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Preservation Assessment of Current HVAC Conditions at the University of Georgia Law Library

Chicora Foundation, Inc.

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PRESERVATION ASSESSMENT OF CURRENT HVAC CONDITIONS AT THE UNIVERSITY OF GEORGIA LAW LIBRARY, UNIVERSITY OF GEORGIA, ATHENS

CHICORA FOUNDATION, INC. COLUMBIA, SOUTH CAROLINA 1994
PRESERVATION ASSESSMENT OF CURRENT HVAC CONDITIONS
AT THE UNIVERSITY OF GEORGIA LAW LIBRARY,
UNIVERSITY OF GEORGIA, ATHENS

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EXECUTIVE SUMMARY

Perhaps the most positive aspect of the current HVAC conditions at the Library involve the interest of the University Operations and Maintenance and their willingness to work with the Law Library to find solutions. This department has previously taken steps (such as the installation of a recording hygrometer) to address some of the issues in the Law Library. A second positive area is the interest in the Dean of the Law School to identify the funds necessary to make improvements. These are situations not found on every campus and they suggest that the Library's problems, no matter how large they may seem, can be brought under control. Equally positive is the interest in preservation on the part of the Library's director, Ann Puckett, Esq. I encourage the Library to maintain the current momentum.

The Library does have a variety of serious problems relating to the current environmental conditions and to any efforts to achieve and maintain a preservation environment. Foremost among these problems are (1) the design of the current HVAC system, which is not intended to maintain adequate humidity control, (2) the absence of adequate moderate or long-term environmental monitoring records, and (3) the very poor level of building cleanliness. These problems are currently manifested in what appear to be high levels of mold in the building and a system which cannot adequately control the humidity level of the building and collections.

It is likely that the solution to these issues will require a two pronged approach of capital improvement -- replacing and/or modifying HVAC equipment -- and an overall building cleaning program -- sufficient to reduce the mold load in the collections. While delayed maintenance programs may be a necessary approach to classrooms and dorms, it is shortsighted to delay maintenance of the Library considering its houses a $19+ million investment in books and other educational materials. The loss or damage of this collection could create a situation from which the University would have trouble recovering. Every effort possible should be taken to protect this investment.

For the bulk of the recommendations offered below there is also some indication of the urgency of the proposed work. Virtually all of the proposed modifications and changes can be accomplished within a 5-year plan and many are of such significance to the well-being of the collection that they should be implemented within the next year.

Recommendations Regarding Monitoring and the HVAC System

The goal of monitoring at the Library is to determine the current environmental conditions -- including both daily and seasonal fluctuations -- on a continuing basis.

1. While there are very clear indications that the current HVAC system is unable to maintain an appropriate preservation quality environment, it is probably premature to recommend major capital expenditures, absent at least six to eight months of environmental monitoring. This monitoring is an essential step in the process of determining the precise changes needed. Consequently, the Library should begin a program of monitoring within the next 30 days. While either data loggers or recording hygrometers can be used, at least eight locations should be monitored: outside conditions, first floor of the main building, second floor of the main building,
third floor of the main building, special collections room, first floor of the annex, second floor of the annex, and third floor of the annex. All eight monitors should cover the same period (i.e., the Library should not attempt to reduce monitoring costs by using only a few monitors and changing their locations periodically - - this will result in adequate data and compromise the monitoring program). This monitoring can perhaps be conducted by the Library staff or it can be contracted out to a preservation group such as Chicora Foundation.

2. While it is tempting to immediately begin efforts to improve the environmental conditions, the monitoring program should be conducted before any efforts to modify the current HVAC system. Only by obtaining baseline data will it be possible to evaluate performance. However, Operations and Maintenance should ensure that routine maintenance (such as filter replacements) are continued during the monitoring period. During this period Operations and Maintenance may also want to evaluate the current equipment, especially in terms of life cycle and need for replacement. It may be that some items are coming to the end of their serviceable life and will need replacement in the next few years.

3. At the conclusion of the monitoring program the data should be evaluated for its impact on the preservation of the collection and recommendations should be developed for modification or replacement of equipment. This should be conducted by a team involving preservation expertise, mechanical engineering expertise, the Library staff, and the University Operations and Maintenance.

4. The Library and Operations and Maintenance, within the next 45 days, should develop a joint disaster plan covering off-normal events in the Library. Examples of such events may include compressor failures, burned out fans, major plumbing failures, major roof leaks, and similar occurrences. The goal should be to develop strategies ensuring that repair or replacement will not require more than a few days. Alternatively, plans should be made to curtail Library functions in an orderly manner and preserve collections until repair or replacement can be made.

5. While the current 60-65% ASHRAE Dust Spot Efficiency filters being used in the air handlers serving the Library are adequate (and are, in fact, better than found in many facilities), Operations and Maintenance should examine techniques of upgrading filtration to at least 80-85% ASHRAE Dust Spot Efficiency in the next 6 months.

Building and Collections Cleaning

The goal of cleaning is to reduce the mold load in the building and eliminate evidence of mold on the collections. This, like the environmental monitoring, will provide a baseline to allow evaluation of future changes. A second goal is to instill in the Custodial Staff an understanding of why very high levels of cleanliness are essential for the preservation of the collection.

1. It is clear from even this limited study that the building has a heavy load of mold and needs more thorough cleaning. The questions is whether this cleaning should be conducted now, absent any environmental improvements, or wait until the monitoring is over and HVAC modifications are underway. After consideration, I believe the first - - immediate cleaning - - is the appropriate response to ensure the well being of the collections. Consequently, plans should be made for a thorough cleaning of the building in the next 3 months. It is likely that this will need to be done by an outside contractor with experience in dealing with library materials. I am not recommending duct work cleaning since my preliminary studies indicate that the problem is in the
building, not in duct work itself. However, Operations and Maintenance should be requested to further evaluate this situation.

2. The Custodial Department should be immediately instructed to increase the care and intensity of their cleaning operations. Areas of specific concern include collecting surface dusts and debris on a continuing basis, more frequent emptying of trash receptacles, daily damp mopping of non-carpeted areas, and use of HEPA-filtered vacuums on carpeted areas. Increased diligence is essential to the preservation of the Library's collections. The full cooperation and understanding of the Custodial Department is essential.

3. Books with evidence of mold should be cleaned within the next 3 months. This may be done by an outside firm or by the Library staff. Once cleaned, it will be easier to monitor conditions in the collection.

4. Ceiling tiles which exhibit soiling should be immediately replaced, being careful not to further displace their loads of dust and mold. Grills and vents should be thoroughly cleaned. This work may be done by the Custodial Staff, Operations and Maintenance, or an outside firm, as appropriate.

Other Recommendations

1. The Library has a variety of preservation needs and concerns. I strongly recommend a general preservation assessment which can evaluate issues such as fire safety, security, binding, patron use, and other issues. It is possible that a preservation assessment can be arranged through SOLINET in the same fashion as the current environmental assessment. I believe that this is an important issue and it should be addressed in the short-term, perhaps within the next six months.

2. Absent a preservation assessment (or hopefully until one is conducted) I would strongly recommend that the following issues be addressed immediately:

   • access to the collections should be limited to those doors directly controlled by the Library staff;
   • all food be prohibited from the library, with a special admonishment to staff;
   • all drinks, except those in spill-proof containers, be prohibited;
   • all combustible materials be immediately removed from fire corridors and stairs;
   • all staff and students be provided with preservation training, focusing on the care and handling of collections; and
   • the Library develop a disaster plan.
INTRODUCTION AND SCOPE

This review and report are intended to assist the University of Georgia Law Library at the University of Georgia in Athens, Georgia in planning an improved preservation environment for their collection. While the emphasis throughout this study is on the Library's Annex Building, observations and recommendations will also be offered for the Main Building. In addition, this study incorporates general observations and recommendations for the preservation of the collections, outside the area of environmental conservation. This report is based on an October 17, 1994 site visit, including a review and brief inspection of some portions of the facilities and meetings with the following:

Ann Puckett, Esq., Library Director and Professor
Mr. Jim Nielson, Assistant Department Manager, Operations & Maintenance
Mr. Stephen A. Wass, A/C Foreman.

While a meeting with the Building’s Custodial Staff Supervisor, Mr. Tommy Dean, was anticipated and planned for by Ms. Puckett, Mr. Dean was not available during the survey.

No maintenance or operation manuals for the existing HVAC equipment, mechanical plans for the facility, or as-built plans for the Library were examined (although I understand that these do exist at the storage vault of Operations and Maintenance). While it is possible or likely that drawings (such as mechanical plans, "as-built" mechanical plans), plans, specs, and post-construction test and balance reports may exist for all or parts of the extant library, archives, and special collection areas, these were not reviewed during this study. Generalized floor plans for the building were, however, made available.

The review and discussions were focused on (1) the environmental conditions (primarily limited to temperature and humidity, although some visible light and ultraviolet light readings were also taken) of the Library’s Main and Annex buildings; (2) the operation of the extant HVAC systems, (3) specifications for a preservation environment, (4) options for achieving such an environment at the Library, and (5) evaluation of current mold conditions. The primary goal of this work was to develop recommendations which would achieve a preservation environment for the Library. Clearly, the Library staff must determine the value to be placed on their collection, in relationship to the efforts to be taken to provide the collection with this preservation environment. This study is not intended to make that judgement, although it will provide some initial estimates and observations for further discussion.

The observations, issues, and recommendations offered here should be used by the University of Georgia Law Library to assist in the subsequent work of HVAC engineers, and should not be construed as intended directly for construction. Chicora Foundation is not an engineering or architectural firm and makes no such representations or claims. Since this study is primarily intended for the Library staff, it includes discussions and digressions not intended for the experienced design professional. The observations on preservation environment criteria, however, may be useful to the design team.
While the University of Georgia was founded in 1785, the Law School Library was not created until 1869. Like other law libraries, this facility serves a variety of functions -- meeting the needs of a diverse community composed of law students, law professors, and the local law community, as well providing regional research collections.

Today the approximately 43,500 square feet of space houses nearly 370,000 volumes, over 337,000 fiche, 5,620 rolls of microfilm, and 1,124 linear feet of U.S. Government and United Nations documents. These materials alone are very conservatively valued at about $23 million, assuming that replacements could be found.\(^1\) The Library houses a large collection of foreign and Anglo-American law books and periodicals, many of which would be very difficult to replace. Clearly, the Library is one of the University's largest and most significant investments. It is questionable if the University could recover from the loss of the Library's resources.

Beyond these items, the Library also houses approximately 5,000 volumes of rare books in a room containing about 500 square feet on the first floor of the main building. The majority date from the early eighteenth through early nineteenth centuries, although the earliest imprint observed was 1610. In this collection the Library owns a valuable collection of the Rota Roman decisions, one of the few sources in the Southeast. This collection needs at least twice its current space and it is suffering mechanical damage from lack of appropriate facilities and care. There is an urgent need for immediate preservation intervention in the rare book collection.

In addition, the Library is responsible for a rather large collection of private papers and books, primarily materials being stored for a retired law professor which includes a number of very significant items. While these materials might serve to significantly broaden the Library's coverage, at present they are inaccessible and serve only to tie-up very scarce stack space.\(^2\)

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\(^1\) This amount is based on the 1994 Bowker Annual Library and Book Trade Almanac 1991 price index of $46.53 for North American academic books and per frame microfilm costs of $0.25. Not only does the calculation include some estimates (such as the number of frames contained in the collections) and the use of old data (from 1991), but it is almost certain that law books will have a higher per volume cost than most other academic books. In addition, many of the library's collections are out-of-print, dramatically increasing the cost of replacement. Further, this figure does not include the cost of other media, such as CD-ROMs. Regardless, the point of this figure is to clearly indicate the huge financial investment the State of Georgia has in the collections of the Law Library.

\(^2\) An October 7, 1994 memo by Ms. Puckett to Dean Ned Spurgeon concerning the Law Library's long-range needs mentioned that, in terms of space, "the law library has reached gridlock." I concur with this assessment and note, in addition, that the conditions not only impact the staff and patrons, but also have a deleterious effect on the collection. Additional space is an important ingredient in any preservation plan for the Law Library.
It is clear that the collections are diverse, representing a variety of materials, including paper, leather, vellum, film, and magnetic media. In the absence of a long-term collection management policy or preservation program, this study will assume a high level of preservation priority for the entire collection. Observations, issues, and particularly recommendations will be made to achieve the highest level of preservation possible for the entire collection. It will be the responsibility of the Library to determine what, if any, compromises can be made either because of cost, limited value of specific materials, or to maintain a "user friendly" environment.

**Preservation Environment Criteria**

In general, the preservation community has established a goal of 45% to 50% RH and a temperature of between 68° and 72° F with a variation of ± 2% RH and ± 5°F (see, for example, the Association of Research Libraries Preservation Planning Manual, Leighton and Weber's Planning Academic and Research Library Buildings, and Thomson's The Museum Environment). These, however, are broad goals, based on our preliminary and imperfect understanding of the effects of temperature and humidity on paper collections. We know that high temperatures will accelerate chemical reactions and hence paper deterioration. Likewise, high relative humidity tends to warp vellums, make paper pulpy, promote mold growth, and enhance the effects of insect pests. Alternatively, low humidity will cause brittleness of paper, cracking of leather bindings, and warping of bindings (especially vellum bindings). Low temperatures tend to promote the preservation of paper, although they may tend to discourage patron use.

To this we can add our knowledge that rapid fluctuations are often more damaging than constant levels, whatever they may be. Consequently, if relative humidity must vary from a low in the winter (perhaps 40% RH) to a high in summer (perhaps 55% RH), then traditionally preservationists have recommended that the change should be gradual over the course of the season. It should not occur quickly within a few days or even within a month. Nor should the variation be daily.

We also are beginning to better understand that not only is preservation affected by the relative humidity (RH), but also by the water content of the substrate or artifact. This water content may be measured and expressed as either a quantitative amount, the equilibrium moisture content (EMC), which is based on a percentage of dry weight, or as a thermodynamic characteristic called the water activity ($a_w$) of the item (which is the more often used of the two, especially since determining the EMC requires the destruction of the item). Water activity is based on the vapor pressure of the water in the substrate as compared to the vapor pressure of pure water at the same temperature and RH. The water activity of pure water is $a_w = 1$, hence the range of $a_w = 0 - 1$. While this seems very complex, it means simply that while the RH may be below the level commonly associated with supporting mold growth (say below 60% RH), mold may still grow because the book, wall board, or other item has a sufficiently high water activity. It is important to understand that mold relies on the suitability of the microclimate, not necessarily the broader macroclimate.

Traditionally we have also suggested that of the two -- temperature and humidity -- the latter is probably the more critical feature in the preservation of collections, especially when mold growth is a problem. Consequently, efforts should be made to first stabilize and control relative humidity allowing, if necessary, temperature to fluctuate. This has strong implications for HVAC control design, since conventional controls treat temperature as the primary goal with humidity as supplementary. The Library should ensure that any system installed, any changes to controls, and any work on the existing systems treats relative humidity as the primary control. Temperature may be allowed to fluctuate, if necessary, in order to maintain a constant level of relative
When the collections include a range of materials there are further problems. Photographic materials, for example, are best stored at relative humidities of about 30%, while this is far too low for leather, vellum, and paper. Consequently, a median of 45% RH has often been chosen as a compromise for the mixed collections.

Recently a new approach, called "isoperms," for evaluating environmental collections has been developed by Don Sebera and a portion of this work has been made readily available by The Commission on Preservation and Access as *Isoperms: An Environmental Management Tool*. The research helps address basic questions, such as: How much longer can I expect collections to be preserved if I improve temperature and humidity conditions? What are the preservation consequences of allowing wider swings in temperature and relative humidity? What are the risks associated with cycling between summer and winter storage conditions? The study is intended specifically for decision-makers and preservation managers who need a quantitative tool to help make real world decisions about environmental conditions and the information to judge how those choices will affect their collections. While intended for use with paper based collections, the general principles can be applied to other hygroscopic materials (the Image Permanence Institute has developed a very similar tool, *IPI Storage Guide for Acetate Film*, for use with certain photographic materials).

To provide one example, the tool accepts the storage of paper at 68°F and 50% RH as the "reference standard," with a relative permanence of 1. The relative permanence at 95°F and 80% RH is ~ 0.03. This means that if the paper stored at the reference standard has a life expectancy of 100 years, under the higher temperature and humidity levels the life expectancy would be only 3 years (100 years times 0.03). Alternatively, the relative permanence at 50°F and 40% RH is ~12 (or 12 times the reference standard, meaning in this example about 1200 years).

The concept of isoperms will be returned to later in this study to evaluate the current conditions in the University of Georgia Law Library.

Filtration is an equally significant issue. Particulates are known to soil collections and are often abrasive, causing damage to paper, bindings, microfilm, and many metals. Particulates can also act as "hosts" on which mold will grow. Particulates in a library or archive setting range from lint (10+ microns) to mold spores (2+ microns) to "dust" (0.01+ microns). Particles 1 micron and smaller do the most harm to collections and are of primary concern.

The best preservation environment will provide particulate filtration at 90-95% ASHRAE Dust Spot Efficiency, which means that the filter will trap 90% of all the small particles about 1 micron to 0.1 micron. Alternatively, filters can be obtained in efficiencies such as 50-55%, 60-

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3 This is an important issue which has tremendous impact on the need for "better than average" housekeeping. Brian Flannigan and J. David Miller noted in their 1993 article "Humidity and Fungal Contaminants," published by the National Institute of Building Sciences in *Bugs, Mold & Rot II*, "Data from several recent studies of molds in dust have demonstrated that the slightly or strongly xerophillic species can form an appreciable percentage of the population. These include a variety of toxigenic species including *Penicillium auranteogriseum*, *Aspergillus versicolor*, etc."

4 The industry bench mark is the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Test Standard for Air Cleaning Devices. The two most

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65%, and 80-85%. Often the 80-85% is an appropriate compromise between the ideal of a clean environment and the energy costs to move air through the higher efficiency filters. Such filters are typically effective on all pollen and dust, most soiling particles, and various oil smokes. The use of such filters may also allow a greater portion of indoor air to be recirculated, which will assist in maintaining a cleaner environment.

Electrostatic filtering must never be used since electrostatic precipitators add ozone (O_3) to the air, thus speeding the deterioration of organic materials, including paper, leather, and vellum. For the same reason photocopiers and laser printers, both of which produce significant quantities of ozone, should never be used in collection areas.

Gaseous pollutants contribute to the destruction of library, archival, and museum materials. Airborne molecules of sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) are absorbed from the air into collections, then combine with water (such as is present in even a dehumidified environment) to form sulfuric and nitric acids that speed the embrittlement of paper and destruction of other materials. Ozone has a specific and complete action on organic compounds. It will break every double bond on a carbon chain (a basic molecular component of organics such as paper) with which it comes into contact and thus destroy the materials.

The U.S. Department of Commerce recommends that, for preservation storage, these be not more than 1 microgram per cubic meter (μg/m³) of sulfur dioxide and not more than 5 μg/m³ of nitrogen dioxide. Ozone should be limited to 25 μg/m³. These gaseous criteria are very low levels, often less than 1/100th of acceptable EPA or "human" levels. This means that a nominally "safe" level of gaseous pollution for people will usually not be safe for collections. Compared to atmospheric pollutants, the off-gassing of new materials, fixtures, and furnishings is considered transient. In a building the age of the Library, it is likely that little off-gassing is currently taking place.

While the major concern in this assessment were the levels of temperature and relative humidity, some minimal attention was also paid to visible and ultraviolet light levels. While all light is damaging, ultraviolet or UV light is significantly more damaging to library and archival materials than other sources. Natural light is of particular concern since it has an extremely high level of UV component compared to other lighting sources. Light damage is cumulative and it is the total dose or exposure which matters in the preservation of collections. A preservation environment for moderately light sensitive materials (for example, materials which the Library wishes to maintain in open collections, but which cannot be easily replaced) is established to reduce visible light to below 600 lux and UV radiation to no more than 75 μw/lumen. For more sensitive materials (such as the Library's rare books) the visible light should be reduced to 50 lux. In both cases direct sunlight should be consistently avoided.

General/Architectural

The Main Library building was built as a three story structure, with the first floor (the basement level) below grade. The library shares the building with offices, classrooms, and a theater, encompassing approximately half of the square footage of the structure. Construction important portions of this test are the Weight Arrestance Test, which measures the larger particles, and the Dust Spot Efficiency Test, which measures smaller particles (less than 1 micron). Most of the larger particles are of limited significance to collections, while the smaller particles are particularly damaging.
includes a stone and brick veneer. Since the building plans were not consulted, I have no information concerning damp proofing or vapor barrier inclusion. Interior partition walls are constructed of wall board. The floors appear to be tiled concrete, although little attention was paid to these construction details. Carpet is installed in the reading room and the balcony areas.

Entrance is via doors in the east facade of the second floor (termed the main floor). Figure 1 shows the entrance, illustrating vegetation adjacent to the building and a faint "tide line," which may indicate moisture migration in the walls. This floor includes a number of staff offices, the rare book storage room, some collection storage, and a large reading room with large north facing windows. Above this is the third floor (termed the balcony level) which incorporates fixed stacks and limited reading areas. Along the south edge are study carrels and additional offices. The first floor houses compact storage (Figure 2).

The Annex, built about 20 years ago, is connected to the main building via a second floor pedestrian walkway (Figure 3). Construction is exclusively brick, with large east facing double glazed windows encompassing all three floors. The entire Annex is carpeted. The first floor is about equally divided between fixed stacks, reading area, and offices for the law school professors. This floor is semi-subterranean along the east edge. Dense vegetation and a deteriorating damp proofing system (Figure 4) both likely contribute to a buildup of relative humidity in the building. The second floor, reduced in size from the first, is primarily stack area with Library offices along the west and south exterior walls. The third floor, further reduced in size, maintains the law school offices along the west and south margins, as well as a minimal amount of stack area. The atrium effect in this building severely reduces the available floor space and an undue amount is devoted to office space.

While neither building roof was incorporated into this survey, there is evidence of possible roof leaks (stained ceiling tiles) in the annex. Both are flat roof decks. Since the roof is extremely important in protecting library materials from water damage, the Library should evaluate the thoroughness of current roof inspections and determine when the roof is scheduled for replacement.

The Library, in conjunction with Operations and Maintenance, should carefully consider if the building can tolerate additional humidification during the winter months. In some instances building envelopes - - the walls, roof, and windows - - may evidence problem condensation at levels of about 45% RH or higher in winter. Under certain circumstances this condensation can cause either cosmetic or structural damage to buildings. Retrofits of the building envelope to prevent condensation are expensive, often costing more than the associated HVAC modifications. The alternative is to reduce relative humidity levels to a point where problem condensation does not occur. The concept of isoperms can help evaluate different humidity level modifications.

The Nature of Humidity

The most obvious scale or technique for measuring humidity in the air might be the amount of moisture contained in a given volume, perhaps 10 grams per cubic meter (10 gm/m³). The problem with this approach is that this amount of moisture will cause serious drying and damage to books when the temperature is hot, while it will likely cause condensation when the air is cool. The reason, of course, is that hot air has a greater capacity for water than cold air. Thus, this scale or technique, called absolute humidity, is not appropriate as a general scale of measurement. Instead, a scale of relative humidity is used and is expressed as a percentage. It describes the percent of moisture that the air can hold at a given temperature. Air at 100% RH is holding all of the water it can and is said to be saturated.
Figure 1. Entrance to the Law Library, main building. Note vegetation and potential "tide line" on stone.

Figure 2. Basement of the main building, used for compact storage. Note lack of work space and very limited ventilation.
Figure 4. Vegetation, organic mulch, and deteriorating water or damp proofing on the east elevation of the Law Library annex.
For any level of relative humidity every material will have a characteristic water content, provided that the temperature is not allowed to fluctuate to extremes. For wood and similar cellulose materials at 55% RH this is about 10 to 12%.

This brief introduction to humidity reveals two points essential in our efforts to control relative humidity in the collection setting. The first is that by changing the temperature of the air, we will also likely change the relative humidity. As the air is made warmer it will have the capability to hold more moisture. Assuming that no additional moisture is added, the relative humidity will fall. Likewise, as the air is cooled it can hold less moisture and the relative humidity will increase. For every 1°F change in temperature there will be a 1.5% change in relative humidity. As an example, lowering the temperature of a room at 70°F and 50% RH to 65°F will increase the relative humidity to about 58%; alternatively, raising it to 75°F will reduce the relative humidity to about 43%. In neither case was any moisture added or removed.

The second point is related to direct refrigerant dehumidification. As we discussed, when air cools it becomes able to hold less moisture and there comes a point where it is holding all the moisture it can and is said to be saturated. If the air is further cooled it will give up some of the moisture as condensation. This is the process used in direct refrigerant dehumidification. The moist air is drawn over low pressure refrigeration coils\(^5\) which cool the air below the point of condensation, resulting in water being condensed from the air.

With a moment’s thought it will be obvious that the air leaving the coils will be near the saturation point. To obtain a decrease (or maximize the decrease) in relative humidity, the departing air must be reheated. This is the feature commonly known as “reheat.” In this process the air temperature is raised, with the resulting fall in relative humidity. Dehumidification by mechanical refrigeration is usually quite efficient and the actually cooling effect can be several times greater than the energy input required to operate the system (i.e., the system can have a high coefficient of performance).

To fully understand dehumidification also requires a basic understanding of sensible and latent heat. When refrigeration is used specifically for dehumidifying air both must be removed from the air. Sensible heat is removed as the dry air bulb temperature is lowered. As air is further cooled below the point of condensation, additional heat is removed -- this is called latent heat -- given up as the water vapor condenses to a liquid. For dehumidification to take place the chilled water or refrigerant in the coils must provide a higher ratio of latent to sensible cooling if the humidity of the building is to be reduced.\(^6\)

\(^5\) Some of the best coils for this purpose are the extended surface or finned coils. Heat is transferred by conduction through the tube walls (the primary surface) and the fins (the secondary surface). Air impinging on these surfaces is cooled by convection. Obviously, if more rows of tubes or coils are used, or if the fins are bent to increase air turbulence, the amount of air bypassing the coils will be reduced and the dehumidification capability of the coils will be increased.

\(^6\) For a more technical discussion of this topic the reader is referred to Roger Haines, "Control of cooling/dehumidifying coils" in *Heating, Piping and Air Conditioning*, December 1986, pages 136-137, 144. A somewhat less technical discussion is also offered by Munters Cargocaire’s second edition of *The Dehumidification Handbook*, also the discussion of desiccant dehumidification should be ignored as inappropriate for libraries and archives.
Mechanical HVAC

The existing HVAC systems for the Library is a central HVAC system incorporating several air handlers. All of the Library's coiling systems operate from chilled water coils, with the chilled water part of a multi-building loop including multiple chillers operating on an as-needed basis. While the design set points are thought to be 59° dry bulb and 58° wet bulb, Operations and Maintenance is attempting to operate the coils at a temperature of 55° dry bulb. At the time of this survey the actual temperature, however, was closer to 57 or 58°. Regardless, the system contains no ability for reheat, so dehumidification is limited to whatever condensation can be pulled off the chilled water coils. *As previously explained, absent reheat capability, this system can provide only minimal levels of dehumidification.*

During my visit the Library staff mentioned that they thought the rare book room (Figure 5) had an auxiliary system for better environmental control, although no one on staff knew exactly what was involved. While the representatives of Operations and Maintenance were not familiar with any special system serving the rare book room they kindly reviewed the building plans and identified that the room is on the Main Building's Air Handler 2, which offers no better, or worse, environmental controls than elsewhere in the building. For example, there is no humidification or dehumidification capability. What likely confused the Library staff, giving them the impression that the rare books were on a "different," or "better" system is that the room does have a redundancy or back-up system designed to operate should the main air handler lose electrical power. This back-up system is a small DX unit with atomizer humidification and electric strip reheat. It seems unlikely that the DX unit has been recently tested, so its ability to control the environmental conditions in the room is suspect.

This central ducted air distribution system incorporates variable air volume units, further complicating dehumidification. Variable air volume (or VAV) systems became popular with the arrival of the energy crisis of the mid-1970s when they were promoted as a method of eliminating reheat and saving fan energy. VAV accomplishes this by supplying only that volume of cold air to a space that is needed to satisfy the cooling load in the space. Fan energy is saved when the volume of air handled by the fan is reduced. This is typically accomplished by installing an automatic damper in the supply duct to each zone. While VAV systems make good short-term economic sense, they make it almost impossible to provide adequate relative humidity control or adequate supply of filtered air.

Heating at the Library relies heavily on the occupants, lighting, and other factors to provide sensible heat during the winter. Perimeter heat, supplied by hot water heating coils, supplies the only "active" heating system in the Annex (heating in the main building was not explored in any significant detail). I understand that this system works well -- at least in the context of building occupant comfort.

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7 A DX or "direct expansion" cooling system is similar to a residential air conditioner, in which refrigerant is used to cool the air and then reject the heat directly to the outside. Such systems also rely on reheat to provide humidity control.

8 As the room temperature becomes satisfied, the thermostat signals the damper operator to move the supply air zone damper toward the closed position. When the zone dampers are throttled, the static pressure in the supply duct is increased. A static pressure sensor senses this increase and adjusts the air volume.
There is a humidifier located in the basement mechanical room for the Annex (no humidifier was noticed for the Main building) (Figure 6). This is on-site engineered system which uses the boiler hot water to heat tap water which is then blown into the supply duct. While it is supposedly tied to a humidistat, the only controls I found during this visit was a simple on-off switch. Regardless, I understand from Operations and Maintenance that the system has been disconnected for several years. For the purpose of this study I will assume that the system is either inoperable or, alternatively, has been disconnected. This should be verified by Operations and Maintenance. In addition, the system should be "locked out" to prevent its operation during the recommended monitoring period.

Filtration for the Library spaces is provided by extended surface "bag-type" filters provided by a variety of manufacturers (at least three different types were observed in use during this visit). This type of filter typically consists of a synthetic media. The Dust Spot Efficiency of those which could be identified in this study were all 60-65% average efficiency. Spot checks of the filters indicated that they were relatively clean. The air handlers inspected had either manometer or magnehelic gages, which is good. These allow air filter changes to be made on the basis of recommended final air resistance levels rather than on their appearance of being "dirty," or on the basis of a certain period of use. However, for this system to operate effectively the initial and final resistance of the specific filters being used must be known. Operations and Maintenance should verify this information and clearly post the information at the gage locations so that all workers can monitor filtration load.

Ventilation is by metal duct work, typically placed overhead, and a variety of diffusers are present throughout the building. Ventilation ranges from adequate to almost non-existent (noted in the main reading room and in the compact storage stacks), resulting in "dead-spots" creating micro-climates. During even this brief inspection diffusers were found closed, almost closed, totally open, and even missing.

While not technically built with an air economizer system, the Library mechanical system is operated in a fashion to produce very similar effects. A true air economizer incorporates outside air intake vents which open to bring in cool outside air. This allows for "free" cooling of the building by maximizing the use of outdoor air. This approach is often used by VAV systems to ensure adequate fresh air. Of course air economizers make dehumidification impossible since they import the high relative humidity levels present in cool outside air. Obviously, this approach does not cause problems during periods when there is cool, dry outside air; however, during the

9 It was in one of these micro-climate areas, the compact storage in the basement of the main building, where a large fan has been operated for some time. For additional information on the problems associated with compact shelving, see "Help: We Can't Breathe in Here! -- The Effects of Limited Air Circulation Within Mobile Shelving Units," by Larry L. LaFollette in the April 1991 Records Management Quarterly. Specifically, he suggests installing one-inch rubber bumpers on the ends and intermediate support panels to prevent the units from closing tightly and allowing air circulation. Ventilation holes on the top, end, and intermediate support panels would also improve air flow. Finally, an inspection program is essential to identify isolated problems before they overwhelm the collection.

10 In a VAV system as the need for cooling decreases, so too does the supply air volume and the outside air intake. This can result in unacceptably low levels of fresh air. Consequently, VAV systems often include an economizer cycle which at low supply air volumes an outside air damper is opened to maximize fresh air intake.
Figure 5. Rare Book Room in the main Law Library building. Note large number of vellum bindings and crowded conditions.

Figure 6. Small humidification system built into duct work for the Law Library annex.
summer months increasing outside air is likely to bring in large quantities of very humid air.

The Library’s HVAC system operates using pneumatic controls. Pneumatic controls are extremely durable, often lasting longer than the building itself. They are simple to operate and can be maintained with a minimum of experience and equipment. They usually have a lower installed cost on buildings the size of the Law Library. Unfortunately, pneumatic systems have considerably greater deviation than direct digital control (DDC) systems. In addition, the regulating devices used in pneumatic control systems require more calibration, at more frequent intervals, than DDC systems. Consequently, from a preservation perspective pneumatic control systems are less than ideal. Since it is unlikely that they will be changed out for a DDC system anytime in the near future, Operations and Maintenance should inspect and calibrate all pneumatic controls at least quarterly.

Current Environmental Conditions

The Library has expressed considerable concern (and rightly so) over the environmental conditions in the Library. Unfortunately, there is no good history of temperature and humidity levels in either the main building or the annex.

Readings were supplied for a week in August 1994 (August 8 through 12), apparently taken using a sling psychrometer at 8:00 am and again at 2:00 pm on the first and second floors of the Annex and the first floor of the Main building (Table 1). The reveal a range of temperature in the Library Annex from 68°F to 74°F and a range in humidity from 60% to 72% RH. While the temperature is not unacceptable, the variation of 6° in the course of a week (or a maximum recorded of 5°F in a 6-hour period) is cause for concern. The humidity levels are entirely too high, with most being at the edge or within the zone considered likely to yield mold. In addition, there was a range of at least 8% RH over the course of a 6-hour period. The Main building evidences a temperature variation from 69°F to 72°F, with a maximum variation of 2°F over a 6-hour period. Relative humidity varied from a low of 50% RH to a high of 60% RH, with a maximum range of 10% RH within a 6-hour period. Again, these are cause for considerable concern, especially since the rare book storage is within the main building.

During my meeting with Operations and Maintenance, they provided sling psychrometer readings taken in September 1994. During this period readings as high as 70% RH were still being recorded.

Operations and Maintenance had also installed a Dickson recording hygrothermograph in the Library Annex (on the KN range) (Figure 7). Unfortunately, the weekly chart had not been changed in five weeks and the readings were so badly overwritten that no real information could be obtained. In general, temperature readings seemed to be relatively stable between 67° and 70°F,

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Pneumatic control systems use compressed air to supply energy for the operation of valves, dampers operators, and other control equipment. The pressurized air circuits that operate the control devices are small diameter copper or plastic tubes.

Direct digital control is accomplished by a digital computer system. Most DDC systems use microprocessors with software programs to maintain variables such as temperature, humidity, and flow rates. This system is also uniquely suited for integration in fire and intruder security systems. The advantages include the simplicity of changing control sequences and set points, the ability to monitor an entire facility (an diagnose problems) from one computer, and extremely precise control of the set points.
Table 1.
Temperature and Relative Humidity Levels,
August 8 - August 12, 1994

<table>
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<tr>
<th>Day</th>
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<th>Annex, 2</th>
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while the humidity levels showed greater variation. While the chart can be evaluated for general stability, the absolute instrument readings cannot be used for analysis since it was last calibrated in October 1993. Hair hygrometers require weekly to monthly calibration for reliable accuracy, combined with yearly cleaning of the hair elements.

Since the August 1994 readings offer the most continuous set of environmental conditions, they are shown below on an isoperm chart (Figure 8). Only one of the readings is on the 1.00 isoperm. All of the remainder range from the 0.95 to the 0.33 isoperms. This means that, assuming these readings are representative and accurate, the collection is facing serious deterioration, potentially shortening its life expectancy to as little as one-third what it might be at the stable temperature of 68°F and stable relative humidity of 50% RH. This should be interpreted with some considerable alarm by the University since the very limited data suggests that the financial and intellectual resources of the Law Library are potentially threatened by inadequate environmental controls.

During my visit spot readings were taken throughout the Main Building and Annex over the course of the day. Early in the morning, when outside conditions were about 52°F and 71% RH, readings in the Annex ranged from 67°F and 49% RH to 70°F and 43% RH. Air flow at the diffusers averaged about 63°F and 60% RH. By mid-morning the Annex readings ranged from 67°F and 54% RH on the third floor to 68°F and 47% RH on the first floor. In the Main Building, I installed a recording hygrothermograph (circulation, second floor) which operated from 8:30 pm on October 16 until 4:45 pm on October 17. This chart is reproduced as Figure 9. Temperature levels were generally stable throughout the monitoring period, as were relative humidity levels. Conditions in the building ranged from about 71°F and 42% RH in the first floor basement compact storage area to 74°F and 42% RH on the third floor. Readings in the rare book storage were consistent with the other readings in the Main Building, being 71°F and 41 RH at 11:30 am.

Air circulation was not monitored, but pockets of still or ‘dead’ were noted in the rare book room, in the Main Library reading room, and in the compact storage areas. We also observed efforts by those using one of the law review offices in the Annex to manually control air flow by taping over the diffuser. These represent specific areas where Operations and Maintenance should evaluate the need for testing and balancing studies. The absence of adequate air flow will...
Figure 7. Recording hygrothermograph on KNP range. Unfortunately, it had been recording over itself for about 5 weeks at the time of this survey.

Figure 8. Isoperm calculations for August 8-12, 1994 temperature and humidity readings taken in the Law Library main building and annex.
Figure 9. Recording hygrothermograph chart for the main floor of the main building of the Law Library, from 8:30 pm October 16 through 4:45 pm October 17, 1994. Red is temperature, blue is relative humidity.
encourage mold growth, regardless of the eventual relative humidity and is a serious problem.

Housekeeping

Overall, housekeeping in the Law Library is poor. I found very heavy loads of dust and soil almost everywhere in the library. It was found on the headcaps of books, on shelves, and on wood molding. Heavy accumulations of dirt and dust were found on the stairs in the Main Building. I observed trash cans which were full by about 10:00 am and which had not been emptied by 4:00 pm. Many of the ceiling tiles are heavily loaded with dirt, dust, and mold (Figure 10). A number of diffusers were observed with clear evidence of mildew growth which has not been cleaned off. Other diffusers were observed with exceptionally heavy accumulations of dirt, dust, and debris (Figure 11). During my visit, which began at 9:00 am and continued until nearly 5:00 pm, I observed no housekeeping staff at all.

There were few areas which meet even the most minimal levels of cleanliness. Most of the Library suggests that there are no substantive cleaning procedures and no attention to detail. As previously mentioned, dust forms a very satisfactory base, or medium, for a range of indoor molds, many of which not only attack books and paper, but which are also classified as toxigenic. This is a very serious problem which deserves immediate attention -- not only must housekeeping procedures be improved, but they must be regularly implemented.

Existing Monitoring Equipment

Operations and Maintenance is currently using a Taylor sling psychrometer, both for individual readings and to calibrate its equipment. Sling instruments, using mercury bulb thermometers, are very accurate assuming only distilled water is used on the wet bulb, that the instrument is properly used, and that the wet bulb wick is kept clean. This instrument should be appropriate for calibration purposes. Because of the time and effort necessary, a sling psychrometer is not typically used for multiple readings and a digital instrument would be more appropriate. One excellent example is the Vaisala HM 34\textsuperscript{13}.

Also being used is one recording hygrothermograph. This instrument is a Dickson model which I have used in the past. It tends to be accurate and reliable, when correctly calibrated and maintained. One recording instrument, however, is not likely to provide the coverage the Library needs, since monitoring should be conducted on each floor, in the rare books room, and on the outside of the building (for a total of eight monitoring stations). Future purchases should consider using the OMEGA CT485RS instruments.\textsuperscript{14} Data loggers may be an appropriate alternative.\textsuperscript{15}

The library may also wish to purchase direct reading digital hygrometers, such as

\textsuperscript{13} Available from Vaisala, Inc., 100 Commerce Way, Woburn, MA 01801, phone 607/933-4500. An information sheet for the instrument is included as an appendix.

\textsuperscript{14} Available from OMEGA Engineering, Inc., PO Box 4047, Stamford, CT 06907, phone 800/826-6342. Additional information is provided in the appendix.

\textsuperscript{15} One data logger which would meet the Library's needs is that offered by the Cascade Group, 68 West Main Street, Oyster Bay, NY 11771, 800/800-0588. Some additional information on data loggers is provided by Michael Barford's article, "More Easy Environmental Monitoring: Dataloggers," in the November 1991 issue of the Abbey Newsletter.
Figure 10. Dust and mold entrapped in a ceiling tile, third floor of the Law Library annex.

Figure 11. Dust and mold entrapped on the grill of a diffuser, Law Library annex building.
as Baxter Scientific's model H9506-3\(^\text{16}\). These are very accurate, offer a minimum and maximum memory, and are inexpensive (under $60).

**Current Mold Levels**

This study is not intended to provide a thorough background of mold research in library and archival collections. Perhaps the single best source (although even it is not complete) is the recent study by Mary-Lou E. Florian entitled, "Conidial Fungi (Mould, Mildew) Biology: A Basis for Logical Prevention, Eradication and Treatment for Museums and Archival Collections," published in the 1994 issue of *Leather Conservation News*. There are a few issues which are important to keep in mind when discussing mold. Mold spore (or more correctly, conidia) are everywhere. Those found in buildings are essentially a cross-section of those found in soils outside. It is relatively easy to kill mold, but very difficult to kill the conidia. Once they "infest" a building or library collection, while the numbers can be reduced, they will likely always be present. Hence, it is easier to prevent the problem than to cure it once a collection is infested. As previously mentioned, molds require specific microclimates, which explains why so often mold prevention (based on macroclimates) fails. For example, when air is cooled to its saturation point and supplied without reheat (as is the case in the Law Library) the diffusers can be extremely cold -- leading to condensation ("sweating") and the growth of mold on the diffusers themselves (a photograph of this is provided later in this study). Where diffusers are located poorly or adjusted incorrectly, this cold, moisture saturated air may be "blown" against books and other surfaces, creating cold spots and localized areas of high relative humidity -- leading to localized mold growth. Often the supply air is under considerable pressure and "jets" of cold air can create extensive localized cooling, which also supports mold growth. In any climate the bottom shelves near ground level tend to have higher relative humidity levels than those higher up. Hence, while 4 feet off the ground the relative humidity may be "only" 60%, at the base of the shelves the levels may reach 80% RH -- a condition which can lead to mold in as little as two days.

And, as noted before, dirt promotes mold. Stefan Michalski of the Canadian Conservation Institute found that several days of 80% RH would cause mold on "dirty" artifacts, while clean paper, paint, and textiles generally needed a level over 90% RH. Poor housekeeping dramatically increases the risk of mold to the collections.

After this admittedly brief review of mold, it is appropriate to turn to the situation at the Law Library.

As previously mentioned, I observed a number of ceiling tiles with heavy loads of particulates -- primarily dust and what appeared to be mold. In discussions with Operations and Maintenance, they believe that this accumulation is the result not of the supply air being dirty, but rather the positive supply air creating a negative pocket which attracts building air, including any dust, and entraps it near the vent. This process, known as "entrapment," is common where housekeeping is poor. In order to evaluate the contents of this debris a scraping was taken with a sterile scalpel and applied to an agar plate in order to qualitatively assess the mold spore levels. The plate was incubated under low light at 80°F for four days. Figure 12 reveals the result -- very heavy mold growth with the colonies so numerous they quickly spread over one another forming a dense mat. This indicates that the contaminants in the ceiling tiles are heavily loaded

\(^{16}\) Available from Baxter Healthcare Corporation, Scientific Products Division, 1430 Waukegan Road, McGraw Park, IL 60085, phone 312/689-8410. An information sheet for the instrument is included as an appendix.
To evaluate whether the duct work was contributing additional mold spores a second agar plate was exposed to the air flow for 1 hour and was then incubated in a manner identical to the previous test. As shown in Figure 13, only one colony was identified. While mold is clearly being spread in the supply air, the load is significantly less than that found in entrapment areas.

A third mold sample was prepared by taking a scraping off a book (KNP A666 A477) exhibiting a number of white "dots," thought to be mold by the Library staff (Figure 14). This sample was incubated in a manner identical to the others and produced a single mold colony (Figure 15). While clearly some mold is present on the book, this test suggests that the white material is not mold.

Examination of a sample of the binding under low power magnification (7x to 30x) reveals that the surface of the leather binding is potmarked or exploded, with a white crystalline powder being found in the potmarks and cracks of the leather. While no chemical tests have been conducted, it appears that the white material is a soluble salt efflorescence. I am not a leather conservator, so I hesitate to offer an explanation; however, the material in question is clearly not mold.

Other books in this range, however, do evidence some slight mold growth (none of which appears, at present, to be active) (Figure 16). In addition, several books were found in the compact storage of the Main Building with light mold covering the entire binding (these were apparently introduced into the collection with the mold already present).

Current Visible and Ultraviolet Light Levels

Ultraviolet (UV) light levels at the west facing Annex windows during the morning of this survey averaged 8500 \( \mu \text{w/lumen} \).\(^{17}\) Visible light readings averaged 1020 lux. In the stack areas of the annex, away from the windows, the UV light levels averaged 1500 \( \mu \text{w/lumen} \) and the visible light was 410 lux. In the Main Building reading room, which has north-facing windows, the UV levels averaged 5000 \( \mu \text{w/lumen} \) and the visible light levels averaged 152 lux. Regrettably, none of these windows have blinds or other mechanical measures for either visible or UV light control. Consequently, the collections are constantly being exposed to very intensive and damaging levels of light. Fortunately, the bulk of the light falls in the reading area, rather than on the stacks, minimizing the damage to the collection. The staff should be made aware of the potential for damage and instructed to more frequently clear the reading room tables of unused materials. The University should also apply a visible light and UV shield to these windows.\(^{18}\)

Examination of the overhead florescent lamps revealed that most were emitting UV in the range of 300 \( \mu \text{w/lumen} \), far exceeding safe levels for the materials present. A few were emitting barely detectable levels, suggesting that at least some of the acrylic safety shields are also serving to shield out UV light.

While light levels were not specifically a part of this study, they are offered here to

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\(^{17}\) Ultraviolet light was monitored with a Crawford type UV monitor. These instruments may be unreliable at very low UV levels, but are typically very accurate at normal and high levels.

\(^{18}\) One such film is produced by Solar Screen Co., Inc., 53-11 105th Street, Corona, NY 11368, 718/592-8222.
Figure 12. Agar collection plate from ceiling tile scraping, third floor of the Law Library annex.

Figure 13. Close-up of single mold colony grown from exposure to supply air duct.
Figure 14. Indian journals exhibiting a white powder, originally thought to be mold.

Figure 15. Single colony of mold grown from wiping taken from Indian journals.
indicate that the collection faces a variety of very serious preservation problems.
Figure 16. Books in the Law Library Annex with a light (inactive, at present) mold outbreak.

Figure 17. Metal diffuser with active mold growth from condensation in the Law Library Annex.
ENVIRONMENTAL EVALUATION

The Library was designed and constructed with virtually no attention given to a preservation environment. It is clear that the mechanical designs were developed for the comfort of the building's occupants, not the safe storage of valuable library collections. While general collections may be less valuable or warrant less preservation attention, this is a decision which can only be made by the Library Staff -- it is likely that the life span of even these general, circulating collections is being shortened by the current environmental conditions. The unshielded glass windows; the semisubterranean construction; the absence of any dehumidification; the absence of adequate humidification; inadequate housekeeping; the probable absence of vapor barriers and adequate insulation; and the absence of gaseous filtration all serve to impede the preservation collections of the staff.

Typically I would recommend significant modifications to the HVAC system, such as:

- dedicated humidification and dehumidification capability, and
- particulate filtration of at least 80% ASHRAE Dust Spot Efficiency.

In fact, of all the concerns, the absence of dehumidification is the greatest because of the mold conditions in the library. We know, for example, that in the range of 95% to 70% RH, a 10% RH reduction does as much to control mold growth as dropping the temperature from 86°F to 50°F.

In the near planning future (perhaps on the basis of a 5-year plan) it will be necessary for the Law Library to substantially upgrade the environmental systems. At the present time, however, I question whether we have sufficient environmental data to cost-effectively tackle the problems at the Law Library. Consequently, I am recommending additional monitoring to collect the data necessary to evaluate the long-term environmental trends in the building.

I am also recommending that a variety of changes in housekeeping be immediately implemented. The seemingly lackadaisical level of cleaning is totally inappropriate for the preservation of the Library's collections and is likely promoting, or has the potential to promote, increased mold growth. The changes in the housekeeping regimen should be coupled with a careful and thorough cleaning of the entire facility. The goal of this work should be to eliminate the heavy load of mold in the building and establish a baseline for future evaluations.
I believe that Operations and Maintenance is doing a good job with the currently available HVAC equipment. It is clear that the systems at the Law Library are not designed to control humidity or provide a preservation environment. Consequently, it is unreasonable to expect Operations and Maintenance to do more than the equipment allows.

I do recommend that the Law Library make several formal requests of Operations and Maintenance:

- Operations and Maintenance should understand the importance of their work in the preservation of the Library Collections. There should be periodic meetings between Operations and Maintenance and the Library Staff to encourage and maintain the flow of information.

- Operations and Maintenance should understand that it is important that the HVAC system be operated and maintained in a normal fashion during the monitoring period. If there are any periods during which the system goes off-line or if there are any irregular events, they should be reported to the Library staff, in writing, along with information on the nature of the problem and the actual or projected duration.

- Operations and Maintenance, in conjunction with the Law Library, should develop detailed emergency or disaster plans for off-normal events. This plan should specify how the Library will be notified and what steps (including closing of the facility, use of fans, etc.) should be taken to safeguard collections. Off-normal events might include loss of electrical power, loss of a compressor, interruption of chiller operation, water leaks, and similar events. Operations and Maintenance, being most familiar with the system, is likely to best understand the range of potential events which might seriously disrupt temperature and humidity levels in the Library. The Library should expect these plans to minimize disruption, ensure the safety of the collections, and help determine when it is best to curtail library activities until the system is again on-line.

- Operations and Maintenance should evaluate the possibility of replacing the current 60-65% efficiency filters with 80-85% ASHRAE Dust Spot Efficiency filters. This will primarily require examination of fan motor capacity.

- Operations and Maintenance should inspect and calibrate all pneumatic controls prior to the monitoring program. Controls should thereafter be inspected and calibrated every 6 months.

- Operations and Maintenance should be requested to evaluate the extent to which the Main Building and Annex envelopes can tolerate additional winter humidification. This will require examination of the as-built plans for information.
• Operations and Maintenance should be requested to "lock out" the operation of the steam humidifier in the Annex to prevent its intermittent use during the monitoring period.

• Operations and Maintenance should post information on the initial and final resistance of the filters by all gages in the air handler rooms. This will help ensure that filters are changed out when loaded.

• Operations and Maintenance should evaluate the need for testing and balancing of the air flow in the Law Library buildings. This study has found some evidence that air velocities may be too low in some areas. This low air movement encourages mold growth and should be avoided wherever possible.

**Monitoring Program**

I strongly recommend that a monitoring program be undertaken within the next 30 days. The urgency involves the ability to begin the monitoring at the change of seasons in order to evaluate seasonal fluctuations. The monitoring should incorporate eight specific locations: (1) outside conditions, (2) conditions specific to the rare book room, (3) Main building, first floor, (4) Main building, second floor, (5) Main building, third floor, (6) Annex, first floor, (7) Annex, second floor, and (8) Annex, third floor. While I am reluctant to indicate that this number can be reduced (institutions are too quick to accept the reduction), generalized outside information can be obtained from NOAA and the second floor of both buildings can be eliminated -- reducing the number of monitoring stations to five. Further reductions, however, would compromise the ability of the data to address the need for HVAC improvements.

The monitoring program should encompass at least nine months, perhaps from late November through August. This would provide information on the dry winter months, the humid summer months, as well as at least full change of seasons.

The University must make several choices: first whether to undertake the monitoring program in-house or to contract it out and second whether to use recording hygrothermographs or data loggers.

Recording instruments are less costly\(^{19}\) and provide immediate gratification -- indicating temperature and humidity fluctuations. They are easy to quickly scan for off-normal events and some even provide alarms to signal trouble. They also require no computer expertise. Correlating large amounts of data, from five to eight stations over nine months, however, takes considerable effort. Data loggers are designed to collect massive amounts of data and, through their computer programs, present syntheses of the information. Some, however, argue that data loggers do not offer the accuracy of recording hygrometers.

The choice to contract out or perform the work in-house is primarily one of staff time. A monitoring program involving the use of recording hygrothermographs will require about 2 to 4 hours of time per week (or about 15 to 30 minutes per instrument to change the chart strip and

\(^{19}\) A reasonably good recording hygrometer will cost about $800, while a comparable quality data logger (with software) will cost about $1200.
make adjustments). The same one or two persons should be responsible for the project from beginning to end to ensure accountability and continuity (in other words, it would not be appropriate for student assistants). If data loggers are used, staff time could be reduced. A typical data logger can store 32,000 readings (actually 16,000 if both temperature and humidity are being recorded). This means that taking a reading every 10 minutes, the information for 111 days can be stored with out loss. Consequently, over a nine month project the data loggers would need to be down-loaded only three times. Each of these would require about a day to down load and generate graphics, reports, and statistics.

An outside organization, such as Chicora Foundation, could conduct the study using data loggers. However, since data loggers are so expensive and difficult to insure (given their complexity, size, and accessibility), the costs of in-house and outside monitoring are virtually identical. The real savings is in staff time -- using an outside consultant frees the Library from the need to deal with the monitoring program.

At the conclusion of the monitoring program the results should be evaluated by a team involving preservation expertise, mechanical engineering expertise, the Library staff, and the University Operations and Maintenance. The ultimate goal of the monitoring is to clearly indicate the range and extent of environmental problems in the Law Library and provide clear justification and design parameters for improving the environmental conditions.

Building and Collections Cleaning

At present there is a large amount of mold present at least in the Annex. There is an equally large amount of particulates throughout both the Annex and Main Building. These are covering the collections, the building fixtures (such as the ranges), and the building details. It is essential that the buildings be thoroughly cleaned.

This means much more than just going in with a few vacuums and dust rags. In fact, I cannot caution strongly enough that typical cleaning strategies are totally inappropriate for the current situation. ALL collections, ALL fixtures, ALL carpeting, ALL building details MUST be thoroughly cleaned using APPROPRIATE techniques. Otherwise, the entire activity will be wasted effort and the mold problem will likely be spread throughout the building.

This cleaning may be done in-house or by an outside contract. Given what I have seen of the Custodial service, I would strongly recommend an outside firm, but this decision is of course left to the University. Issues which should be considered include:

- **Vacuuming** - there are large areas of book ranges, headcaps, and wooded fixtures in the Library which can be vacuumed. However, the use of ordinary, commercial vacuums should be avoided. Pollen, molds, dust-mite feces, and other forms of household and institutional dirt can cause allergic reactions in some people. Vacuuming can launch these items into the air in several ways: a porous cleaner bag can allow them to escape; a rotating brush can kick them up as it is moved across the carpet or floor; or an exhaust vent at the base of the cleaner can blow them around. Use of regular vacuums for this initial cleaning would be disastrous -- it would spread the mold throughout the building, creating an even larger problem than the Library has at present. Only vacuums with HEPA filters should be used for this initial deep cleaning (subsequent maintenance cleanings can use commercial vacuums as noted below). HEPA stands for High Efficiency Particulate Absolute, a filter capable of removing 99.97% of particles down to 0.3 microns. Such concentrated filtering is perfect for cleaning up hazardous materials.
including mold in library, archive, and museum settings. The best HEPA vacuums use a three step process: a collection bag filters out heavier particles, a microfilter or prefilter protects the HEPA filter, and the HEPA filter itself removes the smallest particles (Figure 18).

![Cross-section of a typical HEPA vacuum, showing filter action.](image)

- **dry wiping** -- one traditional approach to cleaning is the use of "dust clothes." In general these either spread the dust and mold spores or, alternatively, contain chemicals which are inappropriate for use on collections. Many contain abrasive fibers which can damage collections and they often create additional lint. Recently an excellent dusting cloth, called the **Dust Bunny™**, has been introduced by Leap Frog™ Technologies. This product is made of a special polymer blend fabric that generates a dust-attracting, electrostatic charge as it is used. Studies suggest that these cloths can "catch" upwards of 98% of the surface debris. The fabric is chemical free and the product can be washed and reused many times. While dry cleaning using these wipes is no substitute for the use of a HEPA vacuum, there will be situations and areas where dry wiping is the only choice.

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20 Appropriate HEPA vacuums include the Nilfisk models which cost about $1000 for the 3\(\frac{4}{5}\) gallon capacity. A smaller, more portable model is the Euroclean HEPA vacuum, which costs about $600. A variety of HEPA vacuums can be obtained from safety supply firms such as Lab Safety, PO Box 1368, Janesville, Wisconsin 53547, 800/356-0783.

21 These are available from preservation supply firms such as University Products, PO Box 101, Holyoke, MA 01041, 800/628-1912. The cost for the 17 by 17 inch cloth is about $4.60.
replacement of ceiling tiles - all stained and particulate loaded ceiling tiles (especially those around dampers and vents) should be discarded and replaced with clean tiles. This replacement should be done before any cleaning. Care should be used not to dislodge the dust and mold from the tiles during their removal. In addition, all soiled tiles - even those requiring the use of scaffolding - must be replaced.

wet cleaning - vents and diffusers with mold staining (see Figure 17) should be wet cleaned using a bleach solution (diluted 5 parts of water to 1 part of 5.25% sodium hypochlorite) after the tiles are removed and before new tiles are put into place.

cleaning of diffusers with heavy particulate build-up - these areas should be vacuumed with a HEPA vacuum and then wet cleaned as described above.

cleaning of volumes with mold - there are some books in the Library collection which evidence inactive mold growth. These should either be discarded or cleaned. Localized cleaning operations on non-unique bindings (unique materials might include items such as leather or vellum rare books) can use small disposal absorbent cloths,22 or even cotton-tipped applicators23, dampened with at least 90% alcohol.24 The binding should be lightly wiped to remove the mold and the cloth or applicator immediately discarded. Naturally all bindings should be tested to ensure that the binding colors will not run in alcohol. Cloths and applicators should not be used between mold spots since this may spread the mold spores. The disposal bag should be removed from the Library whenever the cleaning operation is terminated for more than 15 or 20 minutes (the time it would take the alcohol to evaporate, allowing the mold spores to spread).

Localized cleaning of text blocks or special bindings will require that the

22 The most significant feature is that the cloths should be non-abrasive. One suitable disposable product is Kimberly-Clark’s Kemwipes®. A good choice for general cleaning once the mold is removed is the ‘Dust Bunny’ cloth from Leap Frog Technologies, which has been previously discussed.

23 These applicators should be cotton, not a synthetic substitute, and should have wood, not plastic, handles. They are typically available from either local medical supply companies or from laboratory suppliers such as Baxter Scientific, 800-284-2298 (their product number A50002-1).

24 While ethyl alcohol is often recommended, the lower health risks (reduced toxicity via dermal and inhalation routes) associated with isopropyl alcohol make it an attractive alternative. The most significant factors for all but very rare or valuable books (which are best cleaned by conservators) is that the alcohol have a low water content (hence the recommendation that 90+% be used) and that it be pure. A suitable choice would be 99.5% HPLC grade such as item 27,649-0 from Aldrich Chemical, 800-558-9160. Keep in mind that alcohol is flammable and should be used with extreme caution. Likewise, even isopropyl alcohol should be used only with adequate ventilation.
mold be lightly brushed\(^{25}\) into the nozzle of a HEPA vacuum. The HEPA vacuum will collect the mold as it is brushed from the book. The vacuum nozzle or attachment should not be used to clean the book since it may abrade or damage either the friable paper or binding. The vacuum bag should be discarded at the end of every cleaning episode to ensure that spores do not migrate back into the collection area.

**Housekeeping Improvements**

It is essential that once this deep cleaning has been completed, Custodial Services implement a cleaning program that will “follow through” and make sure that future deep cleaning is not necessary. It would be a foolish waste of funds to implement deep cleaning and then allow the Library to once again become loaded with particulates and mold. An aggressive cleaning program needs to be designed, implemented, and periodically evaluated. It is not my goal to develop such a plan, although a few items are worthy of discussion:

- **vacuuming** — for those areas in the Law Library where there is carpet, using the correct vacuum, in the correct manner, at the correct frequency, is essential. As previously discussed, many vacuums can introduce a wide range of particulates, including mold, into the air. A recent *Consumer Report* study of vacuums found many vacuums unsuitable in the areas of cleaning effectiveness and control of dust emissions. In particular, it is important to emphasize that vacuums that bubble dusty air through a container of water (such as the Rainbow\(^{26}\)), or by filling wet/dry vacuums with water, sometimes with a fungicidal solution) show only a small drop in emissions and can create an aerosol. They should not be used. In contrast, the Nilfisk GS 90 had the best canister filtration, while the Kirby Generation 3 G3D and the Eureka The Boss Plus 2134AT both evidenced excellent filtration capability. The point is that any vacuum used should be evaluated for filtration, then deep cleaning and suction capabilities.

Custodial Services should immediately develop a lifecycle maintenance program for the carpeting in the Library. Such programs are strongly recommended by carpet manufacturers and are a routine part of professional cleaning programs. A program would likely incorporate mapping the key-traffic areas (many of which are common sense, such as entranceways and doorways, halls, traffic lanes created by placement of furnishings, etc.); installing walk-off mats to reduce soil and other debris tracked into the Library on shoes; selecting an appropriate maintenance schedule; and using appropriate vacuum cleaning methods. Given the use of the Law Library, most programs would likely recommend vacuuming key areas and hallways at least every two days and other areas at least weekly. For vacuuming to be effective, at least one manufacturer recommends “at least 2 to 3 passes should be made in low-traffic areas, and 8 or more passes should be made in high-traffic areas.” Key-area cleaning should be conducted at least every 6 weeks, probably using aerosoled concentrated detergent/solvent, although cleaners in absorbent particles has the advantage of introducing no water into the Library environment. The choice, however, should be made on the basis of cleaning needs, with the provision to provide adequate

\(^{25}\) Hake brushes are the most common choice for such cleaning. One source is University Products, 800-628-1912.
dehumidification. Overall cleaning may be appropriate every two years, but typical systems can introduce large quantities of moisture into the building and this process should be undertaken only when the moisture can be adequately removed.

- **hard floor areas** -- the remainder of the Library's tile floors also need a program of routine damp mopping and machine polishing. Dust mopping should be minimized since it tends to spread, rather than collect, dust and mold. Damp mopping should be conducted on a daily basis. Machine polishing is not simply to make floors "look nice," but is intended to seal the tile, minimizing dusting.

- **routine dusting of collections** -- after the deep cleaning some provision should be made for continued inspection and as-needed cleaning of collections using a Dust Bunny™ or some similar product.

- **trash disposal** -- while not directly related to the current particulate and mold problem, the infrequent disposal of trash is a sanitation issue. Custodial staff must more frequently empty trash containers. The Library staff, for their part, must more aggressively prohibit the presence of food in the Library (including the eating of food by staff members).

**Other Recommendations**

In my brief walk through of the facility and discussions with the staff, I noted that the Library has a number of preservation needs and concerns. The new director, Ms. Ann Puckett, is very interested in upgrading a wide range of services and procedures. This is the perfect time to take an integrated, cohesive look at preservation within the Law Library. Consequently, I strongly recommend that the institution consider funding a detailed preservation assessment. Such a study would provide an overview of a range of issues, including the building (including such topics as the structure itself, protection from water damage, pest control, fire protection, security, and disaster planning), processing and technical services, shelving and storage, handling of collections by staff and patrons, storage and use of microforms, an evaluation of the rare book needs, and treatment alternatives (evaluating collections maintenance, minor repair, library binding, and reformatting procedures).

This evaluation can serve as the basis for developing a long-range conservation plan, organizing and prioritizing the various preservation/conservation needs. The study can also be used to justify additional storage space, staffing, and preservation funding needs. It is possible that the study could be partially funded through SOLINET in a manner similar to this current evaluation.

Until such time as a detailed preservation assessment is conducted, I would recommend that the Library seriously re-evaluate several issues:

- **Access** to the collections should be limited to those areas under direct and constant staff supervision. This means that all doors to the facility should be locked, except for the public entrance at the circulation desk. Fire exits can be easily converted to panic alarm bars to allow egress under fire conditions, with the door opening causing a loud alarm signal. While the "open door" policy currently used at the institution has a rich history or tradition, there is evidence that books cannot be adequately accounted for.

- **All food and drink should be prohibited in the Library.** If a compromise must be
Figure 19. Combustible materials in the stairways of the Law Library's main building.

Figure 20. Book caught under and being damaged by compact shelving in the Law Library's main building.
made, it should be limited to drinks in spill proof containers and this should be rigidly enforced by the Library staff. In particular, it is essential that the staff refrain from eating food in the Library - - a practice I observed during my brief survey.

- The Library should immediately remove all of the combustible materials (Figure 19) from the stairways. This is a serious fire hazard and is potentially in violation of the local fire jurisdiction.

- All of the staff, including work-study students or part-time workers, should be provided with a short course in preservation, focusing on the care and handling of collections (Figure 20). While there are some useful videotapes, the Library may find it more friendly, and useful, to sponsor an on-site course over the course of a day. This personal touch frequently provides better results and is more entertaining.

- The Library should begin to develop a disaster plan. There are three alternative approaches: develop the plan in-house, retain a out-side consultant, or use a pre-prepared plan. The first approach tends to become bogged down, especially if the staff has too little time. The second approach is very effective, but is of course the most expensive. The third is the least costly, but typically provides the least protection, simply because little thought is given. If the Library is able to do nothing more than develop an interim plan, I strongly recommend even this approach. One such plan which would be useful is *Steal This Handbook! A Template for Creating a Museum’s Emergency Preparedness Plan*, by Allyn Lord, Carolyn Reno, and Marie Demeroukas. It is distributed by the Southeastern Registrars Association (c/o Michele Baker, South Carolina State Museum, PO Box 100107, Columbia, SC 29202).
ATTACHMENT 1.
CHICORA FOUNDATION QUALIFICATIONS STATEMENT
AND VITAE FOR AUTHOR
Chicora's Philosophy

Chicora Foundation is a public, non-profit organization with a decade of experience working to save our fragile cultural heritage. In an era of shrinking budgets and rising costs, we are well aware that you must maximize the benefits of limited preservation and conservation funding. We work with your team to provide practical, cost-effective solutions for your complex problems.

We will work with you to develop the training, the skills, the programs that your institution needs. And we will do it for much less than you might imagine.

Areas of Expertise

Care and Handling of Collections

The longevity of a collection is related to how it is stored, handled, and treated in the curatorial facility.

Chicora Foundation can develop in-house training programs or workshops to help curators, registrars, archivists, librarians, and other professionals sharpen their skills in collection maintenance. Such sessions discuss different types of objects, the care each should receive, and the types of simple, in-house treatments, such as cleaning, that can be safely performed. In situations where more elaborate treatments are needed, Chicora personnel will provide information on how to select a conservator, what types of questions should be asked, and what to expect.

Preservation Assessments

Perhaps the greatest problem facing many institutions is the uncertainty of just where to begin their preservation efforts, or how to convince others that preservation is an important issue. Chicora will provide a detailed preservation assessment of your institution, examining all of the factors which affect the long-term preservation of collections. Such assessments, typically conducted during a one to two day site visit, include an evaluation of the structure and its impact on preservation, temperature and humidity controls, ventilation and filtration factors, prevention of water damage to collections, security, fire safety, pest control practices and housekeeping, and disaster planning. Chicora will also examine collections handling and storage practices, patron use of the collections (in libraries and archives), the effect of exhibition practices on preservation, and strategies for preservation.

These assessment reports generally range from 50 to 80 pages, and provide a foundation for future preservation funding and internal organization.
Planning for Preservation

Many preservation problems need not exist, if the museum, library, or archive is properly planned with preservation in mind.

Chicora Foundation can assist your institution develop building programs and work with architects to maximize the preservation potential of your new facility or remodeling efforts. We can also work with your physical plant to integrate preservation issues into every day maintenance. Works on this topic cover such diverse issues as designing for preservation, roof types, waterproofing basements, and selecting appropriate paints, flooring, and interior finishes.

Chicora Foundation has worked with the South Carolina State Library to publish a primer for public libraries entitled, *Preservation Concerns in Construction and Remodeling of Libraries: Planning for Preservation.*

Integrated Pest Management

One of the problems facing institutions is the control of pests in collections. Traditional methods have emphasized the use of toxic chemicals -- frequently an expensive and potentially hazardous approach.

Chicora will provide assistance in the identification of potential pest problems (including insects, rodents, and birds) and least toxic solutions. If chemical pesticides are necessary, Chicora will help institutions to identify those suitable and will help establish contracts for pest control treatments.

Although we do not provide chemical treatments, two of our personnel are licensed by the State of South Carolina as commercial applicators in the areas of structural pests and fumigation. This expertise ensures that you receive the most current, up-to-date information possible. It also helps us better communicate with commercial pest control firms which may be providing you with service.

Heating, Ventilation, Air Conditioning

The effects of temperature, humidity, and pollutants on collections can be devastating. Environmental controls are the first line of defense against collection damage. Effective controls can help ensure the longevity of the collections, reduce pest populations, and reduce housekeeping.

Chicora is able to provide institutions with assessments of existing environmental control problems and suggestions on alternative solutions. We can assist museums, libraries, and archives select appropriate monitoring equipment, closely matching needs, budgets, and staffing. We can assist in the development of monitoring strategies and the interpretation of results. When more technical, specialized expertise is required (for example HVAC engineers or industrial hygienists) Chicora Foundation works with individuals sensitive to the particular needs and requirements of the preservation community.

Chicora Foundation, Inc.
P.O. Box 8664
Columbia, SC 29202-8664

*PRESERVING THE PAST FOR THE FUTURE*
Fire Safety
Chicora Foundation is keenly aware that the single greatest threat to museums, libraries, and archives is fire. Able to destroy an entire collection, there is no way to restore collections reduced to ash. We are able to develop and implement steps which make your facility safer from the threat of fire. We will work with your team to develop an awareness of the fire threat and to provide training on the proper response to a fire situation.

The Director of Chicora Foundation, Dr. Michael Trinkley, has authored *A Fire Safety Primer for Libraries, Archives and Museums*, published by SOLINET in 1993. Chicora has also provided hands-on workshops training museum and library professionals on how to use portable fire extinguishers.

Preserving Your Family Memories
One of Chicora's programs for "friends' groups" helps the public understand preservation issues and concerns. In this three to four hour workshop, basic preservation issues such as controlling the environment; care and handling of papers, books and photographs; simple repairs; how to select a conservator; and what to do when disaster strikes, are explained in a simple and straight-forward way. Voted one of the best public programs ever attended by over 96% of all attendees, this course is designed to help museums, libraries, and archives promote preservation concerns among local audiences. Like our professional programs, it consists almost entirely of "hands-on" examples.

Chicora's staff have prepared a booklet for the public entitled, *Preserving Your Family Treasures*, which provides simple, straight-forward preservation advice.

Disaster Planning
Disaster planning doesn't have to be an impossible chore, and your institution can be prepared for everything from leaking pipes to a major hurricane. Chicora Foundation can assist your team develop a comprehensive, working disaster plan in a matter of weeks. And, more than that, we can help you establish recovery procedures, training sessions, and periodic updates of essential information.

For institutions with a written disaster plan, Chicora can review procedures, find weak points, and help with staff training. Like other Chicora services, our disaster planning is individualized, with on-site and off-site consultation and training.

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**Chicora Foundation, Inc.**
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*Preserving the Past for the Future*
Chicora Foundation has worked with Southeastern museums, libraries and archives in a variety of fields, including:

- individual consultations,
- development of specific, individualized preservation plans, and
- workshops and seminars.

We have worked in such South Carolina organizations as the South Carolina State Museum, The Charleston Museum, Historic Camden, The Hartsville Museum, Historic Beaufort Foundation, The Environmental and Historical Museum of Hilton Head Island, The College of Charleston Library, South Carolina State College Library, Clemson University, and the Horry County Museum.

On a regional level we work with the Southeastern Library Network (SOLINET) on preservation issues, offering workshops such as pest management and environmental controls in Atlanta, Gainesville, Tallahassee, Charlotte, Columbia, and Nashville. We have worked with other organizations such as the Atlanta Historical Society, Georgia Society of Archivists, PCUS at Montreat, North Carolina, and the National Oceanic and Atmospheric Administration Libraries. We have consulted with numerous institutions in Connecticut, Virginia, Michigan, Florida, and North Carolina.

Chicora was also consulted by Yarmouk University, Irbid, Jordan, on the design of a major conservation facility. We have worked with a Caribbean group to develop a similar conservation facility.

Chicora Foundation maintains approximately 1000 square feet of office and laboratory space, with additional dedicated conservation laboratory space.

We have the equipment on-hand for workshops in the area of integrated pest management, fire safety, environmental conservation, and collections handling. Specialized equipment (exclusive of conservation materials) includes digital hygrometers, recording hygrothermograph, moisture meter, UV light monitor, and digital lux light meter.

The Foundation also maintains an extensive collection of conservation and preservation publications, including extensive vertical files and product literature.

Chicora is registered as a consultant with the Caribbean Development Bank, Inter-American Development Bank, The World Bank (DACON Registration C-765), and the United Nations Development Program (Registration Number 05914).

Michael Trinkley has a South Carolina Commercial Pesticide License (Number C0006338) in the fields of structural pest control and fumigation. Debi Hacker has a South Carolina Commercial Pesticide License (Number C0006311) in the fields of structural pest control and fumigation.

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PRESEVING THE PAST FOR THE FUTURE
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Degrees:
B.A. 1974 University of South Carolina, Columbia. Anthropology
M.A. 1976 University of North Carolina, Chapel Hill. Anthropology
Ph.D. 1980 University of North Carolina, Chapel Hill. Anthropology

Positions Held:
Chicora Foundation, Inc., 1983-present. Director; Chairman, Board of Directors.
University of South Carolina, Fort Jackson Campus, 1980-1986. Instructor in Undergraduate Program.
University of South Carolina, CCI Campus, 1980. Instructor of Anthropology in Undergraduate Program.

Registrations:
Inter-American Development Bank (Banco Interamericano de Desarrollo/Banco Interamerican de Desenvolvimento); United Nations Development Program (Registration Number 05914); The World Bank (DACON Registration Number C-765); Caribbean Development Bank; SC Commercial Pest Control Licence in Structural Pests and Fumigation (C0006368).

Reviewer:
National Endowment for the Humanities
Institute of Museum Services
National Park Service, Historic Preservation Fund Grants to Indian Tribes and Alaska Natives

Professional Organizations:
American Association of Museums; Southeastern Museums Conference; American Institute for Conservation of Historic and Artistic Works (Associate); National Trust for Historic Preservation; South Carolina Historical Society; American Society for State and Local History; South Carolina Federation of Museums; Palmetto Archives, Libraries, and Museums Council on Preservation; South Carolina Pest Control Association.

Conservation/Preservation Experience:
1994 Participant, Pest, Insect, and Fungus Management: Non-Toxic Fumigation and Alternative
Control Techniques for Preserving Cultural/Historic Properties and Collections 2-day conference, Boston, Massachusetts.

1994 Presenter, Hurricane Disaster Planning: Making Sure Your Institution Survives the Big One Workshop, SOLINET, Maitland, Florida.


1994 Presenter, Hurricane Disaster Planning: Making Sure Your Institution Survives the Big One Workshop, SOLINET, Greenville, North Carolina.

1994 Presenter, Hurricane Disaster Planning: Making Sure Your Institution Survives the Big One Workshop, SOLINET, Jacksonville, Florida.

1994 Presenter, Hurricane Disaster Planning: Making Sure Your Institution Survives the Big One Workshop, SOLINET, New Orleans, Louisiana.

1993 Presenter, series of Preserving Collections in a Hostile Environment Workshops held throughout Florida, under auspices of SOLINET and a LSCA grant from the Florida State Library.


1992 Presenter, Preserving Collections in a Hostile Environment Workshop, SOLINET, Atlanta.


1990 Presenter, Integrated Pest Management Workshop, Atlanta, Southeastern Library Network.

1989 40 hour OSHA Training in Hazardous Material Control and Emergency Response (Instructor, Bill Broadwell, DIVEX, Inc.).


1988  Co-organizer and speaker, Chicora Foundation Museum Pest Control Seminar.


1987−present  Consultant for museums and archives on issues of environmental conservation, design, safety, hazardous materials management, and integrated pest control.

1987−present  Licensed commercial pesticide applicator in the fields of structural pests and fumigation (License No. C0006338).

1986  Co-organizer, Chicora Foundation and University of South Carolina Environmental Services, Archaeologists and Chemicals Seminar.


Professional/Public Presentations:


Preserving Your Family Heritage. Presentation at the Savannah Regional Heritage Fest, McCormick, South Carolina, 1993.


Practical Library Preservation. Class lecture, School of Information and Library Science, University of South Carolina, 1991.


Integrated Pest Management for Librarians. Class lecture, School of Information and Library Science,
University of South Carolina, 1990.


Publications:


1993 Hurricane! Surviving the Big One: A Primer for Libraries, Museums, and Archives. Joint publication of SOLINET and Chicora Foundation, Inc.


