage box had fallen apart as it got wet during the storm. The remaining nine disks-eight recorded, one unrecorded-were examined by opening cartridge shells, but no cleaning operations were performed as no contamination was evident.

This dual sided media consisted of two optical disks laminated together, glass substrate side out. An aluminum spacer was present at the outer edge of the disk and at the inner edge of the disk hub. No delamination of the media occurred during the storm, so that the metal film layer was never exposed to external contaminants. Even though two of the optical discs were heavily contaminated with sand and salt residue, no corrosion of the disks' metallic reflective layers was observed. The only deterioration was observed on non-data critical components, such as steel hub components which were heavily corroded.

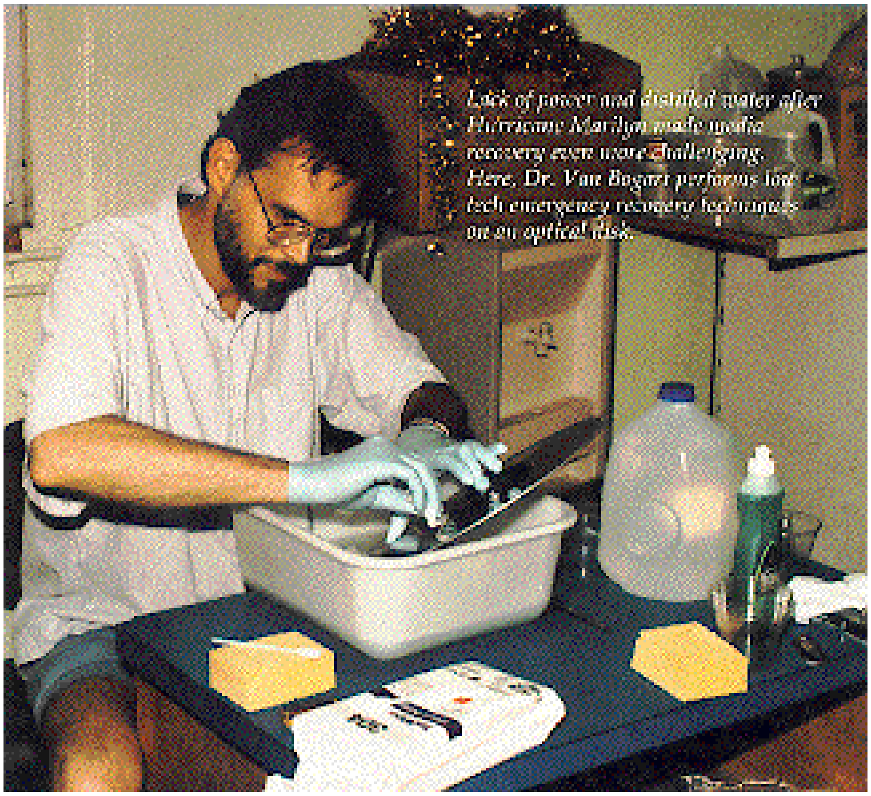

Figure 4: A 12-inch optical disc in the process of being cleaned. Disks were wiped in a radial direction-from the center of the disk to the edge. This minimizes the amount of data obscured on a given track in the event that the disk is inadvertently scratched.

The LMSI 12-inch optical discs from the USVI Legislature were not physically damaged in the storm. All contamination was superficial and data critical components of the disks were intact and uncorroded. Recovery of the optical media simply involved a very careful cleaning of the disks. Disks were first rinsed with a stream of water provided by squeezing a wet sponge to remove coarse debris. The disks were then gently wiped with a wet cotton cloth until all fine sand and salt residue had been removed. At no time were the disks immersed in water for fear that the water may have breached the laminated edges of the disk and contaminated the disk's reflective layer. Figures 4 and 5 show an LMSI disk being cleaned.

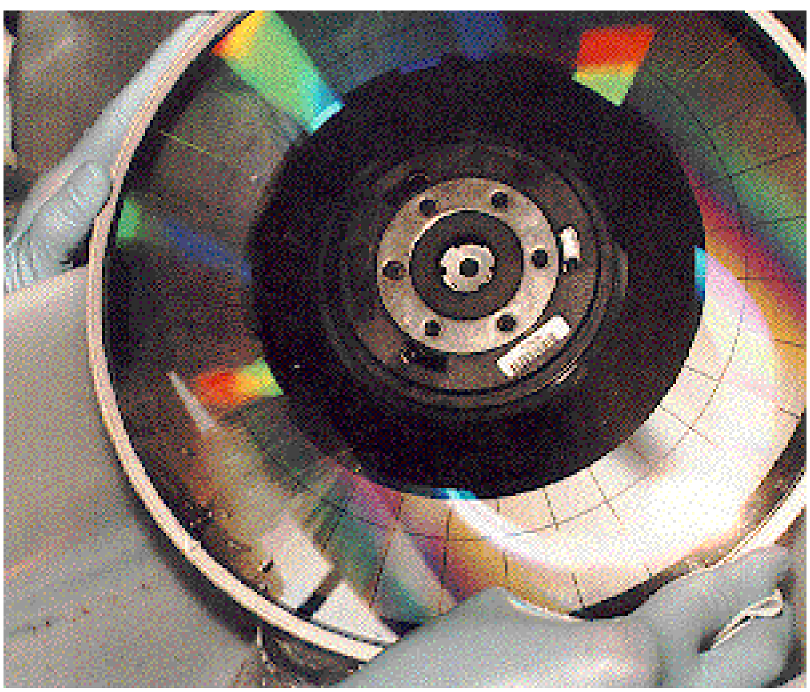

Figure 5: 12-inch optical disc in the middle of cleaning. The right portion of the disk has been cleaned; the left portion of the disk is covered with a film of fine sand and salt. In the photograph, remaining debris appears as a haze on the disk.

The procedure used to clean an LMSI 12-inch optical disc is documented below. A full description of the cleaning items used is provided in Appendix A. In cleaning an optical disc there are two items of utmost importance: (1) one must avoid scratching the disk surface, and (2) one must avoid leaving hard water deposits or residues on the disk from the cleaning operation. A laser beam must pass through the substrate in order to read and write a WORM disk. If this beam is blocked, scattered, or deflected by a scratch or debris on the surface of the disk, written data can be mis-read, and new data written to the disk may not be able to be read back.

The procedure below is specific to an application where clean, running water was unavailable, as was the condition in St. Thomas. If clean, running water is available, the cleaning procedure can be adapted accordingly. Furthermore, the supply of distilled water was limited, so that "towel" drying of the disk platter was required to eliminate water spotting. At the end of the cleaning procedure, disks can be liberally rinsed with distilled water and air dried if an adequate supply is available to avoid the use of having to dry the disk with a cotton swatch.

Procedure Used to Clean the LMSI 12-inch Optical Discs:

First, the optical disc cartridge is expanded. The optical disc cartridge was designed to expand when inserted in the drive so as not to interfere with the spinning disk. It collapses when the disk is removed for storage compactness. By pressing in on the four black plastic linkages at the sides of the cartridge, pins that lock the cartridge will retract and the cartridge can be expanded.

The cartridge is then opened by releasing four locking tabs near the black plastic linkages which lock/unlock the cartridge. There are two channels on either side of the smaller of the two cartridge halves that identify the location of the locking tabs. Once released, the cartridge can be opened.

Before removing the disk from the lower cartridge half, note the orientation of the disk platter relative to the cartridge halves. There will be a bar code scan label attached to the hub of the disk platter which will identify the side of the disk as "A" or "B." This should correspond with the letter that appears on or near the write/write protect lock on the cartridge shell half. Remember this orientation so that the disk can be reassembled properly at the end of the cleaning operation.

Nitrile or latex examination or surgeon's gloves should be worn when handling the disk platter to prevent the transfer of body oils and fingerprints to the disk surface. The gloves should be thin and delicate as not to interfere with the dexterity of the individual handling the disk. Do not use heavy duty rubber gloves as they are too bulky and clumsy.

The disk should always be handled by the aluminum outer rim or the hub. Avoid direct contact with the surface of the disk when holding the disk.

A cleaning station can be prepared by first taping a disposable plastic drinking cup (upside down) or other similar plastic support to the center of a washing basin. The cup serves as a support to keep the edge of the disk platter from being submerged in the water in the washing basin. When cleaning the disk, the disk platter can be supported on the upside down cup and against two adjacent sides of the wash basin. A small cotton TexWipe can be placed on the bottom of the upside down cup to reduce slippage of the disk against the cup. The disk is shown supported in this fashion in Figure 4.

Place water in the wash basin until it is 1 to 2 inches deep. Gently remove the disk from the cartridge and bring it to the cleaning station. Set the edge of the disk on the cup at the center of the wash basin. While holding the disk in place on the cup with a thumb, lay the disk over into one of the corners of the wash basin so that it is supported by two adjacent sides of the wash basin (see Figure 4).

Saturate a sponge with water by placing it in the wash basin. Gently squeeze out the sponge while holding it over the disk platter to provide a stream of running water. This initial rinsing of the disk will remove coarse debris and water soluble residues from the disk surface. During rinsing. avoid getting water inside the hub of the disk platter (water inside can run out onto the disk surface at a later time and contaminate the disk surface). When rinsing, dispense the stream just below the hub and allow it to run down to the edge of the disk. Slowly rotate the disk until the entire side of the disk has been rinsed. Then, turn the disk over and rinse the other side of the disk.

During the entire cleaning process, the water in the wash basin may need to be changed 3 or 4 times, depending on how dirty the disk is. As a rule of thumb, if the water appears to be more dirty or sandy that the disk you are cleaning-the water should be changed.

After the initial rinsing, the disk should be gently wiped with a cotton cloth. A 4 x 4-inch TexWipe was found to be perfect for this task. A single 4 x 4 inch wipe was folded once then folded again to make a 2 x 2 inch square wipe. One edge of this wipe (where it was last folded) will be a rounded edge. Use this edge of the folded cotton swatch to wipe the disk. Avoid the use of paper towels when cleaning an optical disc. Paper towels can be more abrasive than cotton wipes and can scratch the disk surface.

Saturate the wipe in the water in the basin. Using the rounded edge, and as little pressure as possible, gently wipe the disk from the edge of the hub to the edge of the disk. Use only as much pressure as is required to remove debris. If excessive force is used while there is abrasive debris on the disk, the disk surface can be scratched. After each wipe, check the wipe edge for debris or soil. If debris is obvious, remove it by vigorously rinsing the wipe in the water in the wash basin. If the wipe does not come clean, discard it and get a fresh wipe. Slowly rotate the disk until the entire disk surface has been wiped once. Turn over the disk and perform this operation on the other side of the disk.

Always wipe an optical disc from center to edge in a radial direction. Do not wipe around the disk in circles (or wipe tangentially). Data tracks on an optical disc are laid out in concentric circles or in a continuous spiral (as on an old phonograph record). If you happen to inadvertently scratch a disk while wiping it in a radial direction, the scratch will run across data tracks so that only a small portion of each data track is obscured. If a disk is scratched in a tangential direction, a greater portion of a data track can be obscured. Optical discs incorporate error correction code (ECC) schemes so that missing data can be reconstructed. However, the success of error correction is dependent on how much information is missing in the first place. Smaller sections of missing data have a much better chance of being reconstructed that larger sections. Since a radial scratch will obscure less of a data track that a scratch around a disk, the radial direction is the preferred direction for wiping. (Note that the same logic does not apply to floppy disk drives or hard drives. In this case, no ECC scheme is used and missing data is gone forever. A scratch will cause an error whether or not it is radial or tangential. On a floppy disk a radial scratch will cause an error in several data files, whereas a tangential scratch will tend to effect only one or a few files.)

Discarded wipes can be used to clean non-data critical portions of the optical disc platter, such as the disk hub and the disk edge. Avoid using an excessively wet cloth when cleaning the disk hub to avoid getting water inside of the disk hub, which can run out and contaminate the disk surface at a later time.

After the disk has received an initial wiping, a second wiping is performed using slightly greater pressure. This may be a good time to change the water in the was basin if it is dirty or soiled. Again, remember to use only the force necessary to remove debris from the disk surface. If the wipe is clean after a radial pass, either you can apply more force when wiping, or the disk surface is clean. Proceed in this manner until both sides of the disk have been cleaned.

If during cleaning, a particularly stubborn spot is noted that does not clean up readily with clean water. Some more aggressive cleaning solutions can be used. Mineral (from tap water) and calcium carbonate (from sea water) deposits can be removed with a dilute solution of hydrochloric acid in water. Generally, a solution with a pH of around 3.0 (or in the range of 2.5 to 3.5) should be sufficient for removing mineral deposits. The solution can be prepared by dipping the tip of a Q-Tip or tape head cleaning wipe in concentrated hydrochloric acid and then stirring this in a cup of water. pH strips can be used to determine if the solution is in the proper range, and the concentration can be adjusted accordingly. If the pH is greater than 3.5, the solution is not acidic enough and the addition of more acid to the solution will be required. If the pH is less that 2.5, it can be diluted with water until it is in the proper range. Dip the end of a Q-Tip or tape head cleaning wipe in the dilute HCl solution and use this applicator to remove the spot from the disk with gentle rubbing in a radial direction. (Note: Use extreme caution when handling hydrochloric acid. Serious burns can result if allowed to come into contact with skin or clothing. If this happens, rinse the skin under running water for about 15 minutes. The fumes emanating from an open bottle of HCl are also very noxious-avoid breathing or smelling them.)

A solution of soapy water can be used to remove greasy or oily deposits from a disk surface. Prepare a mild solution of soapy water, such as that which would be use for normal dish washing. Wet a Q-Tip or tape head cleaning wipe with this solution and use this to remove the spot from the disk with gentle rubbing in a radial direction.

Note that it may not be possible to remove all spots and residues from the surface of an optical disc. If spots are not removed with moderate rubbing force, it is probably better to leave the spot alone. Aggressive rubbing may result in scratches on the disk surface which may cause more disk read errors than would have been caused by the original spot. Recall that not all disk surface defects will result in hard errors (uncorrectable errors). Small surface defects are readily corrected by the ECC scheme built into the disk's data storage structure.

It is inadvisable to use organic solvents (e.g., isopropyl alcohol, acetone, etc.) to clean residues from optical disc materials. Use organic solvents only if you are certain that they will not harm the disk platter in any way (some solvents may soften, cloud, or dissolve the substrate or protective disk coatings). The manufacturer of the disk will be able to provide information regarding the composition of the disk and which cleaning solvents are acceptable. However, after a disaster, one may be challenged with several types of optical discs of unknown composition. For this reason, it is better to use only water-based cleaning agents (water, soapy water, dilute HCl) in an emergency recovery operation.

During the cleaning operation, water spotting of the disk may become a problem. To help the water flow off of the disk surface more readily and reduce water spotting, the surface tension of the water can be reduced by adding some mild dish washing liquid to the water in the wash basin. Use only enough soap as is necessary to get a sheeting of water on the disks rather than a beading. If you see suds in the wash basin, you have added too much soap. In general, a very tiny drop of soap of roughly this size-O-should be sufficient, depending on how much water is in the wash basin.

When very little or no debris is being removed from the disks and the disks appear to be clean, then it is time to begin the final wipe of the disk platter. The wiping operation is performed as previously discussed, except that it is followed up with a rinse with distilled water and the disk is then dried. Once a small section of the disk has received its final wipe, approximately 1/6 to 1/8 of the disk, rinse the area with distilled water from a squeeze bottle and then gently dry the area with a clean, dry TexWipe.

After the disk has been cleaned and dried, examine both sides of the disk in a very bright light. Look for water spots, debris, or residue that may have been missed during the cleaning operation. If any such spots are found, they can be spot treated with a damp Q-Tip or Tape Head Cleaning Wipe. Rub in a radial direction with just enough force to remove the debris. If moderate force is insufficient to remove the spot or residue, try using a mild hydrochloric acid solution (pH of ~ 3.0) to treat the spot if it appears to be a water spot or a mineral deposit. If it is a greasy, or oily residue, moisten the end of a tape head cleaning wipe with moderately soapy water and use this to remove the residue. Follow up the spot cleaning with a thorough rinse with distilled water. Dry with a cotton swatch.

When the disk platter cleaning operation is completed, or needs to be interrupted, the disks can be temporarily supported. Pass a metal or wooden rod through the opening at the center of the optical disc. Suspend the disk over a large, empty box, with the ends of the rod being supported by the sides of the box.

The disk cartridge shell halves can be cleaned more aggressively that the optical disc. They can be cleaned with a soapy sponge over a sink, rinsed with water, and towel dried. The only caution is to not over saturate the disk labels so that they wrinkle or come off of the cartridge shell.

Once the cartridge shells and disk platter have thoroughly dried, the optical disc platter can be carefully placed onto one half of the cartridge, taking note that the disk is oriented properly with respect to the cartridge half. The second half of the cartridge can be snapped back onto the first cartridge half. The four black plastic locking pins can then be depressed until the cartridge returns to its compressed configuration.

4.2 Department of Planning and Natural Resources (DPNR)

The systems which needed to be recovered from these offices were mostly PC's. During the hurricane, the DPNR offices lost an entire exterior wall and most of its roof (See Figure 1). Computers in this office were exposed to blowing rain mixed with sea water. One desktop PC was missed in the initial clean-up operation and was exposed to the elements for over three weeks before it was discovered. It had been partially protected with a plastic bag. Amazingly, this computer booted properly when it was powered up after being relocated to the Baa Library facility.

4.2.1 General Comments Regarding PC's

Some general observations regarding storm-damaged PC's and the recovery of same are detailed below:

External components: The computer chassis components that were damaged the most were those that had externally exposed surfaces, such as floppy drives, tape drives, boards for peripherals in expansion slots, and power supplies.

Water intrusion: In general, the systems examined were doused or drenched rather than being submerged in water. Rain, sea water, and other debris entered the computer case through external openings in the case: fan port for the power supply, expansion slot bay doors, floppy and tape drive openings, and ventilation holes. All these openings were at the back or front of the case; the top and sides of the case were solid. Therefore, water falling onto the computer from above generally entered the computer case via openings in the front or the back as it drained off of the system.

Internal damage: Damage to internal computer components was localized to where water had leaked through the case and pooled in the system. In general, water would enter and flow down the front or back wall and pool either at the bottom of the computer chassis or on the motherboard. Therefore, internal system components, if they sustained damage, were generally located near the base of the computer chassis. When examining storm damaged computer systems, corrosion was generally seen on the base of the chassis near openings at the front and back of the computer. Whitish mineral or salt deposits were observed on motherboards near case openings (expansion slot cards).

Hard drives: From a data recovery standpoint, the most important computer component is the hard drive. Fortunately, in newer computer systems, hard drives are well protected. They are located well within the computer case away from external openings. They also tend to be located high within the case. For these reasons, a computer system needs to be seriously compromised (e.g., submerged in water) before the hard drive sustains any damage. None of the systems investigated by the NML during this recovery effort had any damaged hard drives. Data was readily recovered from these by relocating the drive in a working PC and backing up the drive to tape.

Board deposits: Computers that had sustained rain and sea water contamination were surprisingly resilient. Electronic boards contaminated with mineral/salt deposits, sand, and other debris could be blown clean with compressed air and/or wiped clean with a damp cloth and placed back in service. The debris on the board was not observed to cause corrosion of board components or circuits. In many cases, the boards functioned prior to removal of the deposits, indicating that the residues were superficial. It is not clear what the long term effects of the deposits would have been had they not been removed. Note that in all cases, the boards were dry when tested. Boards with salt/mineral/sand deposits would not have been expected to function had they been damp or wet, or if the ambient humidity had been extremely high (> 90% RH).

Tower cases: From a water contamination standpoint, the one tower case examined seemed to fair better that the standard PC case. Because of its geometry, very few components are low in the case. The motherboard is generally high in the case and oriented vertically, rather than horizontally so that water does not pool onto it as it did in the standard PC cases examined. If a standard and a tower case PC were both sitting in two inches of standing water, the entire motherboard would be under water in the case of the standard PC whereas only the edge of the motherboard would be effected in the tower PC. The two drawbacks of tower cases are the following: tower cases normally sit on a floor and are more susceptible to standing water that are standard PC's which sit on top of a desk. Secondly, a standing tower case is easily toppled in a strong wind or shock. However, if the tower case is resident on a desktop and is secured so that it will not tip over, this geometry is superior to a conventional PC case from a leaking water intrusion standpoint.

Susceptible system components: The most susceptible system components were those made of steel. Steel screws, fasteners, springs, and bolts were severely corroded by rain water and sea water. Aluminum components also showed evidence of corrosion, but to a lesser degree (aluminum oxide and aluminum chloride forms a more solid, passivating coating than does iron oxide). Stainless steel and nickel plated components may have shown evidence of water or salt deposits, but did not corrode. It was not unusual to find a PC with a printer cable where the pins and sockets were in excellent shape even though the steel fastening screws were severely rusted.

4.2.2 Recovery of Floppy Disk Media

Several 3.5-inch floppy disks were recovered using the following procedure:

The plastic diskette housing is opened up by breaking the plastic welds at the back edge of the diskette (edge opposite the edge with the aluminum shutter). The plastic welds can be popped open by carefully prying open the corners of the back edge of the diskette using a fingernail, knife, or screwdriver. If a sharp object is used to pry open the cassette, care should be taken not to insert the object too far into the diskette as it can scratch or damage the media disk.

The diskette housing is expanded and the disk medium is removed using a gloved hand. Either nylon or cotton gloves are acceptable for this purpose. Rubber gloves can be used if a cloth glove is not available, but it is not as good as oils or greases on the glove can be transferred to the disk (this is less of a problem with the cloth gloves as they are absorbent). DO NOT use bare hands for this task as you will leave fingerprint oils on the disk. Always make sure that you handle the disk medium with a gloved hand.

If the disk is dusty, it can be carefully blown clean using a compressed air canister. If there are salt, mineral, or grease deposits on the disk, the disk can be carefully wiped clean. Place a clean cotton cloth (A TexWipe is good for this task, see Appendix A) on a flat, firm surface. Next, support the disk medium on this surface while carefully wiping the debris from the disk with a cotton cloth dampened with water. Very mild soapy water can be used if the debris does not remove with tap or bottled water. Use extreme caution when wiping the disk medium-take care not to wrinkle or crease the medium. If disk debris is minor, it may be better to forego a cleaning and see if the disk can be read rather that risk wrinkling the medium during a cleaning.

Once the disk medium is clean, it can be placed in a new diskette housing. Make certain that the disk medium is inserted into the new diskette housing with the proper orientation. A new diskette housing is made from a new diskette where the plastic welds have been broken at the back edge and the disk medium is removed and discarded. When expanding the disk housing to allow the media to be inserted, be careful not to expand the housing too far as this will permanently deform the aluminum shutter causing the diskette to catch in the floppy disk drive.

It is recommended that the contents of the recovered diskette be copied immediately to a brand new diskette or onto a working hard drive. Not only does this verify that the disk is readable, but it provides a new copy of the information on reliable media. If the disk cannot be read, software is available, such as Norton Utilities and SpinRite, which can assist in the recovery of the information on the diskette.

The old, recovered disk medium can be kept in the new diskette housing (the back edge of the diskette shell can be taped closed), stored in a plastic 100 mm Petrie dish (the steel hub can be labeled for identification purposes-DO NOT write directly on the surface of the magnetic medium), or discarded. The same "new" housing can be used to allow several damaged diskettes to be recovered. As long as the diskette shell remains clean, it is acceptable to use (look at the diskette shell lining for signs of dirt, debris, or discoloration).

If the recovered diskettes being recopied are not completely clean, it is a good idea to use a diskette cleaning kit at regular intervals to ensure that the read/write head is clean and to reduce the transfer of debris and contaminants to the new diskettes.

4.3 St. Thomas Community Hospital

There was a concern that computer facilities at the St. Thomas hospital had been compromised by Hurricane Marilyn. During the storm, water had leaked through ceiling tiles onto computer components, which had been partially protected with plastic sheeting. Furthermore, the lack of air conditioning following the storm resulted in higher than normal room temperatures and humidities. The systems administrator, Steve Magnus, was worried that dripping water and high humidities had contaminated components in the mainframe IBM AS400 310 system.

IBM had submitted a bid for the recovery of the hospital's mainframe computer systems, desktop PC's, and miscellaneous peripherals. NML was asked to review the condition of the hospital's computer facilities and comment on the IBM bid. NML visited the hospital facilities on October 9, 1995 and examined the two mainframe computer systems and a representative PC. NML concluded that the mainframe computers had been adequately protected from leaking water during storm activity. Furthermore, the AS400 310 system did not appear to have been compromised by the higher ambient humidities and temperatures following the storm.

The PC examined had been slightly damaged by water. Corroded peripheral cable connecting bolts and salt residues on the motherboard and computer chassis were observed. No permanent damage of system components was noted. A cleaning of the motherboard should have been all that was required to return this system to service.

A copy of the IBM bid for computer systems recovery and the NML letter to the hospital regarding the work proposed can be found in Appendices B and C, respectively.

4.4 Department of Education

It was originally planned that the NML recovery team would visit with personnel from the Department of Education on October 10, 1995 to assist with the recovery of electronic records. It was later decided that NML recovery operations at these sites were unnecessary for several reasons. It was reported that there were no problems at the Curriculum Center, and that no data loss had been experienced at Department of Education business offices. There was no loss of vital statistics (student records, report cards) as most of these records were stored on paper.

Computers at school locations had experienced damage during the storm. However, these systems, which were used for educational purposes, did not contain vital electronic records. Furthermore, it was reported that many of these computers had been looted from damaged schools shortly after the storm. For these reasons, recovery efforts were focused on the other agencies discussed in this report.

5 Conclusions

Overall, recovery efforts by NML personnel in St. Thomas in the wake of Hurricane Marilyn were a success:

The LMSI WORM optical discs used to store records of USVI legislative sessions were cleaned and restored. The two disks which were the most severely contaminated were restored to "like new" condition.

The index records for the legislative sessions were successfully rescued from the hard drive of a salt water damaged PC. Two 1/4-inch tape backup copies of the index records were created.

An LMSI disk drive system was cleaned and repaired as much as possible. Progress was made to the point that the disks would load and spin up. However, the laser sub-assembly would never recognize that a disk was in place suggesting a fault existed in the laser circuitry.

The Gateway 2000 computer used to control the LMSI system and access legislative records was restored to working condition. Only the 5.25-inch floppy diskette and the tape drive were damaged beyond repair.

Recommendations were made to the St. Thomas hospital regarding the services necessary to recondition their mainframe computer system, PC terminals, and associated hardware.

Library and USVI government staff were instructed with regard to cleaning and reconditioning of PC's, optical discs, and floppy disks.

Note-all indications were that existing data storage systems were properly stored, used, and maintained prior to damage at the hand of Hurricane Marilyn. Any damage sustained to the systems that NML examined was not the result of negligence on the part of the system operators. Systems had been covered with plastic bags and sheets when it was known that Hurricane Marilyn was approaching.

6 Recommendations for Preservation of Electronic Records in a Disaster

To prevent system and storage media damage from wind and water damage in the future, here are some recommendations:

Computer systems and electronic records should be stored in the central portion of a building. They should be on a floor above the first floor, but not on the uppermost floor (in the event that the building looses the roof in a storm). They should not be in a room with windows to the outside or an exterior wall. It is understood that this is not always practical. There are many buildings that do not offer such a room. Furthermore, people prefer to work in offices with windows and have records readily available at their work desk.

Vital electronic data should be backed up on a regular basis and the backup media should be stored at a remote location. In this way, if ALL of the records are lost or destroyed at the original location, a copy of the files (through the date of the last backup) will be available at a second location. If the computer workstation is connected to a mainframe or network server, backups can be automated to occur weekly or daily with records being conveniently copied to a protected, remote storage device.

When it is known that a hurricane is approaching, the following precautions are recommended. Note-the greatest concern in a disaster is for human safety. These precautions should be observed only if the time required to perform them does not place individuals at risk:

Unplug all electrical equipment.

Place equipment and records on a desktop or table to get them off of the floor. If possible, relocate vital records and PC's containing vital records to a room without windows that is centrally located within the building away from external walls.

Encase electronic components and electronic media (optical discs, magnetic tape, floppy disks) in heavy plastic bags and tie them closed. Simply covering equipment with plastic bags is good, but bags can blow off in a strong wind. It is better if the equipment and media is actually bagged and the open end of the bag is tied, or secured with a string, rope, or wire tie. The bags used should be transparent to facilitate identification of bag contents and should be made of a heavy gage plastic to reduce the chance of puncture. A source for transparent, heavy duty 55 gallon drum liners, which are excellent for bagging and protecting electronic equipment, is provided in Appendix A.

If a disaster has occurred, access to the inside of PC chassis and the operating system and software may be required for data recovery efforts. To facilitate recovery operations following a disaster the following are recommended:

Newer PC's come with chassis locks which prevent the PC from being opened. These keys should be kept with the PC, or kept in a known location so that the PC chassis can be opened if necessary. If keys are unavailable, it will be necessary to break the locking mechanism in order to gain entry to the inside of the PC for cleaning purposes.

The above also applies to system passwords. It may not be possible for an individual to proceed with a data recovery effort unless the password for the operating system or software is known. An individual assigned responsibility for emergency data recovery efforts should have access to a master list of system passwords.

7 Acknowledgments

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Chris Doute: Chris was instrumental in initiating and maintaining contacts between the NML data recovery team and USVI legislature and hospital staff. He helped in the amassing of damaged PC's and systems to a central recovery location at the Enid M. Baa Library. Chris was able to supply the NML recovery team with several computer components necessary for the completion of data retrieval tasks by borrowing equipment from his personal supplies or from DPNR offices.

Devora Molitor: Devora made the initial contacts and recovery trip plans with FEMA, NARA, and USVI personnel. She prepared an excellent briefing on the situation in St. Thomas providing vital information and key points of contact. Devora helped gather equipment and supplies necessary for the trip, including the acquisition of a 1000 Watt generator. Without her assistance, NML's departure to St. Thomas would have been delayed by 1 to 2 days.