GREEN buildings

Commonwealth of Pennsylvania

The Pennsylvania Green Building Operations and Maintenance Manual

Building GREEN in Pennsylvania

Mark Schweiker, *Governor*

Secretary's Letter

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF GENERAL SERVICES
HARRISBURG

KELLY POWELL LOGAN
SECRETARY

717-787-5996

Dear Partners in Conserving the Environment,

In an effort to green government, the Pennsylvania Department of General Services joined with Green Seal to develop this Pennsylvania Green Building Maintenance Manual. This manual was prepared with the expertise of General Services' employees for the maintenance of state government buildings and grounds.

As Co-Chair of the Governor's Green Government Council, I am proud that Pennsylvania is leading by example in keeping our buildings and grounds safe, secure and environmentally friendly. Pennsylvania is the first state in the nation to spearhead a project like this, to make government buildings healthier and more environmentally friendly for state employees and the public.

This manual is used as a tool for everyday operations in Commonwealth buildings. With the recommendations given for green landscaping, lighting maintenance, cleaning procedures and product selection, the Department of General Services is taking another step toward greening government.

Sincerely

Kelly Powell Logan
Secretary

ROOM 515 NORTH OFFICE BUILDING, HARRISBURG, PENNSYLVANIA 17125

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Pennsylvania Green Building Maintenance Manual

This manual for environmentally preferable operation and maintenance of government buildings and associated grounds is designed to help carry out the Commonwealth of Pennsylvania's Executive Order 1998-1 to "incorporate environmentally sustainable practices into [Executive Agencies'] ... operations." Operating and maintaining sustainable government buildings is a fundamental part of this directive, in that virtually all government workers and many citizens of the Commonwealth patronize these buildings throughout the year. Their health and the health of the Commonwealth's environment are directly affected by the practices, products, and services used in these buildings every day.

The impacts of the operation and maintenance of a building and associated grounds on the health of its occupants and the environment at large can be significant. A building and its grounds constitute a microcosm or miniature version of a city: it takes in materials, expels other materials as waste, and uses a lot of energy in lighting, heating, and air conditioning the space. In addition, each building has its own climate and atmosphere, often more polluted than the outside air. The flow of materials alone is significant, with tap water, paper products, lighting, carpet, paint, cleaning products, and many others coming in. Some of these, such as cleaning products, carpet, and paint, may have impacts on maintenance workers and building occupants while used. Others are disgorged to streams through sewage where they can harm aquatic life or escape to the atmosphere to exacerbate local air pollution, global warming, or ozone depletion.

This manual is intended to minimize such adverse impacts on health and the environment from the operation and maintenance of Commonwealth government buildings and grounds. If followed carefully, it should lessen the load of toxic or otherwise unhealthful substances both on maintenance workers and on building occupants. It will also enable maintenance workers to create a building microcosm that minimizes waste, uses more sustainable materials and systems, and uses energy in the most efficient way possible. Maintenance workers can feel proud that they are helping to achieve a safer and more sustainable world for all Commonwealth residents.

The existence of this guide does not imply that current procedures are inadequate or have created unsafe conditions for building occupants, cleaning personnel, or the environment. Rather, this document is intended to go beyond traditional methods to further reduce environmental impacts while at the same time maintaining or improving the healthfulness, comfort, and aesthetics of the Commonwealth's buildings.

This guide is designed for use by maintenance staff of the Commonwealth of Pennsylvania in support of established training programs and is not intended to replace or supersede existing or future Federal, Commonwealth, or local requirements regarding worker safety, environmental protection, or other matters.

The Commonwealth of Pennsylvania contracted with Green Seal, a non-profit organization, to develop this manual in conjunction with a Pennsylvania advisory committee and test it in several government buildings prior to completion. Green Seal was established in 1989 with the mission of improving the environment by identifying environmentally preferable products, services, and operations. Green Seal sets environmental standards for a range of categories of manufactured products and commercial services, and it works with various government agencies around the country to assist them in making their procurement, operations, and facilities management more environmentally sustainable.

A number of dedicated staff of the Commonwealth of Pennsylvania as well as experts in various fields contributed to make this manual possible. The following contributed to specific sections of the manual or provided significant information:

Stephen P. Ashkin
Catherine Coombs
Bob Croft
Donald Horn
Mark T. Petruzzi
Jack W. Ranney, Ph.D.
Karen L. Smith
My K.Ton
Arthur B. Weissman, Ph.D.

The Pennsylvania Advisory Committee provided overall guidance throughout the development of the manual and gave many worthwhile suggestions. Members of the Committee were:

Carol Bender
Marilyn Bygall
Tom Hale
Sam Marsico
Mike Penyak
Frank Szekeres

The field test of the draft manual would not have been possible without the cooperation and dedication of the following people:

Patrick Allen
Bob Campbell
Larry Crummel
Bud Curran
Kim Drawbaugh
Thomas Frisby
Mike Humphrey
Andy Preston
Carlos Ramos
Bob Spoljaric
Scott Sundy
Marc Waxman

Finally, special acknowledgment is made to Deputy Secretary for Property Management James Martin, Department of General Services, who championed the project from the beginning; and Marilyn Bygall, Department of General Services, Property Administration, who served as the Commonwealth's Project Officer and who single-handedly shepherded the project through its various stages within the government.

Lessons Learned from the Field Test

This manual represents a significant amount of research into building maintenance and ways to make the operation and maintenance of buildings more environmentally responsible. However, one of the key items that sets this manual apart is that it actually was tested in the "real world." Often, things that are technically possible on paper may not be actionable due to unforeseen "real world" circumstances. For this reason, a field test in three buildings was deemed an important validation of the draft manual. The three test buildings (the State Capitol and East Wing, the Finance Building, and the Labor & Industry Building) were located in Harrisburg and were all older buildings that were not originally constructed as "green" buildings. The three-month field test occurred during the winter, so some of the summer recommendations were not directly tested. The overall methodology was as follows:

- A draft version of the manual was written and used in a three-month field test in several buildings in Harrisburg (November 2001 to February 2002).
- Building managers, supervisors, and selected staff in the Department of General services were given copies of the draft manual to read and use.
- A "kick-off" meeting was held with the field test participants and Departmental Executives to outline the process and ensure a smooth start.
- Building managers were asked to complete a weekly "feedback form" and give their comments on specific sections of the draft manual as they read and used the procedures and recommendations. A sample of the feedback form is included at the end of this section.
- Participants in the field test met regularly via weekly teleconferences to discuss sections that had been used and identify both successes and concerns.
- Staff from Green Seal visited the test buildings monthly to observe green practices firsthand and investigate areas of concern.
- During the field test, where possible, the general recommendations for green practices were used in a "real world" setting.
- Existing DGS conventional and green practices were documented and generic recommendations were adjusted to harmonize with practices used by Pennsylvania DGS.
- Other assistance provided during the field test included review of products (current and potential alternatives) and research on specific topics/issues.
- Revisions as needed were made to the manual to be used by Commonwealth of Pennsylvania Department of General Services.

During the manual's development, a range of issues presented themselves that should prove useful to other agencies wishing to develop and use similar green building maintenance practices.

Historic building issues

The three test buildings in Harrisburg are all older buildings, with the Capitol and Finance buildings having the additional challenge of being historic buildings, where major modifications to the buildings themselves are not possible due to their historic nature. The presence of historic murals, floor tiles, paintings, furniture, wall coverings, elevator doors and other features, while preventing large-scale modifications and changes, actually make a very good case for green building maintenance and the use of products and procedures that are less harsh/damaging on materials, people, and the environment. In the Capitol, for example, there were limitations on installation of dispensing equipment for cleaning products due to the historic character of the building and lack of space, i.e., when originally constructed, the Capitol restrooms did not contain a housekeeping area with an installed dispensing system. Fortuitously, an unrelated plumbing repair in the basement of the Capitol allowed for a hookup for a single dispensing system to be installed in the Capitol basement. As staff continue to try to install systems on each floor or in each housekeeping area, the system in the basement represents a significant improvement over stocking ready-to-use products or individually packaged doses of cleaning products.

Physical constraints of the buildings

Similarly, any modifications to the three test buildings to date have largely been confined to repartitioning interior spaces due to the impracticality of making other, more fundamental modifications. The walls, windows, hallways, mechanical systems, restrooms, and office spaces have remained largely unchanged, with the occasional cosmetic renovation or remediation to remove hazardous materials (e.g., asbestos insulation or asbestos floor tiles). Within the office spaces, several changes have occurred over the years which led to using interior non-structural wall partitions to put more staff in the same size area. The interior partitions construction affected the HVAC airflow in many areas by cutting off paths, installing new ducting in and around existing ducting, and putting more body heat in an area than the ductwork is sized to handle. Other challenges included operable single pane windows that occupants could open at all times during the year, introducing unwanted outside air into the building, and a lack of centralized programmable thermostats, causing maintenance staff to visit and calibrate each one individually. Even the best green building maintenance practices are sometimes offset by the physical constraints of the buildings.

Equipment (age and type) constraints

In the three test buildings, building managers and staff have done an excellent job of keeping equipment running that is past its design life. For example, chillers installed in the 1940's are still in place, while the design life of a chiller is typically 30 years. From a budgeting standpoint, the building maintenance staff may be a victim of their own success - as long as they can keep the existing equipment functioning, there is little budget motivation to upgrade to newer, more efficient equipment. In addition to the inefficiencies of running outdated equipment, maintaining the equipment requires a tremendous amount of labor each year to manually clean, calibrate, inspect, and fix it.

Role of "pending" renovations in green maintenance

Another situation encountered concerns "pending renovations". Test buildings that were "on the list" for major renovations were at a disadvantage when looking for support for green initiatives that required any

investment. There is a reluctance to invest any significant dollars (or those without immediate payback) in buildings that are going to be substantially gutted and renovated in the near future. However, these same buildings have been "on the list" for several years, and the projected renovations may still be several years away. In the interim, any improvement made in the operation of these buildings is largely cosmetic, and these building managers and staff are left in limbo and cannot effectively make some changes that would result in more environmentally responsible maintenance.

Role of occupant behavior in green maintenance

Building managers and maintenance staff can only affect those items directly related to operations and maintenance activities. The building occupants in their offices are largely unregulated in their daily behavior. Food crumbs and wrappers left around, liquid spills, plants overwatered or placed on/in front of HVAC vents, boxes or files blocking HVAC registers, cleaning products brought into the office from home, and fans or space heaters brought in by occupants can have negative effects on the building environment. Some of these actions, such as food or liquid spills, if not addressed immediately by the occupants will only be addressed by the building staff later in the day as part of their scheduled maintenance activities. Food and liquid spills and overwatered plants can also contribute to longer-term effects such as mold and mildew growth under carpet and in the HVAC ducts, plant spores spreading around the offices, and unwanted insect populations. For employees under government jurisdiction, a brochure outlining the role of occupant behavior on green building maintenance and informing them of their obligations would be useful.

Multiple jurisdictions complicate maintenance

Tenants not under DGS jurisdiction in the buildings provided another challenge. There were several groups of building occupants (e.g., day care centers, snack bars, Treasury offices) who hire or run their own cleaning operations, perform potentially hazardous and unique operations such as photo development, or operate in a secure environment to which the building maintenance staff does not have easy access. This lack of access and outside groups operating in the building made it extremely difficult over the three months of the field test to obtain basic information on what products were being used in these areas to clean and maintain them. In some cases it took repeated requests over the entire three-month period before the information was obtained.

While individual offices within a building may have unique maintenance staff or requirements, in the Capitol, both the House and Senate have their own custodial staffs, and the Judiciary has a private cleaning contractor. Defining what areas the DGS staff maintain and what areas these other staffs handle requires constant attention. Sharing storage space for cleaning products and equipment means that DGS may have questions about what products not used by DGS are stored there, the location of Material Safety Data Sheets for those products, or the products in unlabeled spray bottles. In many cases it is like sharing an apartment with a roommate that you don't know and hardly see. DGS staff generally "pick up the slack" on any tasks not done by the other staffs in order to keep the overall building looking presentable for the government representatives and many visitors to the Capitol, including incidents (e.g., spills that occur when the other cleaning staff are not working) not part of day-to-day maintenance. Having a formal mechanism to include these other custodial staff in the Commonwealth's green maintenance program would be ideal, but will involve many different contacts, some of which are not part of any Commonwealth government agency.

Role of procurement as a supporting organization in green maintenance

Adjusting procedures to be more environmentally responsible is an important component of green maintenance, but just as important are the products used. During the field test it was revealed that some products are purchased directly through DGS, which stocks or has a contract for certain items, and others are purchased from the Pennsylvania state contract for that item. Having the support of the Procurement and Quality Assurance staff in this program made obtaining alternative, more environmentally responsible products easier. In one particular case, a cleaning products contract was reopened to allow other vendors selling packets of cleaning concentrate to be added. The packets were necessary since the Capitol at that time was not able to use dispensing systems and instead used premeasured packets of cleaning product concentrates that were added to buckets of water. While this did take some time, the long-term benefit is worthwhile. All of the staff involved in the field test, as well as many other staff encountered during the field test were very aware of Pennsylvania's efforts to "buy green" and had sought out greener products (paint, carpet, cleaners, HVAC maintenance chemicals) in their day-to-day operations.

Importance of support from Departmental Executives

Having senior-level support for this program, which from the start was envisioned to involve changes in products and procedures, was crucial. Prior to launching the field test, Deputy Secretary for Property Management James Martin prepared two letters, one to Commonwealth employees and one to Commonwealth maintenance workers, outlining the program and enlisting their support during the field test. The letter outlined the program, explained the goals, and gave a contact for questions. Copies of the letters are included at the end of this section. As a result, there were very few complaints during the three-month field test. There is also a high likelihood that the recommendations contained within the manual will be incorporated in the official practices of the Commonwealth of Pennsylvania.

Role of the Advisory Panel

Throughout the project and field test, the Advisory Panel had regular meetings, conference calls, building walk-throughs, email discussions, and input into the process. The knowledge and experience of Commonwealth participants helped to ensure that the manual is a realistic document for Pennsylvania. In addition, national experts brought their expertise and visibility to the development effort. As a result, the manual is not just a state or regional guide, but a document that can be used in private companies, educational entities, and local, state, and Federal agencies.

Ongoing fine-tuning

The reopening of the cleaning products contract was only recently completed, so some of the alternative products will be tested after the manual is issued. A new liquid magnesium chloride deicer was tested twice but the maintenance staff was not happy with the results, so the search for alternative, more environmentally responsible deicing products continues. Responsibility for roof maintenance was solidified during the field test. Currently DGS staff have examined the existing roof maintenance procedures, which mostly involve reacting to roof problems, and are working toward formalizing the procedures to be in line with the manual recommendations, such as regular inspections, periodic

inspections by outside roofing professionals, and trying to be proactive with respect to roof maintenance and repair.

Another finding that is certainly widespread is that large amounts of cleaning chemicals were "inherited" by current building managers (e.g., 28 different cleaning products were found in the cabinets in the Capitol). These products are not necessarily being actively used but the staff must maintain records and Material Safety Data Sheets for these products. The Advisory Panel suggested using up these products where possible, offering them to other buildings/agencies which could use them, or disposing of them properly. Doing so would remove these chemicals from the building storage areas and allow for easier implementation of the green cleaning recommendations in the manual. It was decided that using up the non-green products where possible, while not entirely preferable, is a more cost-effective solution than paying for hazardous waste disposal. Despite the months of effort and a three month field test, dealing with current inventory and long-standing practices is a key part of implementing a green building maintenance program.

Letter from Deputy Secretary Martin to Building Occupants

TO: Commonwealth Employees in Capitol/East Wing Building, Finance Building, and Labor and Industry Building

FROM: James W. Martin
Deputy Secretary for Property Management

The Commonwealth of Pennsylvania is taking a leadership role in adopting and demonstrating practices that promote a healthier and cleaner environment. One key area in which we are doing this is the maintenance of our government buildings. As the employees who work every day in these three buildings, you have the opportunity to be part of this groundbreaking work through a pilot program we are about to initiate in these buildings.

The Department of General Services is working with Green Seal - a highly respected, national, non-profit organization that promotes environmentally responsible products, services, and practices - to develop a "green" building maintenance manual for use in all Commonwealth properties. The draft manual, which has been reviewed and approved by a DGS advisory group, is now going to be tested in practice over the next three months. Maintenance workers will be following the practices, procedures, and product recommendations outlined in the manual so that we can determine how it works on the ground and what final revisions may need to be made.

I do not expect the recommended changes in maintenance practices or products used to cause you any inconvenience, and, in fact, I would expect there to be benefits overall in the healthier environment we hope to foster in our buildings. If you have any questions or problems as the pilot proceeds, please feel free to contact Marilyn Bygall at 783-1162.

You may be interested to know that this pilot and the resulting completed manual will be watched carefully and replicated by the rest of the country. Green Seal has received inquiries about this project from such other states as California and New Jersey. There is great interest nationally in making the buildings in which we work and live healthier and better for the environment, and this project is designed to help achieve this goal.

I thank you in advance for your cooperation in being a part of this very worthwhile project!

Letter from Deputy Secretary Martin to Building Maintenance Workers

TO: Commonwealth Maintenance Workers in Capitol/East Wing Building, Finance Building, and Labor and Industry Building

FROM: James W. Martin
Deputy Secretary for Property Management

The Commonwealth of Pennsylvania is taking a leadership role in adopting and demonstrating practices that promote a healthier and cleaner environment. One key area in which we are doing this is the maintenance of our government buildings. As the workers responsible for maintenance in these three buildings, you have the opportunity to participate in this groundbreaking work through a pilot program we are about to initiate in these buildings.

The Department of General Services is working with Green Seal - a highly respected, national, non-profit organization that promotes environmentally responsible products, services, and practices - to develop a "green" building maintenance manual for use in all Commonwealth properties. The draft manual, which has been reviewed and approved by a DGS advisory group, is now going to be tested in practice over the next three months. Under the direction of your supervisors, you will be following the practices, procedures, and product recommendations outlined in the manual so that we can determine how it works on the ground and what final revisions may need to be made.

I do not expect this pilot to add any significant amount of work to your existing load. The changes that may be required should not be onerous, and they may result in a number of benefits to you and the occupants of the buildings for whom you do your work. There will be some minimal record keeping we will ask of you or your supervisors, such as completing simple checklists, that Green Seal will need in order to evaluate the progress of the pilot.

I want to assure you that this pilot and the resulting completed manual will be watched carefully and replicated by the rest of the country. Green Seal has received inquiries about this project from our colleagues in such other states as California and New Jersey. There is great interest nationally in making the buildings in which we work and live healthier and better for the environment, and this project is designed to help achieve this goal.

I thank you in advance for your cooperation in participating willingly and conscientiously in this very worthwhile project!

Pennsylvania Green Building Maintenance Manual Field Test Feedback Form

To be completed weekly by building managers (and by others as needed).

Name _____ Building _____

Manual Chapter

____ Green Landscaping of Buildings

____ Snow Removal and De-icing

____ Roofing Maintenance

____ Parking Garage Maintenance

____ HVAC Maintenance

____ Lighting Maintenance

____ Cleaning Procedures

____ Cleaning Product Selection

Specific procedures/sections that were completed successfully.

_____

_____

_____

_____

Specific procedures/sections that were difficult to complete.

_____

_____

_____

_____

Recommendations for improvements or additions to specific procedures/sections.

_____

_____

_____

_____

Did you have any problems identifying products or with product performance?

_____

_____

_____

_____

General comments on procedures or product recommendations.

_____

_____

_____

_____

Please fax completed Feedback Forms to Green Seal at 202-872-4324

Green Landscaping of Buildings

	Overview
A	Native Species
B	Potential Pollutants
C	Landscape Layouts and Viewing
D	Planting
E	Maintenance

Overview

Green landscaping generally uses native plant materials to help wildlife, improve local character, and reduce maintenance efforts. More specifically, it focuses on reducing herbicides, pesticides, fertilizers, and watering to help the environment while reducing maintenance costs. Guidelines are based on years of field trials and practical applications. Some of these are unfamiliar to the nursery industry, landscapers, and grounds maintenance industry. Guidelines are grouped into (a) native species, (b) potential pollutants, (c) landscape layouts and viewing, (d) planting, and (e) maintenance. Summarized action items in each category are followed by more detailed explanations. At the end of each grouping is selected contact information.

A. Native Species

Action Items:

1. **Write down site conditions in terms of dryness, slope, shadiness, soil texture (clay, loam, or sand), estimated soil depth, and direction of exposure**
2. **Develop a list of native plants suitable for the written down site conditions and list which species naturally occur together as groups for your site(s) and plant according to these groupings.**
3. **Get a list and pictures (make flash cards) of the 10 to 12 most important pest plants for your area.**
4. **Learn what methods are best for detecting and controlling exotic pest problems and write them down (on the back of the flash cards).**
5. **In landscaping, work toward developing lots of summer shade, barriers to wind, and a layer of leaves or mulch. This helps the right native species grow and helps keeps weeds to a minimum.**
6. **For lowest maintenance, use native plants that tend to form into dense clumps or do well on heavily disturbed soils**

Native plants are desirable because they can offer habitat and food that native wildlife can use. It is common to encounter the need for using non-invasive exotic plants due to costs, limited availability of native materials, and vivid colors of some non-native materials. Many non-native plants also do well on a wide range of site conditions.

Native species would include Acer rubrum (red maple), Liriodendron tulipifera (yellow or tulip poplar), Cercis canadensis (eastern redbud), Tilia americana (basswood), Fagus grandifolia (American beech), Cornus florida (flowering dogwood), species of Rhus (staghorn sumac), and Buchloe dactyloides (buffalo grass) (Daniels1995, Druse 1994).

Some areas of the country are now publicizing lists of native species appropriate for landscaping. They may even list common exotic plant materials and offer native substitutes to achieve more environmental benefit. *Gather a list of these native plants suitable for your area.* You will find it a very handy reference over time.

Nurseries are still learning which native species transplant successfully. Eastern red cedar *(Juniperus virginiana)*, for example, is realizing only a 60% to 80% transplanting success, which is not yet good enough. Smaller sized trees transplant best. Dogwood and sourwood have similar concerns in low maintenance circumstances. In response to slightly higher loss of plant materials, plant larger numbers of smaller materials. Losses level out after 3 to 5 years while interim denser plantings create more shade to limit weed growth. Species may include staghorn and shining sumac, maples, elms, oaks, persimmons, hickories, horse chestnut, etc. Local native species lists are helpful. Nuts or seeds from species such as American beech and basswood may be planted to keep plant material costs low. If this is done, be sure to develop flash cards to help identify these as "seedlings to keep" as opposed to "weeds to pull."

1. Describing site conditions is helpful when seeking assistance in identifying appropriate native and non-native species to plant. These conditions include slope, direction of expose, amount of moisture, shadiness, general type of soil (clay, loam, or sandy), and an idea of how deep the soil is. Other factors include nutrition status and acidity. This can be determined using kits available from some garden stores or by sending soil samples to the Pennsylvania Cooperative Extension Service, Penn State University (see contact information below). Usually a minimum of 7 to 8 samples is required using sampling procedures described by the Extension Service. The information gained is quite valuable for minimizing chemical applications and costs.

2. Developing lists of three or four groups of plants that naturally occur together helps grounds maintenance personnel understand what plants should occur together in landscapes. These lists will vary with site conditions. That is why the description of the site conditions is the first step. The best sources for these lists of plant groupings is from university ecology, botany, and forestry departments such as Penn State University, Cornell University, Rutgers University, and Syracuse University. Private and university associated botanical gardens are arboretums are also good sources (e.g., Morris Arboretum, University of Pennsylvania).

Most exotic or non-native species are not invasive and do not pose a problem for the natural environment. Non-native INVASIVE plants are to be rigorously avoided or eliminated. Examples are Ailanthus altissima (tree-of-heaven), Paulownia tomentosa (royal paulownia or princess tree), Berberis thunbergii

(Japanese barberry), Miscanthus (Japanese silvergrass), and selected species of Ligustrum (Japanese privet) (USDA Forest Service 1997).

3. Weatherproof flashcards. Knowing exotic invasive plants and controlling them properly are two of the most crucial elements of green landscaping. They affect ecological issues (crowd out native plants in natural areas), chemical applications, and, of course, maintenance costs. Weatherproof flashcards of perhaps the worst 10 or 12 offending pest plants works extremely well in helping groundskeepers learn these species. Use the contact information below to secure internet pictures and information necessary to develop your own flashcards for your area.

4. Learn what is needed to control weeds. Staying ahead of invasive species problems is absolutely crucial! An ounce of grounds keeping prevention is worth a pound of catching up once invasive species have become a problem. This is covered under management guidelines. Recognizing the early onset of an exotic invasive plant problem is a vital step. Treatment of pest plants varies with the particular pest plant, its stage of development, and the environment in which it occurs. It is an excellent idea to *identify pest plant control methods on the backside of the plant identification flash cards*.

5. Work toward establishing shady, mulched landscapes. A shady, moist, wind-protected environment with a layer of leaves is the fastest disappearing important environmental condition besides wetlands. It is also the condition that harbors the most diverse and unusual native species besides wetlands. These include plants, lichens, mosses, reptiles, amphibians, birds, insects, soil organisms. Grounds keeping approaches may not be able to restore federally- and state-listed threatened, endangered, and sensitive species but conditions can certainly be improved to help them.

6. Encourage plant combinations that form dense clumps. Shady conditions lead to low maintenance including less fertilizing, watering, weeding, and other tending. Given low maintenance objectives, the hardiest of plant materials are mandatory. This is especially true on disturbed soils. It is more important to get plant materials to survive and be healthy with abundant leaves than it is to have more attractive materials that are struggling to survive, wind up looking bad, and may need to be replaced. This situation may also require more weed control.

Preparation of soil for planting on many sites is an important factor. Soil cultivation, subsoiling, removal of pest plants, improvement of soil texture and nutrition by working in mulches and fertilizers, and use of surface mulches will help plant survival and vigor. This means much less maintenance later and a much more attractive landscape.

Contact Information

Morris Arboretum, University of Pennsylvania, 215-247-5777, www.upenn.edu/morris/

Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Natural Diversity Inventory, (717) 787-3444 (Bureau of Forestry),
http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm

Natural Resource Conservation Service, Plant Materials Program,
http://plant-materials.nrcs.usda.gov/
Cape May Plant Materials Center, NJ (for southeastern PA),
http://plant-materials.nrcs.usda.gov/njpmc/index.html

Big Flats Plant Materials Center, NY (for central and northern PA),
http://plant-materials.nrcs.usda.gov/nypmc/index.html
Alderson Plant Materials Center, WV (for southwestern PA),
http://plant-materials.nrcs.usda.gov/wvpmc/index.html
Pennsylvania Cooperative Extension Service, Penn State University,
http://www.extension.psu.edu/base_nr&em.htm or
http://www.aasl.psu.edu/ for soil sample analysis and guidance
USDA Federal Noxious Weed List (for agriculture),
http://plants.usda.gov/cgi_bin/topics.cgi?earl=noxious.cgi
Mid-Atlantic Exotic Pest Plant Council,
http://www.exoticpestplantcouncil.org/states/midatlantic.cfm
The Nature Conservancy, Wildland Invasive Weed Program,
www.tncweeds.ucdavis.edu/
and also the listserver tncweeds.ucdavis.edu/listarch/arch074.html
Plant Conservation Alliance, **www.nps.gov/plants/**
The USDA-APHIS (Animal and Plant Health Inspection Service), www.aphis.usda.gov/
National Biological Information Infrastructure, **http://www.invasivespecies.gov**

B. Potential Pollutants

Action Items

1. **Never apply more than 250 lbs/ac N active ingredient at one time**
2. **Never apply N fertilizer more than 3 times a year**

Note: Commonwealth procedures include taking soil samples every two years. Samples are sent to Pennsylvania State University for analysis. From this analysis, the proper amount of nutrients is determined and can then be applied.

3. **Target fertilizers around the rooting zone or base of specific plants as much as possible**
4. **Monitor pests and weeds every two weeks through growing season using flash cards for identification and necessary action.**
5. **Always follow herbicide and pesticide labels**
6. **Exceed state erosion and sedimentation control measures during construction as defined in state sediment control guidelines.**

1. Limit nitrogen fertilizer applications. If more fertilizer than about 250 to 300 lbs/ac N active ingredient is applied, that excess amount is unused by plants and seeps into the environment as a pollutant. Nitrogen fertilizers are extremely important to plant growth, but the plant can only take so much and excess seeps away quickly since it dissolves easily in water. This means more nitrogen fertilizer is generally needed than other fertilizers. It is the most expensive macronutrient and the most polluting to manufacture. Minimizing its use is important for the environment. When applying any

nitrogen fertilizer source, it should be coated with a time-release substance such as SCU (sulfur coated urea) or some other industry approved substance. This will insure that the plant will have an adequate source of nitrogen over a longer period of time. This will also diminish nitrogen waste due to irrigation or natural rainfall. Added nitrogen may not be detectable in the soil after 3 months during the growing season.

2. Never apply nitrogen fertilizer more than 3 times a year. Several light applications of nitrogen fertilizer are best (about 200 pounds per acre active ingredient) at 8 to 10 week intervals are recommended. In native species plantings this may not be necessary unless soils are extremely poor. This equates to about a handful of commercial fertilizer spread around the base of each small tree.

3. Spread nitrogen fertilizer where it is needed by plants rather than broadcast fertilizing a whole area (say, large mulched areas). Fertilizing where plants are not growing just enhances weed production. Do not apply nitrogen fertilizer during the dormant season except in early spring just weeks before spring foliage growth begins. Use of native plants and mulches nearly eliminates the need for fertilizer use after the first year of landscape establishment.

4. Monitor for pests about every 2 weeks. Staying ahead of weed problems and anticipating them is extremely important in minimizing chemical use, labor, and cost of maintenance. Grounds should be checked at least every two weeks through the growing season to assess weed and pest conditions. Knowing what to control and when is important. Some pests can be tolerated without action. Others, especially weeds, should be controlled at an early vulnerable stage.

5. Follow herbicide and pesticide labels. Work with county agricultural extension people familiar with integrated pest management to determine appropriate control efforts and write them down on the back-side of pest identification flash cards. Frequent spot control of weeds and pests is much better than catching up with those out of control. Expenses are higher, chemical use or labor use is higher, landscape materials suffer more, and aesthetics are worse when weeds and pests get out of control. This information is readily available from contact information below.

Chemicals are an important element in grounds maintenance. They should be employed in the context of an integrated pest management (IPM) plan that employs other methods of pest control or nutrient balance including biological, mechanical, and ecological grounds management options. Use of native species can nearly eliminate the need for fertilizers although first-year establishment and enrichment of disturbed soils may be necessary early on.

The most common problems in herbicide and pesticide use are with not following their labels on recommended use. Concentrations that are too low let the pest problem expand to cause damage to landscape materials and require a second application. If weeds get too far ahead, it is often difficult to spray weeds without spraying landscape materials in the process. If too much chemical is used, unintended damage often occurs to landscape materials and expensive chemicals are wasted. These are not only big expenses; they are bad for the environment.

The second most common problem is improper application of chemicals. This involves precautions for human health such as not using gloves, respiration masks, or wearing short pants and short-sleeved shirts during application. This also involves application of chemicals under improper environmental conditions

such as windy or rainy days which wastes chemicals, affects non-target plants, and offers risk to human health.

Make sure herbicides are used during their most effective time(s) of year. This will vary by herbicide and the weeds needing control. *It is extremely handy to develop a list of weeds in your area, the herbicides that best control them, and the month(s) for most effective results.* This can help significantly reduce chemical applications and costs.

Grounds keepers take time to match chemicals with the problem. However, it is tempting to use chemicals that are on hand for use on pests not well targeted by them. This can result in a variety of problems already mentioned above.

As farmers have learned, the use of chemicals greatly simplifies the successful establishment of a new crop over large areas. Herbicides such as glysophate can be selected which deteriorate rapidly to pose only a very short-term environmental threat. Making this trade-off with long-term effects of successfully establishing native habitat that should indefinitely require minimum chemical applications (compared to turfgrass) is a value judgment that needs to be based on the local situation and condition. Organic methods of meadow establishment are much more labor intensive and of limited success because most native grasses take two to three years to become fully established. In the meantime, weeds are a constant problem. However, if chemicals are to be minimized or avoided, soil tilling in August, again in September, and again in spring (just before native seed sowing) is effective in controlling weeds for the first couple months of the first growing season. Hand weed control may be possible for small areas. Another alternative is to plant plugs or clumps of native grasses after spring cultivation. This can be quite effective for smaller areas but is expensive for acreage expanses.

The astute grounds manager and his staff will be well trained in chemical use and application, and properly licensed by the Pennsylvania Department of Agriculture, or the appropriate licensing agency. The cost of training will quickly be made up in savings in chemical and maintenance costs as well as quality of grounds aesthetics and worker safety. Follow labels for chemical use, it is important.

6. Exceed state erosion and sedimentation control measures during construction. Sediments and turbidity (murky water) destroy desired biodiversity in streams and rivers of all sizes. This is a major national environmental problem that has significant costs associated with it. Look for murky storm water runoff and find the source to correct the problem. State sediment and erosion control measures were developed with 2 to 5 year frequency storms in mind (several inches of rain over a 24 hour period) and should keep over 90% of disturbed site sediments from reaching a permanent stream. These measures work well if they are maintained, installed properly, sites are quickly stabilized, and more severe storms are not experienced. Grounds keeping needs to know what these state guidelines and regulations are and inspect their grounds for compliance. Most states have free, concise handbooks on this topic with very specific guidelines. In Pennsylvania this is the Department of Environmental Protection.

Contact Information:

http://www.aasl.psu.edu/ for soil sample analysis and guidance on nutrition
http://www.pested.psu.edu/infocenter/ for pest management guidance
http://www.pested.psu.edu/pested.asp for pesticide guidance

http://www.dep.state.pa.us/dep/deputate/watermgt/Wc/FactSheets.htm#Ero-SedCtrl for sediment and water pollution control guidelines for Pennsylvania **<http://www.dep.state.pa.us/dep/efacts/GuideToDEPPermits/Guide%20to%20DEP%20Permits-98.htm>**. This Department has manuals entitled *"Fact Sheet - Controlling Accelerated Soil Erosion and Preventing Sediment Pollution," "Erosion and Sediment Pollution Control Program Manual,"* and *"Erosion and Sedimentation Control Plan Development Checklist and Worksheets"* that can be obtained free of charge. Contact the Permit Coordinator at one of 6 regional offices in the PA Department of Environmental Protection for these publications.

C. Landscape Layouts and Viewing

Action Items

1. **Across a landscape, connect wooded areas with wooded corridors**
2. **Avoid and eliminate narrow fencerows. They cause pest plant problems.**
3. **Along forest edges, mow to the trunks of the outer most trees (mow under the canopy) to eliminate pest plant habitat.**
4. **Develop wooded streamside corridors 100' wide or more if possible, the wider the better.**
5. **Shade the south and west side of buildings with deciduous trees**
6. **In any planting, include some native evergreens that will act as year-round vegetative wind barriers**
7. **Work with the appropriate NRCS Plant Materials Center in establishing native grass plots to avoid having an entire area in mowed turfgrass. This minimized mowing, fertilizers, and weed control.**
8. **Lay out edges of plantings and native grass plots so they are easily maneuverable by maintenance equipment**
9. **Establish or encourage an herbaceous layer. Lists of appropriate plants are available from native species nurseries, some university extension agents, and nearest botanical gardens or arboretums. Develop flash cards for these.**

1. Across a landscape, connect wooded areas with wooded corridors
It helps wildlife when larger forested tracts can be connected with smaller ones across the landscape. Connections such as wide fencerows and streamside corridors, both of which are habitats in themselves, accomplish needed connections. It is not always possible to connect natural habitats but it is sometimes possible to avoid separating them. This means minimizing the clearing of trees across forested corridors or through woodlots.

2. Avoid and eliminate narrow fencerows. They cause pest plant problems.
Unmaintained narrow fencerows are a haven for invasive plants that can spread from these areas. Grounds keepers and land stewards can either control invasive plants in these fencerows, make the fencerows wider to help reduce weed problems, or eliminate the fencerows. Not controlling invasive plants in fencerows just makes grounds maintenance more difficult in surrounding areas.

3. Along forest edges, mow to the trunks of the outer most trees (mow under the canopy) to eliminate pest plant habitat.
Along forested edges, make sure mowing occurs right up to the base of tree trunks rather than beyond the limit of the lowest limbs. This eliminates pest plant habitat and saves money in the longrun.

- utilizing evergreen plants a year-round wind barriers to protect other plantings and wildlife from hot, dry summer winds or cold winter winds,
- converting large, mowed, turfgrass areas to meadows that require less mowing and provide more habitat,
- laying out edges of landscape areas that allow for easy mowing, and
- establishing a low vegetation layer in some parts of landscaped areas as an important element in creating quality wildlife habitat.

4. Develop wooded streamside corridors 100' wide or more if possible, the wider the better.
Studies of edges show they may be dominated by invasive plants and extend 30 feet or more into a forest. The exotic invasive species may dominate the very outer edge. In order to create a habitat corridor for something other than pest species, a wooded corridor width of 100 feet or more is desirable. Wider widths are more desirable and narrow widths less so. Mowing underneath the limbs of the outer most trees also eliminates pest plant problems over the broader landscape.

5. Shade the south and west side of buildings with deciduous trees
The south and west sides of buildings receive sunlight at the hottest times of the day. Shading these walls with trees can reduce air conditioning costs by 1 to 25 percent depending on the structure being shaded. Industrial processing buildings may have benefits as low as one percent while residential structures can benefit as much as 25 percent. Office building benefits are somewhere in between and are benefited most when buildings are small, have a large component of glass, and exist in open settings, especially on south facing slopes. Generally, trees should be planted 20 to 25 feet apart at about 20 feet from a building.

Deciduous trees are desired because they allow the sun to strike these same walls in the winter time to help reduce winter heating costs. Evergreen trees in these locations might cause winter heating costs to increase slightly.

Trees to avoid are those with larger maintenance costs or safety hazards. For example, silver maples and cottonwoods/poplars/aspens can develop shallow roots that cause mowing problems and are more vulnerable to wind and ice damage than other tree species. Trees with large or numerous fruits can be a problem along sidewalks and parking lots. Yellow poplar, although mentioned above, may be slightly more prone to attracting lightening strikes. In all cases, mulching around these plantings will significantly increase maintenance costs.

6. In any planting, include some native evergreens that will act as year-round vegetative wind barriers
Evergreen trees provide important year-round protection against soil-drying winds and winter cover for wildlife. To accomplish this, these trees must have foliage that reaches the ground. Evergreens are most

effective when planted on the westerly edges of plantings. If this is not possible, other positions are better than none at all.

7. Work with a NRCS Plant Materials Center in establishing native grass plots to avoid having an entire area in mowed turfgrass.

To be sure, grass turf is one of the least expensive forms of maintained landscapes. About the only thing less expensive is forest with minimum maintenance. Establishment of *prairies or meadows of native species of grasses, forbs, wildflowers, and sedges offers another option that provides more variety than turf grass* although cost trade-offs are not clear. Maintenance of these meadows may require mowing annually or less or may be maintained by prescribed burning once every few years. They provide viewers with seasonal varieties of colors and textures as well as a variety of arrangements in contrast to turf grass across a landscape. Costs of wild meadow maintenance is much less predictable than for turfgrass. Meadows don't require fertilizers and frequent mowing, Meadows and turfgrass both require herbicides and weed control. Turfgrass does not require special or unfamiliar maintenance techniques such as prescribed burning. However, meadows do provide more wildlife habitat, more seasonal variability, and a greater sense of place than turfgrass.

[Picture of created meadow in turf grass area]

It is more difficult and expensive to establish meadows of native species than turfgrass. Establishing these meadows may take two to three years. Persistent exotic turf grasses and aggressive invasion of exotic pest plants (weeds) are a challenge in the meantime. Once native grasses have been established, invasive species are not as much of a problem. Mowing around meadow areas creates the smooth edges and neatness desired.

In the Mid-Atlantic States, a mixture of cool and warm season native grasses work best. Buffalo grass, Canada wildrye, redtop, and June grass are some native cool season grasses while bluestem, switchgrass, and indiangrass are warm season examples.

The method of establishing mixes of native grasses can vary. The conventional establishment method is to first completely kill existing grasses and weeds, especially if they are comprised of exotic turf grasses. This process usually starts in August when complete kills are attainable. The site may then immediately be tilled and left fallow long enough for remaining seeds to germinate. A second herbicide application is then used to kill the new plants. After this, native seed may be sown and just slightly covered by a very light disking. Straw mulching will help stabilize a site through the winter. Spring sowing is difficult because of wet soil conditions but is appropriate for numerous native grasses as soon as sites become accessible. Anywhere from four to twelve pounds of seed per acre may be needed. This will vary by grass species and a mix of 3 to 5 species is desirable. Wildflower seed may be added to the mix.

8. Lay out edges of plantings and native grass plots so they are easily maneuverable by maintenance equipment

Clean, smooth edges are aesthetically desirable. Their presence is important but their maintenance needs to be compatible with equipment to minimize costs. Work with available equipment and operators to determine the angles and sweeps of edges that can be easily maintained and still meet landscaping objectives.

9. Establish or encourage an herbaceous layer. Lists of appropriate plants are available from native species nurseries, some university extension agents, and nearest botanical gardens or arboretums. Develop flash cards for these.

One of the major features of quality wildlife habitat in the East is the presence of an herbaceous layer. This provides important cover and food to many native species. Herbaceous layers look less tidy than clean, clear grounds so they are not desirable for all locations. Instead, look for areas where herbaceous layers are permissible and allow them to develop. The plant species to include in these layers can be identified by the Pennsylvania Natural Diversity Inventory (see contact information below).

Contact Information

University of Maryland's Maryland Cooperative Extension website at
http://www.agnr.umd.edu/CES/Pubs/html/fs728/fs728.html.

Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Natural Diversity Inventory, (717) 787-3444 (Bureau of Forestry),
http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm

Natural Resource Conservation Service, Plant Materials Program,
http://plant-materials.nrcs.usda.gov/
Cape May Plant Materials Center, NJ (for southeastern PA),
http://plant-materials.nrcs.usda.gov/njpmc/index.html
Big Flats Plant Materials Center, NY (for central and northern PA),
http://plant-materials.nrcs.usda.gov/nypmc/index.html
Alderson Plant Materials Center, WV (for southwestern PA),
http://plant-materials.nrcs.usda.gov/wvpmc/index.html

Pennsylvania Cooperative Extension Service, Penn State University,
http://www.extension.psu.edu/base_nr&em.htm

D. Planting

Action Items

1. **When possible, plant immediately after last spring frost (March/April) or after first fall frost (November) until ground gets too wet or is frozen. Avoid summer planting if at all possible**
2. **When planting hand-moved balled-and-burlapped plant materials, dig a hole twice the diameter of the ball and just a little deeper than the ball.**
3. **Lay a couple inches of loose soil in the bottom of the hole and place the tree gently in the hole by holding onto the ball, not the stem of the plant. Remove any plastic wrappings; burlap can stay on the ball.**
4. **Don't do anything that might break the root ball (handle gently and insist emphatically on nursery and grounds help doing the same)**
5. **Make sure the top of the ball is at ground level, make sure to untie wires and twine around the root collar, and just barely cover the ball with dirt at ground level.**
6. **Fill in loose dirt around the sides of the ball. Do not pack down tightly by standing on loose dirt. Tamping lightly with shovel handle or foot works well to get rid of any air pockets and firm the soil to hold the tree straight is all that is needed.**
7. **For plants over 6-8' tall, use standard guying procedures to secure the plant from leaning due to wind or settling of soil around the ball.**
8. **Where possible, water plants every few weeks through the summer after planting.**

These actions are conventional practice so they are only summarized. However, if they are not followed, plant survival is jeopardized. This means increased maintenance and replacement costs later on which carry additional environmental costs as well. They are reviewed to apply during replacement and maintenance of plant materials.

E. Maintenance

Action Items

1. **Use NRCS guidelines for maintenance of meadows or prairie-type habitat.**
2. **Consider using rocks, sand, plastic mulch, and plants adapted to very dry conditions in smaller, steep, or difficult to maintain areas where viewing traffic will be high**
3. **Do not use plastic for planting beds except within the warmer coastal plain of the Mid Atlantic region.**
4. **Develop weatherproof flash cards of important small/young plant species that may come in on their own or are planted as nuts or seeds. This helps to know what to weed out and what to keep.**
5. **Train weed eater operators and mower operators not to girdle young trees; Protect the trees with basal guards anyway and mulch far enough away from the plant to avoid any maintenance girdling.**

6. **Utilize mulches but beware of their installation and maintenance costs. Mulches require 1 to 2 upgrades per year to keep areas looking nice.**
7. **Establish an on-site or nearby compost pile using local landscaping wastes.**

1. Use NRCS guidelines for maintenance of meadows or prairie-type habitat.
Prairie-type habitat can be difficult to establish but once established requires limited maintenance. Sometimes burning is recommended once every 3 to 7 years. It is important to determine if burning is permissible and possible before establishment. Otherwise, other methods of maintenance are required that may be more costly. Maintenance involves control of exotic invasive plants and most woody plants. This can be accomplished by adjusting mowing heights and mowing once a year or less. This is often done in combination with other actions such as spot control of exotic invasive plants, prescribed burning, and broadcast herbicide use such as Transline. Use NRCS contact information to locate management guidelines for your area.

2. Consider using rocks, sand, plastic mulch, and plants adapted to very dry conditions in smaller, steep, or difficult to maintain areas where viewing traffic will be high
Xeriscaping is an alternative for reducing maintenance and watering. It means "dry landscaping," and mainly avoids the need to water turf grass. This involves the use of coarse landscape materials such as sand, gravel, boulders, coarse ground covers, cactus, yucca, sedum, some native grasses, and drought-tolerant species associated with rock outcrops in nature. It is excellent for steep slopes. In the Mid-Atlantic region, less drought tolerant species can be used because of adequate rainfall. These include black locust (not recommended because of pest problems), several species of sumac, some pine species, junipers, red maple, hackberry, elm, and selected ericaceous shrubs. In reality, many species can be used, even species not tolerant of drought such as red maple, native grasses, sweetgum, sycamore, and numerous oak species. No maintenance is required other than weed control and seasonal cleaning of leaves and debris. Xeriscapes can be expensive to establish because of the cost of rocks, gravel, plant materials, and the need to lay down plastic mulches to help prevent weed growth and prevent mud from surfacing. To reduce costs, on-site materials can be used and plastic mulches avoided. Small, locally collected plant materials can work well and can be supplemented with the planting of nuts and seeds of other species to fill out the site over several years. Once established, such landscape can be very easily maintained almost indefinitely. The reduced maintenance involves less water needs, fewer chemicals, no mowing, and little fertilizers - all improvements for the environment and cash flow.

3. Do not use plastic for planting beds except within the warmer coastal plain of the Mid Atlantic region.
Plastic mulches are best used when a very aggressive weed problem is anticipated. In cooler areas (outside the Mid Atlantic Coastal Plain) their overall benefit is not as critical in reducing weed problems. *Plastic is not recommended for most areas.* Plastic underneath mulch does not prevent weeds. Organic mulch, once slightly weathered, eventually supports weeds. The same frequency of weed maintenance (about every two weeks through the growing season) is needed even though there are slightly fewer weeds to control and thus slightly less chemicals or weed pulling needed.

4. Develop weatherproof flash cards of important small/young plant species that may come in on their own or are planted as nuts or seeds. This helps to know what to weed out and what to keep.
Although mentioned earlier, this idea is worth highlighting. *Weatherproof flash cards for important native plants and exotic invasive plants are extremely helpful to grounds maintenance people.* Letting appropriate native species grow in and recognizing exotic invasive species to immediately eliminate requires identification skills. Flash cards provide this. As a result, significant weed control problems can be avoided while new approaches to landscaping can take hold. You will need to develop your own flash cards or work with one of the conservation groups/agencies that will do this for you.

5. Train weed eater operators and mower operators not to girdle young trees; Protect the trees with basal guards anyway and mulch far enough away from the plant to avoid any maintenance girdling.
Weed eating has its best use in trimming ditches and slopes too difficult for mowers. They also work well trimming vegetation around hard edges such as wall, walkways, and isolated older trees. *They should never be used in mulch beds or around younger trees.* If they are used around younger trees, tree guards are essential. The least experienced grounds-keeping help is often placed on weed eater duty. Many young trees and herbaceous layer landscaping plants have been killed due to careless weed eater use through girdling of trees or thinking ground plants were weeds. Replacement of dead trees is more expensive than training weed eater operators how to avoid girdling trees.

6. Utilize mulches but beware of their installation and maintenance costs. Mulches require 1 to 2 upgrades per year to keep areas looking nice.
Mulches are very attractive. They are outstanding for conserving soil moisture and keeping soil temperatures cool during the summer and warm during winter. They are man's way of simulating a forest floor of leaves and decaying organic material. They offer an expanded excellent rooting zone for many plants. Consequently, plant survival is better, growth is faster, and needs for watering and fertilization are reduced or eliminated. Weeds can be temporarily hindered. These are all big advantages. *However, mulches may come with a heavy cost.* To minimize this cost, consider composting and use of on-site organic sources as mulch such as leaves and shredded landscape trimming wastes. Do not use grass clippings unless they have been well composted. Establish a compost pile. For information on mulch types and application rates, contact: 1) Department of Conservation and Natural Resources, 2) Department of Agriculture, 3) Pennsylvania State University Dauphin County Extension Office. Another good resource for mulch types and application rates is the University of Florida Institute of Food and Agricultural Sciences (website http://edis.ifas.ufl.edu/MG251).

First applications should be 2 to 3 inches deep. For large areas, the cost adds up quickly. Deeper applications hurt plants by depriving soil of oxygen. Shallower first applications do not hinder weeds, hardly conserve moisture, often allow soil to quickly show through, and do not keep soils sufficiently cool during the summer and warm during the winter. Spreading mulch, when done by hand, is labor intensive which can be costly. Mulch most also be spread evenly and smoothly to be attractive. This requires supervision during the installation process. New automated pneumatic application systems are much faster, require less labor, leave a very smooth application, and usually show a cost-savings if it is locally available. One of many sources of information on these systems is available at 800-451-8838 (see

the website: http://www.hydrograsscorp.com/hydroseeders.html). Renewal applications are needed 1 to 2 times a year to replenish decaying mulch and to improve attractiveness and neatness. These can be only 1 inch deep per application. Do not let mulch get more than about 3 inches deep.

When mulches dry out, they can be a fire hazard. Discarded cigarettes commonly cause smoldering burns that at the worst could threaten buildings and at best leave unattractive dark patches. This only seems to be a problem during extended dry periods.

Mulches should be restricted to flat ground or gentle slopes not exceeding a few percent. During heavy rainstorms, mulch can float and wash onto sidewalks or away altogether leaving unattractive conditions.

When mulches are not tended for weed control or are not renewed frequently enough, weed problems can be excessive, especially regarding warm-season grasses such as crabgrass and johnsongrass in mid- and late-summer. Weeding by hand is very labor intensive, expensive, and not very effective. Seeds and rhizomes (roots) are often left behind. Short-lived herbicides such as glyphosate-based herbicides are very effective and useful for any weeds. They are also dangerous to non-target plants when the slightest amount of wind drift occurs. The answer to this is 2-week close inspections for weeds during the growing season accompanied by spot spraying.

It is imperative to stay ahead of the weed problem with mulches even more so than for other areas. Once weeds are able to establish themselves, they become extremely aggressive in mulches. Further, if pulling of weeds is avoided, more frequent mulching can be avoided.

7. Establish an on-site or nearby compost pile using local landscaping wastes.
Reusing and recycling landscape trimmings and wastes is a well known environmental benefit that can save money and avoid waste disposal challenges. Work with site managers to determine if and where mulching piles can be established with landscape wastes. Once composted, the materials will provide appropriate mulching material for some areas.

Contact Information

Maryland Cooperative Extension,
http://www.agnr.umd.edu/MCE/Publications/Category.cfm?ID=9&top=32
Pennsylvania Department of Conservation and Natural Resources,
http://www.dcnr.state.pa.us/aboutdcnr/ataglance/fswrcf.htm
Natural Resource Conservation Service, Plant Materials Program,
http://plant-materials.nrcs.usda.gov/
Cape May Plant Materials Center, NJ (for southeastern PA),
http://plant-materials.nrcs.usda.gov/njpmc/index.html
Big Flats Plant Materials Center, NY (for central and northern PA),
http://plant-materials.nrcs.usda.gov/nypmc/index.html
Alderson Plant Materials Center, WV (for southwestern PA),
http://plant-materials.nrcs.usda.gov/wvpmc/index.html

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Druse, Ken. 1994. The Natural Habitat Garden. Clarkson N. Potter, Inc., 201 East 50th St. NY, NY. 10022. 248 pp.

USDA Forest Service and Tennessee Exotic Pest Plant Council. 1997. Exotic Pests of Eastern Forests, Conference Proceedings, April 8-10, Nashville, Tennessee. 198 pp.

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Snow Removal and De-icing

Actions Items:

1. **Reduce the need for de-icing chemicals through selective closing of stairs, sidewalks, and roads.**
2. **Improve mechanical removal strategies by increasing the frequency of shoveling, brushing, or plowing and increasing the amount of equipment in use.**
3. **Use potassium chloride or magnesium chloride ice melting products instead of sodium chloride or calcium chloride.**

A. Reduce the Need for Chemical Usage

Removing snow and ice from sidewalks and roadways is an important health and safety issue that can have significant environmental impacts depending on the ice melting chemicals used. Common ice melters include: ammonium sulfate, urea (nitrogen fertilizer), sodium chloride (rock salt), calcium chloride, magnesium chloride, potassium chloride, potassium acetate and calcium magnesium acetate. Ice melters should be used to break the bond between ice and the road surface so that the ice and snow and can be physically removed by shoveling or plowing. An application of a liquid anti-icing agent may be considered where it is especially important to prevent ice from forming or where the use of an ice melting chemical is not possible.

Where occupant and visitor movement and building materials permit, closing redundant stairways, sidewalks, and roads during the winter season can reduce the area that must be cleared of snow and ice. Maintenance staff can better clear snow from necessary areas and de-icing chemicals will be used over a smaller surface area.

Keep the weather in mind. A light, powdery snow may not require a de-icing chemical, just shoveling or sweeping. If freezing rain, wet, heavy snow, or sleet are expected, apply an ice melter before precipitation begins to maximize its effectiveness.

B. Mechanical Removal

The use of de-icing chemicals can be reduced by preventing the formation of ice after snow falls. Removing snow in a timely fashion using shovels, snow blowers or plows before it is compacted by traffic can reduce the need for de-icing chemicals. When manual shoveling is used, ensure that workers are adequately protected from the cold and using appropriate techniques to eliminate back and other potential injuries. When mechanical equipment is utilized, make sure that equipment is well maintained to minimize environmental impacts such as leaking gas, oil, or lubricant. Workers operating mechanical equipment should have access to safety goggles and ear protection.

C. Chemical Considerations

Switch from sodium and calcium chloride products to potassium and magnesium chloride products. While all chlorides may be toxic to vegetation if used in large quantities, potassium and magnesium chloride products are less damaging to plants, concrete, carpeting and hard surface flooring. Apply chemical deicing compounds with a spreader (or sprayer for liquids) to minimize the amount of product used and ensure a uniform application.

Roofing Maintenance

Action Items:

1. **Perform routine roof inspections monthly.**
2. **Keep roofs clean and free of debris.**
3. **Keep drainage systems clear.**
4. **Keep roof access limited to authorized personnel to minimize foot traffic.**
5. **Consider adding a reflective roof coating or replacing existing roofs with a more reflective roof.**

The life expectancy of commercial roofs in North America is in the range of 20 years. Proper roof maintenance can identify and correct minor defects and problems that, if left unattended, can eventually lead to damage or roof failure.

A. Perform Regular Inspections and Remove Debris

Qualified staff should perform routine roof inspections monthly. Remove all debris, leaves, paper, vegetation, and other items that can clog drains and gutters, and clean out roof drains. Additional inspections should be performed after severe weather (e.g., high winds, heavy snow or ice loads, hail), installation or servicing of rooftop equipment, or building construction. Avoid chopping ice and digging snow off the roof - roofs can be damaged. After removing vegetation with large roots, patch the holes left in the roof membrane.

Qualified staff should thoroughly inspect the roof twice a year - once in the spring and once in the fall - to identify problems such as split seams, separated layers, failed flashings, clogged drains, and surface punctures. The inspections should include an examination of the building interior areas directly below the roof.

Pay particular attention to rooftop equipment and other roof penetrations, such as skylights, exhaust fans, air handlers, and vent stacks. Grease from exhaust fans, oil leaking from HVAC units, and air pollutants can damage roof materials.

Specialized or extensive roof repairs that are identified during routine inspections may need to be performed by a roofing professional if building staff have not been trained in the proper procedures.

B. Keep Roof Access Restricted

The more people who walk on the roof the more potential for damage. Limit roof access to authorized personnel. Keep foot traffic to a minimum.

C. Consider a More Reflective Roof

Consider adding a light-colored reflective coating to the roof to reduce the building energy use (by reducing the solar heat gain in the building) and extend the life of the roof (by reflecting the ultraviolet

rays in sunlight that break down many roofing materials). Reflective, or "cool roofs," can provide a building with up to 50 percent energy savings and reduce peak cooling demand by 10-15 percent. Dark-colored roofs can absorb more than 70 percent of the solar energy that falls on them, making the rooftop temperature as much as 100 degrees F above the ambient air temperature. The heat is absorbed by the roof, radiated upward into the atmosphere, and radiated downward into the building.

Also consider specifying white or light color finishes on rooftop equipment. Paint existing equipment with a light-colored paint the next time the equipment requires painting.

Parking Garage Maintenance

Action Items:

1. **Collect and remove trash daily.**
2. **Sweep the parking deck surface and stairwells weekly.**
3. **Wash the parking deck surface at least twice a year (spring and fall). Dust, oil, grease, dirt, and de-icing chemicals from parking structures can be tracked inside the building.**
4. **Inspect floor drains and lighting fixtures for proper function.**

A regular maintenance program will prolong the useful life of a parking structure and reduce the cost of operation if problems are found and addressed early on.

A. Clean Parking Structure Regularly

In addition to presenting a well-kept public image, regular cleaning of a parking garage can help identify and address potential problems. Trash that is not removed regularly can block floor drains and lead to water buildup, and trash left in walkways and stairwells can be a pedestrian hazard. Removing trash also eliminates debris that can hold moisture and deicing salts in contact with concrete.

Sweeping and washing the parking deck helps remove dust, oil, grease, dirt, and de-icing chemicals from parking structures which can be tracked inside the building. Fluids from vehicles, such as grease, oil, and antifreeze, can build up in parking spaces and at the garage entrances and exits, and may become a slip hazard for pedestrians. If it is not possible to collect the dirty water after a washdown, consider using a mechanical scrubber that collects the dirty cleaning fluid as it cleans.

Maintain waterproofing systems (e.g., deck sealers, joint sealants, membranes) according to manufacturer's instructions to ensure performance and check monthly for leaks or deterioration.

B. Inspect Floor Drains and Lighting Fixtures

Water penetration into concrete presents a potential structural hazard to the reinforcing steel. Keeping water from ponding and penetrating is crucial for long-term structural stability. Making sure that floor drains, basins, and traps are kept free of trash and debris helps prevent clogging and standing water. Temporary filters (e.g., burlap) may be used during washdowns to prevent sediment and trash from entering the drains.

Pedestrian safety requires adequate lighting in all areas of the garage at all times. Inspect lighting fixtures for burned out bulbs, dirty lenses, dirty photocells or sensors, and battery pack status on emergency lighting (see also section on Lighting).

HVAC equipment for control rooms or operator booths should have filters cleaned or replaced regularly (see also section on HVAC).

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HVAC Maintenance

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Overview

HVAC maintenance practices can have a significant effect on a building's energy use and the comfort of its occupants. Mechanical systems - heating, ventilation, air-conditioning, and the associated component such as fans, pumps, etc. for space conditioning - are the second largest user of energy in most buildings, exceeded in most cases only by lighting energy consumption. This section discusses the overall goals of HVAC maintenance and provides a number of maintenance practices and tips that can help to reduce overall HVAC energy consumption.

The proportion of space-conditioning energy consumed by various mechanical HVAC components varies according to system design and climate. For most large and multistoried buildings in temperate climates, fans or ventilation equipment energy consumption may be the largest consumer of energy. Depending on the specific climate, space-heating and cooling energy is usually less energy-intensive than building ventilation, followed by service water heating.

Yet, even in most new buildings, the design of space conditioning and ventilation systems, and the factors that affect their efficiency, may come as an afterthought to the architecture design work. In some existing buildings, the HVAC system is either retrofitted or appended as an upgrade or addition to the building. In addition, most modern commercial and office buildings HVAC are designed to prevent occupants from altering thermostat settings or air circulation systems. Operable windows in most new buildings are a thing of the past, and some old buildings that had operable windows have either painted them shut or discouraged their use.

Sophisticated HVAC control systems now rely on electronic sensors instead of direct occupant feedback to maintain uniform temperature within a prescribed "comfort zone." Sometimes this "comfort zone" is

strictly maintained by the system without regard to whether or not the occupant feels hot or cold, or even present. As a result, up to 50 percent of office workers in a recent survey reported dissatisfaction with their office environment - complaints about offices being too hot or too cold often head the list of employee dissatisfaction.

All of these factors point to the difficult tasks that the building HVAC engineer and the maintenance staff must carry out in order to balance occupant comfort with building and equipment efficiency, while keeping maintenance costs low. It is a challenging task not only because even if the levels of employee dissatisfaction have a minimal impact on their productivity, it can substantially affect employee output, and the combined effects on employee output may outweigh the cost of cooling, heating or ventilating the building.

A. HVAC Maintenance Considerations

Key HVAC maintenance considerations:

- **Focus on keeping people comfortable instead of keeping buildings in "comfort zones."**
- **Where possible, provide temperature for spaces according to their function to reduce HVAC loads (e.g., hallways can be cooler in the winter and warmer in the summer than office areas).**
- **Allow occupants to self-regulate temperature within a predetermined range through better access to vents and thermostats.**
- **Install blinds, window shades, and other devices to control HVAC loads in areas with load factors not considered in the HVAC control loop (e.g., leaky windows, heat gain in east and south facing offices, poorly insulated walls).**
- **Look for low-cost or no-cost system modifications, such as changing operation procedures or automating system settings.**
- **Stay current on routine maintenance practices.**

The HVAC maintenance team must maintain a balance between system efficiency and occupancy comfort, which at times seem like incompatible tasks. But this balance may be arrived by following a number of broad considerations, summarized below (in order of broad to narrow focus):

- Human factors: Focus on individuals' comfort zones and levels. One of the main reasons for occupant dissatisfaction is the fact that preferences for ambient temperature vary by individuals. Further complicating the problem, individual preferences for environmental conditions may vary by hour or day, and can be affected by factors ranging from clothing to diet. Thus, finding ways to keep people comfortable instead of maintaining buildings at prescribed "zones" may be the key to improving energy-efficiency as well as occupant comfort.
- Location, temperature, and load factors: Focus on providing temperature for spaces according to their function, where and if possible. For example, with suitable barriers and settings, corridors can be set to have different temperatures than offices (i.e. warmer in summer, cooler in winter). This can help to reduce buildings' heating or cooling load substantially. Shutting off vents to empty offices and other unused spaces can also reduce loads.

- Localize effects: One of the best examples of this practice is "spot heating," where a radiant heat source is used to heat occupants, rather than the whole space. This approach allows occupants to self-regulate their temperature by moving closer or farther away from the heat source as their comfort levels dictate. This is more difficult to achieve with cooling and in office settings, as air vents are not quite the functional equivalent, but allowing occupants more access and control to outlets may provide them with the same opportunity.
- External factors: Often, occupant comfort is affected by other factors that are not in the HVAC control loop. For example, in older buildings retrofitted with forced-air ventilation system, factors such as leaky or low-R windows, thermal retention by east and south facing walls, heat gain or loss through poorly insulated walls, etc. are often not accounted for in the control loop. All of these factors can affect occupant comfort differently, depending on their location in relation to these heat or cold sources. Blinds, window shades, and other envelope measures may help to control heating or cooling loads in these different situations more effectively and often yield significant energy savings in the long run.
- Low-cost or no-cost system modifications: In addition to operation and maintenance practices, there are a number of relatively low-cost or no-cost, quick return measures that can help existing systems maximize their operating efficiency, increase efficiency, or help reduce energy consumption. These are also discussed in details below, they can range from changes in operating procedures, to automating system settings - for example, installing automatic set back thermostats, or checking and sealing ducts.
- System upkeep: This is the "normal," routine maintenance as required by the building's particular systems and operation schedule. This includes filter replacement, motor maintenance, and other measures. Keep in mind that this is sometimes the best, simplest, and most conventional approach to maximizing energy efficiency in buildings. Often, a poorly designed building with good operations and maintenance (O&M) practices will usually outperform a well-designed building with poor O&M practices.

B. HVAC Maintenance Practices

HVAC maintenance practices vary depending on the type of equipment, building types, and existing envelope measures, as well as building location, size, use pattern, and purpose. Thus, it is almost impossible to come up with a set of specific maintenance practices that fits all of the possible combinations. Rather, the set of maintenance practices below should be used as guidelines to help you develop a combination of building maintenance and operation practices and schedule that will best serve the occupants' needs, maintain good indoor air quality, and above all, reduce energy consumption and environmental impacts. One of the possible first steps in improving system efficiency is a preliminary energy audit to assess the savings potential of various efficiency measures. A preliminary audit can be obtained from energy service companies, architecture and engineering firms, or utilities. (Note to government facility managers: FEMP, the Federal Energy Management Program, can also provide this technical support, on a reimbursable sub-contract basis).

Efficient Chillers/Chilled Water Cooling Operations and Water Treatment

Key points for operating chillers efficiently at part-load:

- **Consider lowering entering condenser water temperature, or keeping the temperature constant to reduce chiller energy use.**
- **Pre-cool outside air before it enters the air-conditioning system through indirect evaporative cooling.**
- **Use cool water from cooling towers to satisfy partial loads when outside temperatures permit instead of operating chillers.**
- **Use of 100% outside air in the air handling system when temperatures and configuration permit.**

Efficient Chiller Operations: Most large commercial, industrial, and institutional buildings often employ chillers for cooling and boilers or other steam-generating equipment for heating. The medium or "working fluid" employed by these devices to transmit heat or cold is often large amounts of water. How the water is "conditioned" before it enters the system can affect the system's efficiency. In addition, how the chillers are operated can also significantly affect the system's efficiency.

One of the most fundamental factors of chiller operation from the maintenance and energy efficiency perspective is that chillers (and other large size air-conditioning equipment) work best at full-load rather than part-load. However, conditions do not always favor full-load operations. Therefore, improving chiller performance at part-load conditions requires a close monitoring of inlet water temperatures, and a better match of equipment and operations in order to meet the part load conditions that constitute most of a plant's operating hours. Measures to improve chiller efficiency and energy consumption for chillers at part-load include:

- Lowering entering condenser water temperatures, or keeping the temperature constant can result in a reduction in power consumption since the chiller's compressor will not have to work as hard.
- A reduced load on each chiller also decreases the temperature difference across the evaporator and condenser heat exchangers and thus further reduces the power consumed by the system. These measures can help increase overall chiller plant efficiency dramatically at partial load conditions.
- Indirect evaporative cooling, which can be added to pre-cool outside air before it enters the air-conditioning system, is a cost effective way to increase overall chiller efficiency.
- Additionally, "free cooling" can be accomplished on the water-side through the use of economizers to utilize cool water from cooling towers to satisfy partial loads without the use of chillers.
- Similarly to "free cooling" on the water-side, "free cooling" on the air-side can be accomplished by using economizers to satisfy partial loads through the use of 100% outside air in the air handling system.

A possible, low-cost approach to automate this practice is to design and implement a simple and economical chiller plant control network for the chillers, pumps and tower fans that automatically operates and sequences all equipment to meet the load and optimize efficiency. A change in operation from conventional operations to an efficiency focused plant operations strategy can easily reduce annual

chiller plant energy costs by $20 to $100 or more per installed ton, depending on climate, application and utility rates.

Water Treatments: Reliable and efficient chiller operations depend significantly on the conditions of the heat transfer surfaces and passages within the chiller and the rest of the piping system. As chillers are operated, the chilled water used as the working fluid can deposit scales from minerals and other compounds in the water (known as "fouling"). Oil from lubrication and other areas of maintenance can be deposited on the inside surfaces as well. "Biofouling" - the contamination of water with algae and slime - is also a concern.

"Fouling" is the most significant O & M issue for chilled-water operations because it decreases both the efficiency and the capacity of the chiller. Therefore, regular maintenance of the water in the systems is a must. This maintenance action will help maintain the chiller at peak efficiency and may reduce future maintenance costs.

Cooling tower water treatments - key points:

- **Conserve water by minimizing excess "blow-downs" since water from "blow down" can contain a variety of chemical pollutants.**
- **Use make-up water only as needed, which conserves water and reduces the need for treatment chemicals.**
- **Investigate whether proper handling and treatment of "blow-down" water is required by your municipality, which can be costly over time.**

For water cooling towers, the main concern of O & M practices are scaling, corrosion, and biological growth. These are also the main concerns for all water-based, evaporative cooling systems. These problems are exacerbated by increased water-level concentrations of mineral salts during normal operations as a result of evaporation. Scaling, corrosion, and biological growth act to reduce heat transfer capacity and contribute to system "fouling."

Biological and bacterial growth in some cooling systems can include the pathogenic organism such as *Legionella Pneumophila* (attributed to "Legionnaire's disease"), where the water is warm (95 to 99 degrees F), with a high concentration of minerals. Although awareness of the issue has helped to reduce incidences of water-borne or air-borne sickness from cooling water. The separation of the systems' air intake vents from the cooling tower plumes is perhaps the best strategy to minimize sicknesses.

Therefore, good water maintenance practices are essential in suppressing any potential pathogens as well as helping to maintain peak system efficiency. This process requires vigilance on the part of the operations and maintenance staff. In closed-loop systems, scales may not be a significant concern on the water-side of the evaporator tubes. Oil separators, which are standard on newer machines, can remove oil from the refrigerants. However, the rest of the system requires a careful balance of treatment and monitoring.

In most existing systems, the most common treatments for scaling, corrosion, and biological/bacterial growth are the use of various chemical additives, and significant over-use of water. Most system operators use chemical biocides to inhibit biological growth, and allow a significant amount of "blow

down" or deliberate cooling water overflow to introduce fresh water into the systems, thereby reducing the concentration of contaminants and the buildup of scales.

The above water treatment practices can have significant impacts on the environment, near and far, and can create a number of issues and costs for O & M.

- Chemical contamination: The most common biocides used in cooling water treatment typically contain significant amounts of chlorides and/or chromates. Both of these compounds can be toxic in low concentrations when released into the environment (through "blow down" water getting into the sewage system, for example). In addition, water from "blow down" can contain corrosion inhibitors, high amount of sulfides (if the water is treated for pH), and concentrated amounts of salt (from evaporation).
- High water consumption rate: large amounts of "make up" water are needed during chiller operations when "blow downs" are involved. Typically, 20% more than the water needed for normal chiller operations. The use of large amounts of fresh water can be costly, creates a need for more treatment chemicals, and requires additional amounts of energy for pumping and storage.
- Wastewater treatment: proper handling and treatment of "blow down" is now required in some municipalities, and the process can be costly and also consumes large amounts of energy.

Energy Efficiency and Environmental Water Treatment Options: There are a number of options to convert from chemical treatment of water; however, they tend to require additional investments in the chilled water system. These are discussed below. However, if conversion is not an option for your chilled water system, there are a number of steps that can be taken to minimize the environmental impacts of your operations while maintaining system efficiency. These include:

Minimize excess "blow down" by creating, maintaining, and following a strict maintenance schedule, including "blow down" times and the amount of water needed, and identifying opportunities to reduce water use.

Minimize excess chemical treatment and use, and identify opportunities for reduction by setting up a strict maintenance schedule similar to the "blow down" schedule.

Chemical/Biocide water treatments - key points:

- **Obtain an MSDS (Material Safety Data Sheet) on chemical additives to help you understand the chemicals present.**
- **Avoid the use of chromate-based and chloride-based additives where possible.**
- **Avoid the use of additives with phosphates where possible.**
- **Give preference to additives that are propylene-based over ethylene-based products.**
- **Keep chemical usage to a minimum by tracking and closely monitoring the amounts used and the system's water conditions.**
- **Consider using ozone and/or automatic tube cleaning systems as non-chemical biocide alternatives.**

Alternatives to Chemical Biocides: As mentioned, there are 2 viable alternatives to the use of chemical biocides - ozone treatment and mechanical cleaning. Both have their own advantages and disadvantages, and can have high initial cost.

Ozone Treatment of Water in Cooling Towers: Ozone is a more reactive form of the element oxygen. It can act as a powerful biocide and oxidant, and can replace chemicals in the treatment of cooling water in some applications. A typical ozone set up for cooling tower treatment include an air compressor, an air dryer (desiccant), ozone generator(s), ozone injectors, and a control/monitoring system. The ozone generator applies high voltage to the compressed dry air to create ozone, which is then injected into the system. Ozone cannot be stored and must be produced on an as-needed basis.

Advantages of ozone systems include:

Operating costs: Typically, the installed cost of an ozone treatment system is much higher than a chemical system set up. However, the operating costs of ozone systems tend to be much less in the long run, as no chemicals are required once the system is in place. The labor and maintenance costs for both chemical and ozone systems are about the same.

Compliance/Disposal costs: In some municipalities, the treatment and disposal of "blow down" water can make the use of chemical treatment impractical. Ozone-treated chiller water does not have to meet strict regulations.

Water conservation: In most cases, chiller operations with ozone-treated water can benefit from a lower "bleed rate" than conventional chemical systems, reducing water and energy consumption.

System efficiency: in some cases, previously improperly treated chemical systems can experience increased efficiency with the introduction of an effective ozone treatment program.

Automatic tube cleaning systems for chillers: Chiller tube cleaning systems involve the installation of small nylon brushes in each condenser tube, which are propelled along the tube length by the water flow, continuously cleaning the inside surfaces of the system. The installation of such a system can increase the first cost of chillers to about $300 per chiller ton capacity. The system includes the installation of brushes and catch baskets, and a diverter valve designed to reverse the water flow (and brush direction) in the condenser. Energy and water savings of automatic brush systems depends on the state of the chiller when such a system is installed, but generally, the savings and advantages are the same if not better than those of ozone treatment, listed above.

C. Ducts and Filters

Ducts and filters - key points:

- **Maintain uniform airflow to increase filter performance and longevity.**
- **Place filters upstream of fans and cooling coils to increase effectiveness.**
- **Maintain low filter face velocity for an effective and energy efficient filtering system.**
- **Minimize filter frames or casings to minimize pressure drops across the filters.**
- **Choose a reusable filter medium such as bag or wet filters where possible.**
- **Set up a regular schedule to inspect and replace or clean filters.**
- **Locate and seal leaks in duct systems.**

Field studies and computer-based simulations of commercial HVAC equipment revealed that "common" problems with equipment and controls can increase a building's energy consumption about 15 to 30 percent. Often, these problems can be eliminated by better maintenance and inspection practices.

Ducts: Locating and sealing leaky ducts in older buildings is another area where system efficiency can be improved. Leaky ducts can account for 25 to 30 percent of the energy losses in HVAC systems. Therefore, you may want to consider implementing a systematic and regular inspection and maintenance program to locate and fix leaky ducts throughout the buildings and systems. Similarly, insulation on ducts, hot water lines, and chilled water pipes and fittings should be repaired or added where missing. While a program such as this may requires a higher effort, it can pay for itself. Note that the typical duct leakage in light commercial buildings has been found to average about 26 percent of the fan flow, which is nearly 50 percent higher than the average leakage of 17 percent found for residential duct systems.

Filters: HVAC systems can suffer from infrequent inspection and maintenance without a comprehensive schedule by the maintenance staff - overworked staff sometimes inspect the system only if problems are reported. One of the most simple and effective methods of increasing an HVAC system's airflow and efficiency is to inspect and replace system air filters on a regular basis. Clean air filters increase airflow through the system, resulting in improved system efficiency, indoor air-quality, and better occupant satisfaction.

Filters work by capturing dust particles through a variety of common methods: centrifugal, gravity, screening, impingement, and adsorption. For a filter material, there are two separate metrics to determine their performance:

Filter Efficiency refers to how well the filter material works to remove dust particles from the air stream.

Pressure Drop measures how much fan energy is needed to move air through the filter material.

For typical HVAC-duty filters in office, commercial, or institutional setting, a reasonable pressure drop across the filter material is 0.1"wg, or 125 Pa. Maintaining a proper pressure drop across filter materials is an extremely important maintenance task, as dirty, too thick (or the wrong thickness), and poorly designed and maintained filters can create a system pressure drop of 2 "wg (inch-water gauge), or 250 Pa (Pascal). As a comparison, a 250 Pa pressure drop is equivalent to the frictional drag of the entire duct system in a building. A higher pressure drop forces the fan or fans in the system to work harder, thereby consuming additional energy. The higher pressure needed also increases fan noise and vibration, can result in duct leakage, and generally increases the wear and tear on the entire mechanical system, resulting in increased maintenance needs and costs.

There are seven general types of filters in use, each with its own advantages and disadvantages in performance and environmental effects (in terms of their manufacture, handling, and disposal). Large or industrial filter applications sometimes use cyclone filters. These filters use both centrifugal and gravitational effects to remove dust particles, and are beyond the scope of this discussion.

Wet Filters: this type of filter traps dust particles using a flat mat of coarse fibers coated with a viscous, oily or sticky substance. This trapping substance can be washed off, filtered, and reapplied to the fiber mat, thus reducing the amount of waste entering the waste stream. However, this type of filter is

generally not as effective in trapping fine particles, and it is being replaced by dry-type filters. Wet filters have a pressure drop range of 100 to 150 Pa, depending on their state of cleanliness.

Bag Filters: this type of filter also uses dry materials to trap dust, but as the name implies, they are not contained in rigid frames, but arranged in long stocking-like shapes to increase their surface area. Bag filters are fine at handling medium and large-sized particles. Their main advantage is that they allow the recovery of trapped materials and can be cleaned and reused when dirty instead of discarded. Bag filters are also being replaced by dry-type rigid filters.

Dry Filters: this popular HVAC type of filter traps dust using fine, closely packed strands of fiber or fabric in a rigid cardboard frame. Dry filters usually have a pleated surface to create a greater trapping surface area, and are better at trapping finer particles. These filter screens are periodically replaced, and are discarded when dirty, which can contribute to the solid waste stream. Dry filters tend to have higher pressure drops than wet filters (ranging from 50 to 250 PA), especially when they are dirty.

HEPA Filters: High-Efficiency Particulate Air filters are a specialized type of dry rigid filters. These use materials with very small pores that can trap fine and super fine particles. They can create significant pressure drops, up to 500 Pa. HEPA filters should only be used for demanding applications such as electronic manufacturing or hospital filters. They are also discarded when dirty.

Electrostatic Precipitators: this approach uses a high voltage to charge dust particles and then pass the air stream between oppositely-charged plates to remove the charged dust particles from the flow. Because the intake air does not physically pass through any filtering elements, there is no pressure drop. However, the power required to charge the air stream and maintaining the charged plates can consume large amounts of energy (from 20W to 40W per 1000 cfm of air flow in typical applications). EP filters are generally used with coarse dry filters to help remove larger particles prior to charging. Thus, they are not as preferable because they use more energy while increasing the amount of filter waste. Filter plates must also be cleaned periodically, adding to maintenance issues.

Carbon Filters: These filters are designed to filter out gases and vapors by using activated charcoal. These filters are also better for specialized applications. They are preferable from an environmental standpoint because carbon filters can adsorb up to half their own weight in gases, at which point they can be heated to drive off the adsorbed gases and then reused.

Automatic Roll: These are also a specialized application of dry-type filters. The filter element consists of a roll of filter material that can be periodically advanced, exposing fresh filter material automatically. The advancing mechanism uses either a photocell (dirty filters result in less light passing through), or a differential pressure sensor (dirty filters result in a higher pressure drop). These systems tend to have high pressure loss, high leakage rates, and high initial costs. Although they are designed to function automatically, their low reliability rates have resulted in higher maintenance costs.

Energy and Environmentally Preferable filter use: Below are some guidelines for filter use than can reduce waste and energy consumption:

- Maintain uniform airflow: Filter performance and longevity can be increased with uniform airflow upstream of the supply fan. The placement of filters upstream of fans and cooling coils can help to clean the intake air before it moves through these components, and helps to improve their efficiency.

- Maintain low filter face velocity: For an effective and energy-efficient filtering system, it is extremely important to keep the filter face velocity (the airflow per unit area of filter materials) as low as possible. The recommended target for typical office, commercial, and institutional HVAC systems face velocity is about 200 to 300 feet per minute. This maintains a low pressure drop while allowing sufficient flow for most applications. Note: to get proper filtration at lower face velocity may require a larger filter surface area. This may increase the initial filter purchase cost, but the filters will last longer at the lower airspeed, resulting in significant savings in both materials and labor costs.
- Minimize filter frames or casings: Rigid filter casings from different manufacturers come in a wide range of widths. When ordering, choose the filter materials with the most surface area and the least casing and framing materials. Choosing filters with more filtering materials make the most sense, since you want to maximize the filter area, not the overall frame area. Filters with large frame areas may actually increase face velocity, increasing pressure drops across the filters.
- Choose reusable: While the rigid, disposable dry filter type is the most prevalent, some systems can still utilize bag or wet filters, or other reusable materials. Where possible, choose these types of filters to minimize the amount of waste generated. However, if you choose reusable materials, it is important to have a strict maintenance schedule set up to minimize additional maintenance and labor costs.

D. Temperature Settings and Regimens

Temperature setting and regimen - key points:

- **Turn off HVAC vents and/or ducts to unoccupied or infrequently used areas.**
- **Coordinate janitorial hours and work hours to minimize the number of hours the HVAC system must run.**
- **Consider raising temperature settings to 74º F in the summer and lowering them to 68º F in the winter.**
- **Consider delayed cooling, in combination with/or early shut down of the HVAC system before the close of the business day.**
- **Use outside air where feasible for cooling needs.**

As with almost any equipment, the easiest way to save energy is to switch it off when not needed. HVAC equipment that can be shut off during unoccupied hours should be shut off promptly, after hours, just before the end of the workday, and over weekends and holidays. Additional savings can be achieved in commercial and institutional buildings through close coordination with janitorial hours. Where zone control is available, services to unoccupied zones can be shut off with no loss to occupant comfort.

Modifying the temperature setting range during the workday is another no-cost way to reduce energy consumption. Consider raising your air conditioning temperature settings to 74º F during the summer, and lowering the heating thermostat set point to 68º F during the winter. Also consider delaying turning on heating and air conditioning at the start of the day, and turning off heating and air-conditioning sooner at the end of the day. During the winter, heating temperature can be gradually lowered at the end of the day to allow people to adjust without becoming uncomfortable. Similarly, cooling temperatures can be gradually raised at the end of the workday with minimal comfort loss.

Manual or automatic "night setbacks" of heating or cooling temperature should be implemented during unoccupied building hours. Heating should be setback to 55º F, and then returned to the occupied setting in time for early morning warm-up. Cold outside air supply should not be used during the warm-up when there are few people in the building. Similarly, cooling should not occur during unoccupied hours, and the building should be flushed with outside air just before occupancy, where feasible.

E. Sensors and Thermostats, and Other Devices

Sensors and thermostat - key points:

- **Use zones to help control temperature of occupied and unoccupied spaces.**
- **Inspect and maintain sensors for peak system operations.**
- **Use automatic set-back thermostats where feasible.**
- **Investigate the feasibility of air-to-air heat exchangers or Heat Recovery Units (HRUs).**

As discussed previously, "zoned" systems can provide better control of building temperatures during both occupied and unoccupied hours. Where available, sensors located throughout a building can help maximize the potential of a "zoned" system. Some sensors allow for both temperature and occupancy detection, and can be the basis of an automated setback system.

Another low-cost measure to reduce energy consumption, if you have not already done so, is the installation of automatic set-back thermostats. Programmable thermostats are a great way to squeeze maximum efficiency out of the HVAC system. They automatically change the temperature of buildings or zones to meet the needs of occupants' schedule. It's been estimated that for every degree the automatic thermostat can lower your heating or increase your cooling temperature setting, you can reduce the energy consumption of your building systems by about two percent.

Air-to-air heat exchangers are another type of energy-saving devices in which heat energy is transferred from one air stream to another through contact with a plate or film separating the air streams. Air-to-air heat exchangers or Heat Recovery Units (HRU's) should be considered whenever air is continuously exhausted and make-up or ventilation air is required. Heat exchangers should be considered for building areas where air is normally exhausted. Heat exchangers are modular in construction and can be assembled for air stream capacities up to 80,000 cubic feet per minute (CFM). These exchangers are often specified with exhaust and supply fans to provide a balanced HRU that can meet all necessary ventilation needs without producing drafts or air pressure imbalance.

Heat exchangers can work in both directions, effectively reducing both heating and cooling loads. In the winter, the warm exhaust air heats the incoming ventilation air. In summer the cooler inside air passes through the exchanger and cools the incoming ventilation air. Heat transfer from the warm side to the cool side of the exchanger depends on the amount of surface contact area per CFM of air moving through the exchanger. Generally, heat transfer efficiencies of 80% are attainable at a material cost of the heat exchanger of $1.60 to $2.00 per CFM.

Devices Brought by Employees

Keys to dealing with devices brought by employees:

- **Conduct a building survey to identify heating or cooling devices brought by building occupants, which may indicate the occupants have additional heating or cooling needs.**
- **Negotiate an agreement with all occupants where they can choose from a variety of energy-efficient devices to suit their needs.**
- **In exchange, reduce the zones' or building's heating or cooling to a lower level.**
- **Use a pilot program to identify individual devices that work.**
- **Set guidelines for these supplemental devices (maximum wattages, safety ratings, etc).**

High on the list of "external factors" are devices brought in by building occupants to help them deal with variable comfort levels and building conditions during the day. These devices range from desk lamps to electric fans to space heaters and blankets or other devices. These devices at best, help to provide occupants with the additional environmental controls that modern buildings have taken away, and at worst, become a nuisance, if not a fire hazard.

Usually, building operations and maintenance personnel tend to ignore such devices, unless they interfere with the proper operations of the system - for example, a heater located too close to the zone's thermostat or sensor can result in the rest of the zone or the building being too cold. However, if the goal of O&M practices is to minimize building energy use, these devices have the potential to wreak havoc with system settings and other reduction measures, resulting in an increase in the building's energy consumption, instead of reducing it.

To maximize savings, one approach to addressing this situation is the possibility of negotiating an agreement with all of the building's or heating/cooling zones' occupants, where they can choose from a variety of solutions to meet their comfort needs. In exchange, the zones' or building's temperature settings can be set to take these devices into account - higher thermostat setting in the summer, and lower in the winter. A pilot program can be used to identify the devices that work well for occupants and the right temperature setting with these devices in use. Guidelines can also be set for these devices (maximum wattages, safety ratings, types of heating elements, etc; or the use of heating pads or feet warmers in winter, which use much less energy and actually provide more comfort than a space heater, due to their direct contact with the user) during these pilots.

Overall, there are opportunities in reducing energy consumption if these devices are taken into account rather than ignored. In addition, the involvement of the building occupants in the pilot and decision making process often helps to make the process work better, resulting in maximum energy savings.

Lighting Maintenance

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Overview

Lighting operations and maintenance (O&M) practices can have a significant effect on a building's energy use and the productivity of its occupants. A building's lighting systems - illuminating offices, hallways, reception areas, etc. - constitute the largest user of energy in most office and commercial buildings. Overall, energy used for lighting accounts for about 17 percent of all US electricity use - this proportion can increase to 22 percent or even more when the energy needed to cool the heat generated by all the lighting systems is added. This section discusses the overall goals of building lighting maintenance and provides a number of maintenance practices and tips that can help to reduce overall lighting energy consumption.

The design, operation, and maintenance of lighting systems need to be considered as an integrated, functional system in order to achieve maximum utilization and to control factors that can affect system efficiency. Operation and maintenance practices for lighting systems, therefore, must also be considered as an important part of the building energy efficiency equation. In addition, many newly-available lighting technologies require building lighting maintenance personnel to stay informed to get the most out of existing systems as well as identify new technologies that can help improve O&M practices.

All of these factors point to the difficult tasks that the building maintenance engineer and the maintenance staff must carry out in order to keep maintenance costs low while balancing occupant lighting needs with equipment efficiency. It is a challenging task because a building's lighting quality has a direct impact on employee productivity, and a reduction in employee output may outweigh the cost of lighting their workspace.

A. Lighting Maintenance Considerations

Overall Lighting Maintenance Considerations:

- **Provide good, high-quality lighting suitable to the work being performed.**
- **Consider external factors that affect lighting levels and comforts, such as direct sunlight or the layout of partitions, but may not be in the control loop.**

- **Look for low-cost or no-cost system modifications such as occupancy sensors in low-use areas or de-lamping over-lit areas.**
- **Keep up with "regular" system maintenance such as fixture cleaning and bulb replacement.**

The lighting maintenance team must strike a balance between system efficiency and occupancy comfort, which at times seem like incompatible tasks. But this balance may be achieved by considering a range of factors, summarized below (in order of broad to narrow focus):

- **Lighting needs differ:** Focus on lighting of work zones and tasks, and provide these areas with good, high-quality lighting suitable to the work being performed. Not all office lighting suits workers' needs - reading or writing documents requires a different light level than examining and preparing blue prints, or performing work on computer monitors. Thus, finding ways to provide people with comfortable light levels instead of providing the same light level throughout a building may be the key to improving energy efficiency and maintaining productivity. This practice can help to reduce a building's lighting loads, but also may help to reduce its cooling load substantially by reducing lighting heat build-up.
- **Watch external factors:** Often, occupant lighting levels and comforts are affected by other factors that may not be in the lighting control loop. For example, office buildings with windows offices have different lighting needs and are affected by daylight differently than that of buildings with open, partitioned, or "cubed" floor plans. In addition, the glare from south-facing windows can affect occupants differently than occupants with north-facing windows. These external factors will require different lighting strategies to maintain occupant comfort. Day-lighting, or daylight-sensors, blinds, window shades, and other measures may help to control the lighting loads in these different situations more effectively.
- **Look for low-cost or no-cost system modifications first:** In addition to operation and maintenance practices, there are a number of relatively low-cost or no-cost, quick return measures that can help existing systems maximize their operating efficiency, increase efficiency, or help reduce energy consumption. These are discussed in detail below. They can range from changes in operating procedures, to automating system settings - for example, installing occupancy sensors for low-use areas, automatic switching, or de-lamping may yield additional savings.
- **Keep up with "regular" system upkeep:** These are the "normal," routine maintenance practices as required by the buildings' particular lighting systems and operation schedule. This includes maintenance, fixture cleaning, lamp replacement, and other measures such as testing and fine tuning sensors, etc.. Keep in mind that this is sometimes the best, simplest, and most conventional approach to maximizing energy efficiency in any buildings. Often, a poorly designed building with good O&M (operations and maintenance) practices will outperform a well-designed building with poor O&M practices.

B. Lighting Maintenance Practices

Lighting maintenance practices vary widely, depending on the type of equipment, building type, and the tasks performed by its occupants, as well as building location, size, use pattern, and purpose. Thus, it is

almost impossible to come up with a set of specific maintenance practices that fits all of the possible combinations. Rather, the set of maintenance practices below should be used as guidelines to help you develop a combination of building maintenance and operation practices as well as schedules that will best serve the occupants' lighting needs while maintaining the proper lighting levels and light quality.

One of the possible first steps in improving system efficiency is a preliminary energy audit to assess the savings potential of various efficiency measures. A preliminary audit can be obtained from energy service companies, architecture and engineering firms, or utilities. Audits can also be done by qualified internal staff or maintenance engineers. These audits are essential for lighting energy efficiency because there are a number of easy efficiency measures available that offer very short payback periods, depending on the age and type of lighting equipment you have in service.

1. Sensors

Use occupancy sensors to switch lights off when not needed.

Basic sensor usage guide:

- **Set sensors to avoid "false-offs."**
- **Watch for non-human sources of motion that can trigger sensors.**
- **Be aware of equipment that uses radio frequencies or emits infrared signals, which may affect sensor settings.**
- **Set sensors to fail on the "on" position in dark areas**
- **Inspect regularly for user overrides to the sensor settings.**
- **Keep clear and accurate diagrams with marked areas of sensed zones, distinguishing high and low-sensitivity areas**

As with almost any energy-consuming equipment, the easiest way to save energy is to switch it off when not needed. Lights that can be shut off during unoccupied hours should be shut off promptly at the end of the workday, and over weekends and holidays. Additional savings can be achieved in commercial and institutional buildings through close coordination with janitorial hours. Where zone control is available, lighting in unoccupied zones can be shut off with no loss to occupant comfort. "Zoned" systems can provide better control of building lighting during both occupied and unoccupied hours.

Using sensors located throughout a building can help in maximizing the potential of a "zoned" system at minimal cost. Some sensors allow for both temperature and occupancy detection, and can be the basis of an automated setback system for both lights and HVAC. In general, simple occupancy sensors are the most common lighting control used in buildings today. For outdoor lighting, the simple photocell helps to turn lights on at dusk and off at dawn, which can help to reduce energy use further.

Two technologies currently dominate the market for occupancy sensors: infrared and ultrasonic. Infrared sensors detect temperature changes in a room, and work well where the entire room is within the sensor's field of view. Ultrasonic sensors use high frequency sound to detect motion (even around corners). There are also dual-technology sensors that use both methods, increasing accuracy and flexibility, but they are more expensive. Even though lamp life may be somewhat shortened by increased on-off switching, the overall life of lamps is usually extended by the reduced daily burn hours. Sensors work best in areas

with low occupant densities, such as single or double offices, meeting rooms, lunch rooms, locker rooms, hallways, bathrooms, or warehouses and storage spaces. Note that care must be used in setting sensors for adjoining offices, as ultrasonic sensors may interfere with each other.

In higher-density areas such as "cube farms" with many partitions or other open area offices, an automated, scheduled on-off system may make more sense, unless occupants tend to keep an irregular schedule, then a wide-area infrared sensor could be used. In these areas, it is important to remember that partitions can easily mask occupants, especially if the work being done there is mostly desk-related. As with any type of automated controls, maintenance practices must ensure that any existing automatic controls are operating properly. Additionally, outdoor lights are often controlled by photocells, and these may need to be cleaned occasionally or replaced.

Basic sensor usage guide:

- For computer intensive office environment, sensors need to be set to avoid "false-offs" such as when a computer user remains motionless for long periods.
- Beware of other false sources of sensor triggers, such as air diffusers or curtained windows.
- Radio frequencies such as remote controls or other emitters may affect sensor settings.
- Set sensors to fail to the "on" position in dark areas to avoid creating dangerous conditions.
- Routine inspection of sensors may be needed to account for user overrides.
- Keep clear and accurate diagrams with marked areas of sensed zones, distinguishing high and low-sensitivity areas.

2. Lighting levels
Main lighting level maintenance goals:

Set lighting at levels that are appropriate to the tasks, rather than uniform everywhere.

- **Check lighting levels for compliance with IESNA lighting recommendations (Table A below) for adequate light.**
- **De-lamp over-lit areas.**
- **Clean and maintain fixtures so they distribute light as designed and provide the intended light quality.**
- **Reduce operating time.**
- **Use daylight wherever possible.**
- **Use the most efficient luminaires when installing replacements.**
- **Invest in a light meter and use on a regular basis.**

As discussed above, it is more important to provide illumination suitable for the task or tasks being performed, rather than to provide an area with a uniform, pre-determined light level. The human eye is more sensitive to contrast and difference in lighting levels rather than the highest level of light available to it. Because different tasks require differing light levels, it is also better to provide high-quality light where needed, rather than high levels of light.

The IESNA (Illuminating Engineering Society of North America), has worked to determined a range of suitable light levels measured in foot-candles for certain indoor tasks. Nine general categories for typical office, institutional, and educational settings and their IESNA-recommended light levels are listed below, in Table A. Note that these recommended light levels do not distinguish the ambient light levels - which are required for general illumination, from the task levels, which is the light level needed at the work surface. Therefore, it is important to remember that these levels can be met with a combination of ambient and task illumination.

Table A

Type of Activity	Recommended Illumination levels (range in foot-candles)	Notes
Public Spaces	2-5	General or ambient lighting
Short, temporary visits or short visual tasks (for example, bathrooms, closets)	5-10	General lighting
Occasional visual rasks (for example, lobby)	10-20	
Visual tasks of high contrast or large size (for example, reception areas)	20-50	Measured at work surface, may require supplemental task lighting
Visual tasks of medium contrast or small size (most office work fall into this and the above category)	50-100	
Visual tasks of low contrast or small size (for example, light assembly work)	100-200	
Visual tasks of low contrast or small size over long periods (most electronics assembly/inspection work are at this level or below)	200-500	Illumination at work surface requires a combination of general and task lighting
Very prolonged and exacting visual tasks	500-1000	
Very prolonged visual tasks of low contrast and small size	1000-2000	

The opportunity for energy savings here is that the ambient, or general level of lighting can be lowered as long as there are sufficient light levels at the work surface for the tasks to be accomplished.

It is also important to keep in mind that many fluorescent lighting systems put in place a decade or more ago tend to provide too much lighting, or may provide the inappropriate type of lighting for current office use. These ten or fifteen years-old systems also tend to use more energy and produce excess heat, resulting in high energy consumption and user discomfort. Strategies to bring these spaces into conformation with the IESNA recommendations include:

- Bringing over-lit areas to more comfortable lighting levels through de-lamping.
- Improving existing fixtures (through add-ons) to distribute and improve light quality.
- Installing control technologies such as sensors or automatic switching systems to reduce operating time.
- Retrofitting or replacing existing systems with the most efficient luminaires.

In addition to these strategies, following the IESNA recommendations allows the ambient light levels in public areas to be reduced or turned off if sufficient day-lighting levels are available. Where possible, lighting levels in areas such as interior hallways (where no natural light is available,) can also be reduced, yielding additional savings. Areas that are typically over-lit include public spaces, corridors with outside windows, as well as hallways, storage areas, and meeting spaces - where the lighting levels in these areas can be reduced by "de-lamping." This practice involves the removal of lamps from multiple-lamp fixtures (for example, a 4-lamp 2 x 4 fixture).

3. Lighting Regimens

Using a daily lighting regimen reduces overall energy usage:

- **Use natural daylight and dim or switch off interior lights as appropriate.**
- **Use task lighting to avoid over-lighting non-work areas.**
- **Use time scheduling systems to match lighting to work hours.**
- **Set non-work and less intensive work areas to lower lighting levels.**
- **Provide dimming controls for areas where full light levels are not needed.**

In addition to the use of sensors to reduce the need for lighting in unoccupied areas, the implementation of a regular building-specific or even work area-specific illumination schedule or schedules can help provide additional energy savings in office buildings where workers tend to keep fairly regular work hours. For buildings with irregular work hours, such as computer or security offices, for example, task lighting is usually the best approach to energy savings. Other strategies discussed earlier can also be incorporated in a building's lighting regimen to further increase lighting energy savings:

Daylighting

Natural daylight can be used to great benefit and allows interior lights to be dimmed or switched off when appropriate. Not only does natural daylight consume no electricity, it produces less heat than any other electric light source. Thus, careful use of daylight can reduce air conditioning costs as well as lighting costs. Available automatic dimming systems can be used to maintain the proper light levels automatically. However, maintenance O&M practices can include such manual measures as adjustable blinds and light switches to maximize the use of daylight. In addition, reflective film may be used to control intensity and glare, especially on east and west windows. Corridors and open cubicles near windows, particularly those with task lighting, are good candidates for daylighting controls. Private offices with windows can also be equipped with individual daylight sensors.

Task Lighting

As seen in the IESNA lighting levels recommendations, light level requirements vary for different tasks, thus the existing ambient levels can be reduced with no loss to comfort if everyone is provided with supplemental task lighting, or if task lighting already exists for an area. Light levels for other areas such as lobby, hallways, and conference rooms can also be reduced, provided that work areas are sufficiently lit.

Time Scheduling

Large open office areas - which may not work well with other sensor measures, tend to work well with simple time scheduling - automatic switching of lights at fixed hours of the day. Time scheduling can be accomplished by maintenance staff, with simple time clocks, if more sophisticated computer controls are not available. Time scheduling systems can be designed so that lights are turned on manually rather than automatically at the beginning of the day, but are turned off automatically at 1- or 2-hour intervals after close of business, to help save more energy. The addition of override switches allows users to turn on the lights after hours (using wall switches or telephone dial-up codes) when needed.

Bi-level Switching

In offices where occupants work intensively with computers, it may be better to lower overhead lighting levels (especially if daylight is available), especially if the lighting in these areas were not designed for computer-intensive work. Lower light levels are also preferred for meetings, or tasks that are not visually demanding. Bi-level switching can provide simple manual control for these work areas. For example, in a typical 3-lamp fluorescent fixture, the outer lamps can be set to be switched separately from the middle lamp, allowing the user to switch on one, two, or all three lamps. This low-cost measure is a minimum control requirement in some state energy codes, and can provide a simple means of load- shedding during peak hours if the bi-level lighting circuits are remotely controllable.

Manual Dimming
In rooms where different light levels are needed at different times, such as conference rooms and some private offices, the use of manually-operated dimming controls is a common solution to reduce energy use.

4. Maintenance and Replacement

Lamp Maintenance

Lamp and system maintenance key points:

- **Use an Energy Management System, if available, to control lighting and HVAC.**
- **Inspect and test sensor functions and operations.**
- **Test daylight sensor functions and get user feedback.**
- **Schedule regular maintenance and cleaning of sensors.**

Energy Management Systems (EMS) are often used to control HVAC systems but can also control lights. It may be worth some time to investigate to see whether or not your present EMS can be used to control your lighting. If you are in the process of purchasing a new EMS, consider the addition of lighting control options. One typical type of control system switches off all but emergency lighting periodically, e.g. every hour outside work hours. Time scheduling controls should be set so that the switching times and intervals make serve the needs of the occupants, and usage pattern of the area. In addition, occupants need to be informed about the system and how to override the schedule when needed.

The proper installation and maintenance of daylight and occupancy sensors is another essential O&M task. Placement of controls should take into account furniture placement as much as possible, as occupancy sensors need to be able to sense all occupants to avoid turning off lights while the space is occupied. At the same time, some "false-on" incidents can be triggered by an automatic on/off sensor that can sense passersby in an adjoining hallway if the settings are too sensitive.

Daylight sensors that are placed where they are exposed to an amount of daylight not proportionate to the daylight at the desktops or work areas being served will not properly control lighting levels, and will likely result in dissatisfied users (who may attempt to disable the control system). Daylight sensors should be selected for their ability to be calibrated quickly and easily. They also need to be correctly calibrated. The dimming adjustment should be easily accessible to the installer and provide an acceptable range of dimming.

The maintenance and calibration of lighting controls are essential if energy savings are to be achieved and maintained. Occupancy sensors with sensitivity set too high can fail to save energy, but occupancy sensors with too low a sensitivity or too short a delay time can be annoying to occupants. Similarly, improperly adjusted daylighting controls can dim the lights too low, causing occupants to override them (e.g., by taping over the sensor), or can fail to dim the lights at all.

5. Lamp Replacements

Lamp replacement - routine replacement key points:

- **Select replacement linear lamps with a minimum of 12, 000 hours rated life.**
- **Use replacement lamps with low mercury content (3.8 mg per 4ft lamp or less).**
- **Replace existing lamps with more efficient equivalents.**
- **Use CFLs (compact fluorescent lamps) instead of incandescent bulbs.**
- **De-lamp or reduce the number of lamps in low-use areas.**
- **Where appropriate, set a regular schedule for group lamp replacement**

Lamp replacement - upgrading key points:

- **Specify T-8 lamps and electronic ballasts.**
- **Specify replacement lamps with the lowest mercury content (3.8 mg of mercury or less per 4 foot lamp).**
- **Specify longer-life linear fluorescent lamps with 20,000 hours rated life.**
- **Specify 2-by-4 foot troffer luminaires for most applications.**

Lamp replacements - individual or group replacement key points:

- **Determine a replacement schedule for lamps based on current use.**
- **Incorporate other maintenance activities such as ballast inspection and fixture cleaning into the replacement process.**
- **Use more energy efficient lamps of the same color temperature for replacement.**
- **Where possible (in a large, open office area, for example), consider group relamping, which tends to costs less on a per-lamp basis and helps ensure lighting of the same quality in areas where this is practiced.**
- **Schedule replacement outside of working hours, to minimize disruptions. Outside contractors can be used for lamp replacement if necessary.**

There are two different replacement topics - replacing existing lamps with more energy-efficient products, and routine replacement of lamps in service. Regardless of your replacement practices, there are two important lamp characteristics that can directly affect the environment. In addition to color rendering and color temperature (both of which can affect lamp/lighting system performance and user satisfaction) the two most important environmental characteristics of linear fluorescent lamps are:

Lamp Longevity - Although most linear fluorescent sources last for a long time, various factors can affect system performance and reduce lamp life. The selection of a durable system not only ensures that less solid waste will be introduced into the environment, it also means that the components have been tested to be used as a system, thus ensuring user satisfaction and reduces failure incidents. We recommend that you choose systems with rated lamp life of 12,000 hours or more.

Lamp Mercury Content - All fluorescent lamps contain a small amount of mercury vapor. We recommend that you select lamps with the lowest mercury content for your particular application. Maximum lamp mercury level should not exceed the State of California's requirements, at 3.8 milligrams per 4-ft lamp.

a. Existing lamps:

One of the most cost-effective lamp replacement strategies is to replace existing lamps with a more energy efficient equivalent, or take the energy consuming lamps out of service. For office and other commercial/institutional spaces, this strategy often involves replacing incandescent lamps with compact fluorescent lamps (CFLs). CFLs now come in an ever-expanding variety of shapes and sizes to fit incandescent fixtures, and cost has dramatically dropped. Using the 1/3 or 1/4 to one rule for CFL replacement wattage (use CFLs that are 1/3 to 1/4 the wattage of the existing incandescent lamp) should provide the space served by these fixtures with the same, if not more, light. Replacement of incandescent lamps with CFLs will dramatically reduce the energy consumption of any space - CFLs are also available with "anti-theft" locking devices to minimize losses.

Selecting CFLs - look for CFLs that have qualified to carry the USEPA/DOE's ENERGY STARÒ label, which have met certain performance requirements such as efficacy, lamp life, and UL/safety testing). At a minimum, choose CFLs with

- electronic ballast
- 10,000 hours rated life or more
- illuminates within 1 second
- minimum color rendering index (CRI) of 80
- mercury content of 3 mg or less

The chart below provides the most common incandescent equivalencies and minimum CFL efficacy (lumens per watt - the amount of light output for the amount of power input):

CFLs

Incandescent watt	Equiv. Lumens	Equiv. CFL	Min. Efficacy Levels
40 watts	495 or more	11 - 14 watts	45 lpw or more
60 watts	900 or more	15 - 19 watts	60 lpw or more
75 watts	1200 or more	20 - 25 watts	60 lpw or more
100 watts	1750 or more	29 + watts	60 lpw or more

Another possibility is to take incandescent lamps out of service completely. If you have spaces where the ambient light levels are provided by incandescent downlights (also known as "cans" or "high hats," such as hallways, meeting rooms, bathrooms, etc., consider taking these fixtures out of service and installing fluorescent fixtures in their place. While these fixtures can accept the newer generation of CFLs, the design of these fixtures tends to shorten the service life of CFLs due to heat build-up. CFLs used in these fixtures can also suffer performance and optic problems such as glare, and can result in user discomfort.

However, if you choose CFL reflector type bulbs, use the above criteria, and use the chart below to help your selection:

Reflector-Type CFLs

Incandescent watt	Equiv. Lumens	Equiv. CFL	Min. Efficacy Levels
50 watts	550 or more	17 - 19 watts	33 lpw or more
60 watts	675 or more	20 - 21 watts	40 lpw or more
75 watts	875 or more	22 + watts	40 lpw or more

Finally, as discussed above, de-lamping is another possibility for reducing energy consumption. If you choose to practice de-lamping, care must be taken to insure that lamps are removed in a uniform fashion to eliminate "dark-spots," and that the remaining light levels are sufficient for the tasks. In addition, de-lamping is most effective when the remaining lamps and ballasts are still matched. Depending on the existing wiring, some ballast can consume as much energy with a partial load as with a full load.

Lamp/Ballast General Replacement Recommendations - Ambient Lighting

- Choose T8 lamps and electronic ballasts where both lamp and ballast replacement is feasible.
- Choose replacement lamps with the lowest mercury content available for your application (3.8 mg of mercury or less per 4 foot lamp).
- Select replacement linear fluorescent lamps with 12,000 hours rated life or more
- Generally, a 2-lamp in a 2-by-4 foot troffer luminaire is suitable for most applications. Most 4-lamp fixtures can be de-lamped to this configuration.

b. Routine Replacement

If your O&M practice involves individual replacement of fluorescent lamps (especially linear tubes) as they are burned out, consider switching to group replacement of lamps (see the above section to help you select replacement lamps). However, if group replacement is not an option in your maintenance schedule, consider adopting or incorporating some of the other maintenance tasks into the replacement routine, such as fixture cleaning and ballast inspection to help maintain light output and keeping fixtures at peak performance. Below are some key points to add to your maintenance practices:

Individual lamp replacement key points:

- **Inspect building for lamps failure on a regular basis.**
- **Do not wait for complaints from users.**
- **Set up a maintenance request system for occupants to report lamp failure.**
- **Clean fixtures on a regular basis.**
- **Inspect ballasts and perform other maintenance on a regular basis.**

If you are considering switching from individual lamp replacement to group lamp replacement in your maintenance practices, below are some factors to consider.

- Group relamping actually costs less on a per-lamp basis. To replace one individual fluorescent tube (or CFL) can actually take a worker as much as one half hour or longer from the start to finish. Having all of the materials on hand and systematically moving from one fixture to another reduces the per-lamp replacement time to about three to five minutes. Another added advantage is that the whole process can be done outside of working hour, and minimizing disruptions.
- Group replacement is an easy task to schedule, and can even be handled by an outside contractor. This can reduce the administration cost, and reduce the need for dedicated staff time for lamp replacement.
- Other maintenance activities can be incorporated into the replacement process, such as ballast inspection, and reflector and diffuser inspection and cleaning. It also provides an opportunity to upgrade reflectors, installing lenses, or other maintenance and servicing tasks.
- Group replacement can provide better control over replacement lamps, since the same types and color lamps will be used. It helps to reduce instances of incompatible lamps, or where lamps of different color temperatures and color rendering indices are mixed, and therefore affecting user comfort.
- Finally, group relamping can provide users with brighter and uniform light levels, because it reduces the chances of lamps reaching their end-of-life characteristics or lumen depreciation curve. This also reduces user complaints (flickering lamps) and reduces instances of on-the-spot maintenance calls.

Note that you can typically calculate group relamping intervals, but the exact burn hours and lamp life usually are not known accurately enough. Thus, some organizations use a simple method of determining when to re-lamp: When group re-lamping, buy 10 percent more lamps than needed to re-lamp the area. The use of this 10% overstock is limited to spot relamping only. When the 10% is depleted, it is an indication that it is time to group re-lamp again. The 10 percent overstock typically result in group relamping at about 70 percent rated lamp life.

Lamp/Ballast General Replacement Recommendations - Computer-Intensive Lighting

- Choose T-8 lamps and electronic ballasts where both lamp and ballast replacement is feasible.
- Choose replacement lamps with the lowest mercury content available for your application (3.8 mg of mercury or less per 4 foot lamp).
- Select replacement linear fluorescent lamps with 12,000 hours or more of rated life.
- Parabolic troffers are better than lensed troffers for better glare control, and should be kept in use where task lighting is not available.

c. Fixture and Lamp Cleaning

Routine fixture and lamp cleaning key points:

- **Clean fixtures and lenses at every relamping.**
- **Replace lenses whenever ballasts are replaced.**
- **Clean multi-celled, metal parabolic louvers with an ultrasonic machine.**

- **A good maintenance plan that includes routine cleaning alone can justify the de-lamping of some office spaces.**
- **Two overlooked sources of office dirt and dust in offices are copying machines/printers and paper shredders.**

Lamp and fixture cleaning details:

- **Clean lamps and fixtures with a soft, moist (to prevent static) cotton cloth.**
- **Keep turning the cloth to present a clean surface as the cloth becomes dirty.**
- **Other acceptable re-useable cleaning devices include: soft-bristled brushes with anti-static material, low-powered hand vacuum).**
- **Avoid using disposable cleaning materials such as paper towels.**
- **Clean both sides of acrylic lenses with a mild solution of dishwashing detergent and allow to air-dry.**
- **Use an environmentally preferable laundry fabric-softener in the rinse water to reduce static electricity where needed.**

The routine cleaning of lamps and fixtures is one of the single biggest issues in lighting maintenance. Light-reflecting surfaces and light sources must be kept clean so that the existing systems can deliver designed light levels. Most likely, worker productivity will also suffer if the light levels decline beyond comfortable levels.

Light levels from fluorescent systems can decline gradually over a period of months, due to both dust accumulation and system decline. All light sources used for interior lighting lose their ability to produce light as they age. This condition is more noticeable with fluorescent systems due to their longevity. The term "lamp lumen depreciation" or LLD is used to describe this phenomenon. The values of LLD, also called lumen maintenance, vary between lamp types and manufacturers, and have changed with the newer lamps with rare-earth phosphor, which tend to lose less light output over time.

It is important to note that generally the LLD characteristics of the T8 fluorescent lamp are better than that of the T12 lamps. The T8 lumen depreciation curve tends to level off as it reaches its low point at about 90 percent, instead of continuing to depreciate as the T12 does. In addition, new T8 HO (high output) lamps have especially good lumen maintenance.

Because of the light loss factors from both LLD and poor maintenance practices, lighting designers typically planed for more fixtures and bulbs than needed to ensure there will be sufficient light levels. Therefore, a good maintenance plan that includes routine cleaning alone can justify the de-lamping of some office spaces. Typically, the money saved in energy and lamp costs from de-lamping can more than pay for the regular fixture cleaning and relamping practices.

The use of specular reflectors in computer-intensive has greatly changed lighting maintenance practices, especially fixture cleaning. Parabolic fixtures and specular reflectors must be cleaned to preserve their reflecting properties so light levels can be maintained. Lamp cleaning practices can be simpler with today's offices, as they tend to be cleaner, especially in facilities in which smoking is limited to designated areas.

However, two sources of office dirt and dust in offices remain: copying machines/printers and paper shredders. These machines are often overlooked, but they can greatly affect the amount of dust generated in an office environment. White paper dust generated by copiers and shredders can coat the reflecting surfaces of fixtures, as well as walls and ceilings, resulting in reduced light levels. Copy machines are another source of dust: they can release toner dust that can coat fixture surfaces. The most effective solution is to move these types of equipment to an area with a separate exhaust.

Fixture cleaning - It is recommended that the lamp-replacement crew clean the interior reflecting surfaces of fixtures when lamps are changed. In some office environments, fixtures may need to be cleaned before the lamps are replaced, but in most interiors, cleaning at lamp change intervals may prove to be adequate.

Environmentally preferable fixture cleaning practices: generally, fixtures and lamps cleaning do not require harsh chemicals or volatile cleaning solutions. Fixtures usually require a simple dusting of the interiors (as well as the dusting of lamps, depending on your cleaning and re-lamping schedule). Below are some recommended environmentally preferable fixture and lamp cleaning practices:

- A good rule of thumb is to clean fixtures and lenses at every relamping, and replace lenses whenever ballasts are replaced.
- Unusually dirty fixtures or multi-celled, metal parabolic louvers may need to be professionally cleaned with an ultrasonic machine.
- Lamp and fixture cleaning can typically be done using a soft moist cotton cloth, which needs to be continually turned to present a clean surface as the cloth becomes dirty. Care should be used to keep the cloth moist, thereby avoiding the building up of static electricity, which will re-attract dust. Other re-useable cleaning devices (such as a soft-bristled brushes with anti-static material or low-powered hand vacuum) can and should be used instead of disposable materials.
- Most fixtures' acrylic lenses can come clean with a mild solution of dishwashing detergent. Both sides of the lens should be rinsed and allow to air-dry. (A dirty lens can reduce a fixture's light output up to 50%).
- With some fixtures, static electricity can be a problem in attracting airborne dirt. The use of an anti-static material, such as an environmentally preferable laundry fabric-softener in the rinse water, is a possible solution where static electricity is a problem.

Note that there can be some resistance to cleaning practices when electricians are asked to clean lamps and fixtures instead of custodial workers. Usually, electricians probably can be put towards more productive tasks than changing lamps or cleaning fixtures. In addition, custodians who are tasked with relamping may be more likely to clean fixtures properly.

O&M managers should consider developing and implementing a maintenance action plan that include both regular cleaning and relamping to achieve the full range of benefits generated by well-maintained lighting. We recommend that you consider taking the following steps to achieve better energy and maintenance savings:

- Survey your facility to establish and record the maintenance condition of the lighting systems.
- Schedule relamping in groups and spot re-lamp intervals suitable to your workers' needs and lamp types to reduce lumen depreciation, save labor cost and improve productivity.
- Include routine cleaning of fixtures when lamps are replaced.
- Consolidate bulbs and tubes based on suggested criteria to reduce the inventory of different types of lamps.
- Develop a lighting system maintenance policy and review it with your maintenance team to ensure workers use the correct lamps and ballasts and that your lighting system components and sensor components are cleaned and properly maintained.

C. Devices Brought by Employees

Keys to dealing with lighting devices brought by employees:

- **Pay attention to the presence of extra lighting brought by occupants, which indicates additional lighting needs.**
- **Watch for fire hazards (and energy wasters) in the form of halogen torchieres.**
- **Negotiate an agreement with all occupants where they can choose from a variety of energy-efficient desk or task lighting to meet their needs.**
- **In exchange, reduce the zones' or building's lighting to a lower level.**
- **Use a pilot program to identify lighting devices that work.**
- **Set guidelines for these supplemental fixtures (maximum wattages, safety ratings, lumen output, etc).**

High on the list of "external factors" are devices brought in by building occupants to help them deal with variable lighting conditions at their work surface. These devices range from desk lamps to halogen torchieres and other lighting fixtures. These devices at best help to provide occupants with the additional light needed for their tasks, and at worst, become a nuisance, if not a fire hazard, as in the case with halogen torchieres. However, if the goal of O&M practices is to minimize building energy use, these additional fixtures have the potential to wreak havoc with system settings and other reduction measures, resulting in an increase in the building's energy consumption, instead of reducing it.

To maximize savings, one approach to addressing this situation is the possibility of negotiating an agreement with all of the building's or work area's occupants, where they can choose from a variety of energy-efficient desk or task lighting to meet their needs. In exchange, the zones' or building's lighting levels can be set to take these devices into account, such as providing the area with only ambient lighting at low levels. A pilot program can be used to identify the devices that work well for occupants and the lighting levels. Guidelines can also be set for these supplemental fixtures (maximum wattages, safety ratings, lumen output, etc) during these pilots.

Overall, there are opportunities in reducing energy consumption if these devices are taken into account rather than ignored. In addition, the involvement of the building occupants in the pilot and decision making process often help to make the process work better, resulting in maximum energy savings.

D. Outdoor and Exterior Lighting Maintenance

Keys to energy-efficient outdoor and exterior lighting:

- **Turn off all unnecessary light.**
- **Use daylight controls, or photo sensors to turn off lights whenever adequate daylight is available. Inspect and test sensors regularly.**
- **Use energy management systems and time clocks to limit lighting to certain operating hours.**
- **Check system setting and adjust time clocks with time of year to minimize operating hours and maximize savings**
- **Adjust timer switches and sensor to turn on lights for only short duration, especially for non-essential or non-security lights (loading docks, for example).**
- **Clearly label all switching devices to save time and help employees identify which lights should be shut-off at specific times.**
- **Check and adjust fixtures so that lights are aimed where needed.**
- **Use incandescent sources only if they are integrated with a control mechanism that significantly limits the time that they operate.**

Overview

Generally, there are four ways in which outdoor and exterior lighting can contribute to unnecessary light and energy use:

1.To have non-essential lighting energized especially after hours.

2.Using energy inefficient equipment.

3.Sending light up into the atmosphere either by direct light or by reflected light.

4.Over lighting or poor lighting (as indicated by excessive glare or eye adjustment).

Effective outdoor and exterior lighting design often incorporates careful consideration of many variables such as overall visibility, safety and security, and energy efficiency. More recently, there are other outdoor lighting concerns that may also need to be evaluated depending on the location and type of application. Most often, there will be concerns with a combination of these issues, listed in the table below. These concerns have arisen from a combination of poor design and over-use of outdoor and exterior lighting for commercial and institutional buildings.

Table 1. Outdoor and Exterior Over-Lighting Issues

Concern	Description and Cause	Ways to Minimize
Sky glow	The haze or "glow" of light that surrounds highly populated areas and reduces the ability to view the night time sky. It results from: • Light emitted from a luminaire in a direction above the plane of the horizon. • Light emitted from a luminaire in a direction below the plane of the horizon but reflected from the surrounding surface towards the sky.	• Turn off non-critical lighting late at night. • Limit the use of non-cutoff luminaires. • Insure that luminaires emit little to no light above the plane of the horizon. • Utilize internal or external shielding that minimizes the component of light above horizontal.Note: non-cut off luminaires have no shielding or are open at the top, allowing light to shine upward as well as downward. For example - post lamps.
Light trespass	Light trespass occurs when neighbors of an illuminated space are affected by the lighting system's inability to contain its light within the area intended. Light trespass is caused by the inappropriate selection, tilting or aiming of outdoor luminaires for the particular lighting task.	Light trespass can be minimized through careful selection of lamp wattage, luminaire type, and placement. Appropriate reflector selection, aiming and shielding of the luminaires can keep the projection of the light within property boundaries.
Glare	Glare occurs when a bright source causes the eye to continually be drawn toward the bright image or the brightness of the source prevents the viewer from adequately viewing the intended target. Glare may create a loss of contrast or an afterimage on the retina of the eye reducing overall visibility.	Luminaires may be equipped with louvers and/or exterior visors to prevent viewing a bright source at lower angles. Luminaire shielding, or "cut off" luminaires (luminaires with specific light output patterns) can prevent the direct image of a bright source and lower the intensity of the light at high angles and direct more light downward. The use of quality prismatic or opaque lens materials can reduce the brightness of the source.

Many states and municipalities have developed outdoor lighting codes to address these issues. These codes are designed to reduce "sky glow," minimize light trespass onto adjacent properties, as well as limit glare and energy consumption. These legislation efforts may include requirements such as use of specific light source types or wattages, pole height limitations, or requirements for full cutoff luminaires. In addition, the Illuminating Engineer Society of North America (IESNA) have arrived at the levels of illumination listed in the table below

Table 2. IESNA Recommended Outdoor Lighting Levels

Location	**Light level in footcandle (fc)[1]**	**Uniformity ratio[2]**
(a) Streets, local commercial Residential	0.9 Avg. 0.4 Avg.	6:1 6:1
(b) Parking, multi-family residential, • Low vehicular/pedestrian activity • Medium vehicular/pedestrian activity	0.2 Min. 0.6 Min.	4:1 4:1
(c) Parking, industrial/commercial/institutional/municipal • High activity, e.g., regional shopping centers/fast food facilities, major athletic/civic/cultural events. • Medium activity, e.g. community shopping centers, office parks, hospitals, commuter lots, cultural/civic/ recreational events • Low activity, e.g., neighborhood shopping, industrial employee parking, schools.	0.9 Min. 0.6 Min. 0.2 Min.	4:1 4:1 4.1
(d) Sidewalks	0.5 Avg.	5:1
(e) Building entrances, commercial, industrial, institutional	0.5 Avg.	-

Notes: 1. Illumination levels are maintained horizontal footcandles on the task, e.g., pavement or area surface.

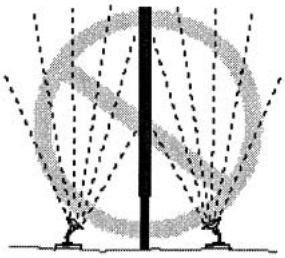
2. Uniformity ratios dictate that average illuminance values shall not exceed minimum values by more than the product of the minimum value and the specified ratio. E.g., for commercial parking high activity, the average footcandles shall not be in excess of 3.6 (0.9 x 4).

The following measures can help to maintain outdoor and exterior illumination levels necessary for the safety of the public, employees, and property, while reducing total electrical usage.

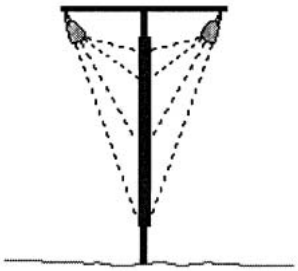
- Evaluate existing exterior lighting systems and identify non-critical lighting. Clearly label all switching devices to save time and help employees identify which lights should be shut-off at specific times.
- Use only and replace inefficient light sources mercury vapor, incandescent, halogen) with energy efficient lamp technologies wherever possible (metal halide, induction lamps, high-pressure sodium, and linear and compact fluorescent sources). Avoid using fluorescent sources that are not suited for low temperature operation. Incandescent sources can be used only if they are integrated with a control mechanism that significantly limits the time that they operate.
- Use IESNA recommended light level ranges. Use the lower recommended values in order to lower energy usage. Abnormally bright lights can create glare and deep shadows, which can make seeing extremely difficult. Illumination ratios between areas should be minimal (e.g., less than 10:1)
- Locate outdoor lighting where it is needed. For example, locate outdoor lighting below tree canopies, not above.
- In parking lots, use efficient and cutoff lighting fixtures that emit no light above the horizontal or into the sky, fixtures that emit no more than 2.5 percent of the lamp lumens upward. Use cutoff lighting fixtures for all lamps greater than 2800 lumens. This will minimize wasted light going up into the atmosphere.

Examples of some Common Lighting Fixtures

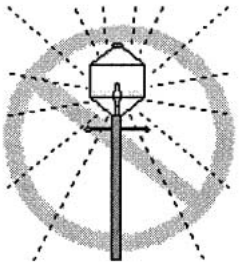
Poor | Good



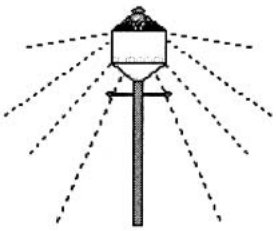
Ground-mounted
Billboard Floodlights



Top-mounted
Billboard Floodlights
(carefully focused onto billboard)



Post-style Lamp
(more then 1,800 lumers)



Post-style Lamp
(Lamp set in opaque top)

Outdoor and Exterior Lighting Controls

There are a number of excellent automatic lighting controls that may be used to turn off exterior lights when appropriate:

1.Daylight controls, or photo sensors, used to turn off lights whenever adequate daylight is available.

2.Energy management systems and time clocks, used to limit lighting to within certain operating hours.

3.Timer switches, used to turn on lights for only short duration.

Evaluate and set specific outdoor lighting, as appropriate, to automatically lower or turn off after the close of business and/or after all employees have left the premises. After business hours, lower light levels to minimal levels, just enough to detect movement and provide sufficient security. Use timers, motion sensors, or an energy management system to turn-off or reduce lighting.

Some security lighting can be activated with motion sensors so that lights come on only when someone is in the immediate area (consult with local law enforcement). Energy efficient lamp sources ideal for motion sensors include fluorescent and induction lamps. When using "on-off" motion sensors for security lighting, avoid the use of sources that require a period of time to achieve full brightness (HID sources such as Metal Halide or High Pressure Sodium). Incandescent sources can also be an effective source for this type of application since it will only operate a limited time and is not sensitive to temperature effects.

E. Lamp Disposal

Lamp disposal key points:

- **Handle spent lamps with care**
- **Avoid crushing or breaking lamps during transport**
- **Set aside a location to collect spent lamp**
- **Educate everyone on the need for careful handling**
- **Do not discard broken lamps - they should also be put aside for recycling.**
- **Arrange for regular recycling pickup.**

Fluorescent and other high-intensity-discharge light sources generally require care in their handling and disposal. Fluorescent light sources and other efficient sources such as HID, and even inefficient sources like mercury vapor lamps, require small amounts of mercury to operate. Care is needed during the unpacking, installing or replacing process for these light sources. CFLs, linear fluorescent, and HID are made of glass tubing and can break if it is dropped or mishandled

Mercury is a hazardous material, and its disposal and handling is regulated by the EPA and state regulations. In general, state waste disposal regulations take precedence over federal regulations. Additionally, some county disposal regulations may even be more stringent than a state's regulations.

On July 6, 1999 EPA added hazardous waste lamps to the federal list of "universal wastes". Hazardous waste lamps are any lamps that are characteristically hazardous. That is, they fail the TCLP (Toxicity Characteristic Leaching Procedure). This includes fluorescent, high intensity discharge, neon, mercury

vapor, high-pressure sodium, and metal halide lamps, if they are characteristically hazardous. Fluorescent lamps are hazardous because they contain mercury.

The new rule became effective on January 6, 2000. The Universal Waste Rule of 1995 was designed to reduce the amount of RCRA hazardous waste disposed of in municipal waste landfills, encourage recycling and proper management of some common hazardous wastes, and reduce the regulatory burden on businesses currently managing these materials as hazardous waste. "Universal wastes" are hazardous wastes; however, they have less stringent requirements for storing, transporting, and collection. Universal wastes are regulated under 40 CFR 273 and 25 PA Code 266(b). Options for managing lamps include managing them as hazardous waste, managing them under the universal waste rule, or using a type of lamp that is not hazardous.

The change in federal regulations has been adopted into the Pennsylvania Hazardous Waste Management regulations by reference under 25 Pa Code 260a.1. The major difference between the federal regulations and the PA regulations is that the federal regulations allow a conditionally exempt small quantity generator (someone generating less than 220 pounds of hazardous waste /month) to dispose of their waste in a municipal waste landfill. **However, the Pennsylvania regulations state "a conditionally exempt small quantity generator may not dispose of hazardous waste in a municipal or residual waste landfill in this Commonwealth" (see 25 PA Code 261a.5 (b)).** The effect of this regulation is that, in Pennsylvania, all fluorescent lamps, if hazardous, must be managed as either a universal waste or manifested as
hazardous waste. There are newer lamps on the market that have lower levels of mercury and thus are not hazardous waste. If the lamps pass the TCLP they are not hazardous waste and may be disposed in a municipal waste landfill.

A list of fluorescent lamp recyclers is available from the Pennsylvania Department of Environmental Protection at: **http://www.dep.state.pa.us/dep/deputate/airwaste/wm/hw/florlist.htm**

Three of the best and most accurate resources can be found on the internet, listed below.

The U.S. Environmental Protection Agency (EPA) maintains a web site that lists contact information for state agencies charged with hazardous waste regulations:

http://www.epa.gov/epaoswer/hazwaste/state/links.htm

Another helpful web site can be found at Envirobiz International Environmental Information Network's web site (click on government regulatory agencies) at:

www.envirobiz.com/searchmenu.htm

Earth's 911, a non profit educational organization, provides recycling resources by zip code at its web-site:

www.1800cleanup.org

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Cleaning Procedures

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Overview

Green maintenance services are a process that reduces the overall impacts of cleaning on health and the environment. While product selection is important as discussed earlier, procedures for green maintenance services are equally important, and perhaps more so.

In Section 12 of the Green Cleaning Appendix, "Defining Environmentally Preferable Products," the issue of preferability is defined specifically to state that it is not one of "good" green products versus "bad" traditional products. Rather the issue is defined as one of preference -- to reduce impacts on health and the environment. When addressing procedures in a green maintenance program the same approach must be followed.

In general, green maintenance procedures are similar to traditional procedures. The differences are more a matter of focus then one of technique. Thus, this is not a "how to" document. Rather, the focus of this section is on pollution prevention strategies and some specific opportunities to modify traditional procedures to reduce impacts on health and the environment.

With the use of any chemical cleaning product or piece of custodial equipment, it is important that appropriate personal protective equipment (PPE) be used and directions followed.

A. Specific Procedure Modifications

While this section will be alphabetized based on subject, the first issue to be addressed is dealing with the needs of people with special needs in the facility. This issue not only emphasizes the focus on protecting health, it also epitomizes the green maintenance focus and need for involvement throughout the facility.

B. People with Special Needs

Action Items:

1. **Identify those building occupants with individual needs and sensitivities.**
2. **Develop a plan to address the individual needs of people with sensitivities.**
3. **Change products and/or cleaning schedules as necessary to accommodate their individual needs.**
4. **Address ventilation requirements to help mitigate the problems.**

One of the primary goals of a green maintenance program is to protect the health of building occupants. This is done in many ways including the identification and removal of harmful contaminants, such as particulates, mold spores, bacteria and viruses. And while the cleaning process can reduce exposure to these and other harmful contaminants, unfortunately, the process of cleaning and cleaning products themselves can cause adverse health impacts from building occupants. This is especially true for those who are very sensitive to odors, those with pre-existing health conditions such as asthma and allergies, those with reduced immune systems such as those recovering from cancer, and other health conditions.

For these individuals accommodations must be made relative to cleaning activities such as noise levels, dust, etc. Some may be very sensitive to the fragrances of cleaning products. In some cases reported sensitivities may not even be caused by cleaning products, but rather sensitivities to pet allergens from guide dogs and even co-workers' household pets. Understanding the sensitivities is essential for accommodating the occupants. In some cases different product may be necessary, in other cases the time of day that cleaning takes place may need to be altered and in other cases occupants who are reacting to their co-workers may need to be relocated to other areas within the building.

While in some cases changing the cleaning products or cleaning schedule may address the situation, in other times relocating the individual or reconfiguring their workspace may be necessary, which needs to be addressed by facility management. In many situations these issues cannot be resolved by the cleaning contractor, but requires everyone, including the affected individual, to work together to achieve the best outcome.

C. Dusting and Dust Mopping

Action Items:

1. **Ensure that dust mops are properly treated (see section on product selection) to capture dust.**
2. **Use wide area vacuums fitted with appropriate bags/filters, as much as possible.**
3. **Use lint-free dusting cloths or a vacuum instead of feather dusters.**

Traditional dusting and dust mopping techniques frequently move dust and other contaminants from one area to another, such as from a bookshelf to the floor. It is important to recognize that moving the dust around is more then just an efficiency issue. Dusting and dust mopping activities that do not capture soils frequently stir them into the air where people can then inhale the particles, which for some can become a serious health hazard.

In addition to the traditional procedures for dusting and dust mopping it is preferable to minimize chemical dust treatments. It is preferable to use a vacuum cleaner fitted with a wide area hard floor attachment as compared to a dust mop treated with a high VOC content solvent. If dust mopping is used prefer the widest swivel action mop possible (based on the size of area and the physical abilities of the custodial worker) and a water-based dust mop treatment. Feather dusters should not be used. It is preferable to dust with lint-free damp clothes that are neatly folded like a handkerchief to expose multiple sides for absorbing dust (for recommendations on vacuums and dusting compounds see the section of product selection).

DUST MOPPING

1. Fill a properly labeled trigger spray bottle with dust mop treatment, which has been prepared according to label directions.
2. Spray dust mop treatment onto a clean dust mop. Follow manufacturers directions for application rate. Apply next to the backing, at the base of the yarn. Do not over treat.
3. Roll the dust mop, treated side in. Place in a plastic bag to cure for at least 24 hours. After 24 hours, place treated/cured dust mop on the frame.
4. Dust mop the area, use a continuous motion, without lifting the mop from the floor.
5. Begin with the mop next to the wall. Walk to the other end of the work area. At the opposite end, pivot the dust mop so that the leading edge remains the same. Return to the opposite end. Overlap the previously mopped path by 2 to 4 inches, to ensure complete coverage.
6. One pass with a properly treated dust mop removes dirt, dust and abrasive particles, without leaving the floor dull or slippery. Sweep accumulated soil to a collection area, lightly shake loose soil from the dust mop, and continue. Remove gum, tape or other sticky residue with a scraper, using care not to mar or scratch the floor finish. Continue the dust mopping process until the entire area has been dust mopped. When completely finished, pick up the collected debris using a counter brush and dustpan.
7. Clean excess dust from the mop head. Place the mop over a trash container. Brush with a stiff bristle brush in a firm, downward motion.

8. Store the mop in a hanging position. DO NOT store the dust mop on the floor. The mop treatment will stain the floor, and the mop fibers will become matted.
9. When the dust mop no longer attracts soil, it may be re-treated. Spray the mop at the end of the work shift, and hang to cure overnight.
10. Dust cloths may also be treated with dust mop treatment. Spray lightly and allow to cure for 24 hours before use.
11. Launder soiled dust mop heads. Soak mop heads overnight in a neutral pH cleaning solution. Rinse thoroughly, wring out and hang to dry.
12. Re-treat as directed for initial treatment.

D. Entryways

Action Items:

1. **Clean entryways beginning outside the building.**
2. **Use walk-off matting outside and inside entry. Vacuum, sweep, cleaning these mats frequently, especially during inclement weather.**
3. **Make sure mopping solutions are kept clean using only the correct amount of cleaning chemical (see section on product selection). Do not overuse concentrated cleaning chemicals. Remake as necessary and dispose spent solution appropriately.**
4. **Use appropriate vacuums (see section on product selection). Dispose of captured material or empty bags before half full. Dispose appropriately.**

Entryways are the first line of defense against contaminants. Thus, special effort should be focused in these areas. Begin by cleaning outside walkways leading into the facility. This is especially true during inclement weather.

Large outside entryway areas can be swept daily (weather permitting) with a mechanized sweeper and smaller areas with a large, high quality push broom. Outdoor areas should be periodically cleaned with a high-pressure power washer. During snow and ice, procedures need to be put in place to first protect occupants and visitors from slips and falls. The selection of the appropriate ice melting compounds that will not be tracked into the building is important.

Use walk-off mats both outside the entryways, as well as just inside the doors. Mats should be long enough so that as an adult walks across the mat each foot hits the mat at least twice (typically a minimum of ten to twelve feet). Walk-off mats should not just be used during inclement weather, but all year round. Vacuum walk-off mats at least daily and more frequently in high traffic entryways using a vacuum with a beater bar and vacuum in both directions. Walk-off mats must be cleaned frequently and don't forget to periodically clean underneath them as well.

E. Floor Care

FLOOR CARE - GENERAL MAINTENANCE

Action Items:

1. **Select appropriate metal-free floor finishes that are extremely durable to minimize the need for stripping and recoating.**
2. **Build a solid base, which can be between 6 and 12 coats for a 20% solids floor finish.**
3. **Develop a system to maintain floors on a daily basis, using walk-off mats, dust mopping or vacuuming.**
4. **Develop an interim restoration program to maintain adequate levels of floor finish and appearances.**

The procedures for floor care in a green maintenance program are similar in most instances with those of a traditional program. Beyond the traditional issues, floor care in a green maintenance program addresses the selection of environmentally preferable products and equipment, along with some minor modifications of the procedures themselves.

In a green maintenance program the primary effort should be a pollution prevention strategy, or one that minimizes the need to strip and recoat a floor, or extract a carpet. Thus, a specific focus should be on preventative measures, such as

- Keep outside entryways clean to prevent soils from being tracked into the facility. This may include sweeping, use of a power sprayer, etc.
- Use entry mats to capture soils and moisture from shoes. It is preferable that the mats be large enough for each shoe to hit the mat two times (approximately ten to twelve feet).
- Frequent vacuuming of entryway mats and grating systems.
- Frequent dust mopping of resilient tile floors, especially close to entryways and other sources of particulates (i.e. near copier rooms).
- Periodically clean under floor mats to reduce the potential for moisture to lead to bacterial and fungal growth. Floor mats should be replaced when they get wet with dry mats.
- In general, an intensive cleaning focus on the entryways to capture soils at the entries rather then to remove it after it has spread throughout the entire facility.

When floors and carpets need to be spray buffed or spot cleaned, solutions should be applied from a sprayer in a stream, as compared to a fine mist. This will minimize the amount of material that is atomized and potentially inhaled, as well as minimize over-spray. When floors and carpets need to be stripped, recoated or extracted, it is important that occupants be notified. It is preferable to use the least toxic products possible. Use the least amount of water and ventilate the area with fans if necessary for rapid drying to minimize both the possibility of mold growth and slip-fall incidents.

It is preferable to conduct major cleaning activities on a weekend or some other extended time period when occupants will not be in the facility. This allows maximum time for the building to be ventilated (flushed with fresh air) prior to the return of the occupants.

FLOOR CARE - FLOOR STRIPPING

Action Items:

1. **Notify occupants beforehand if a strip-out is scheduled.**
2. **Select the least toxic products available (see section on product selection). Mix and use products according to manufacturer's directions.**
3. **Use the appropriate personal protective equipment. Gloves, goggles and non-slip foot ware are a must. Aprons, respirators may be necessary depending on products selected.**
4. **Ventilate both during and after stripping.**

The procedure for floor stripping is similar in most instances with those of a traditional program. Beyond the traditional issues, floor care in a green maintenance program addresses the selection of environmentally preferable products and equipment, along with some minor modifications of the procedures themselves.

In a green maintenance program the primary effort should be a pollution prevention strategy, or one that minimizes the need to strip and recoat a floor, or extract a carpet. Thus, a specific focus should be on preventative measures, such as

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- In general, an intensive cleaning focus on the entryways to capture soils at the entries rather then to remove it after it has spread throughout the entire facility.

When floors and carpets need to be spray buffed or spot cleaned, solutions should be applied from a sprayer in a stream, as compared to a fine mist. This will minimize the amount of material that is atomized and potentially inhaled, as well as minimize over-spray. When floors need to be stripped, recoated or extracted, it is important that occupants be notified. It is preferable to use the least toxic products possible (see the section on product selection). Use the least amount of water and ventilate the area with fans if necessary for rapid drying to minimize both the possibility of mold growth and slip-fall incidents.

It is preferable to conduct major cleaning activities on a weekend or some other extended time period when occupants will not be in the facility. This allows maximum time for the building to be ventilated (flushed with fresh air) prior to the return of the occupants.

FLOOR STRIPPING

1. Prepare the area. Place "Floor Hazard" signs at entrances to the area being stripped. Move furniture. Work around heavy furniture or equipment that cannot be moved. Sweep the floor with a treated dust mop. Remove gum, tape and other foreign materials with a scraper using care not to mar or scratch the surface finish.
2. Prepare equipment. Assemble two mop heads and handles. Label one ***"Strip Mop"***. Label the other ***"Rinse Mop"***. Assemble two mop buckets and wringers. Label one ***"Strip Bucket"***. Label the other ***"Rinse Bucket"***. Place black or high productivity stripping pad on the rotary floor machine. Fill the ***Strip Bucket*** with a solution of floor stripper (see section on product selection) following manufacturer's recommendations for dilution rates and water temperature. Fill the ***Rinse Bucket*** with clean, cold water. Add a small amount of a neutral pH cleaner (see section on product selection) following manufacturer's recommendations for dilution rates. Equip a wet vacuum with a floor squeegee tool. Place the equipment in the area where the work will begin.
3. Apply stripping solution to the floor, using the ***Strip Mop*** and ***Strip Bucket***. Dip mop in stripping solution. Lift mop and allow excess stripper to drain back into the bucket. Fan out the mop head on the floor and apply stripping solution along the edges. Continue applying solution using an arc motion from right to left, covering the area between the edges. Apply sufficient solution to thoroughly wet the floor, but DO NOT flood it. (Adequate solution coverage will allow a match or toothpick to float on the surface.) Do not allow solution to dry on the floor. Re-apply as necessary to keep the floor wet. Immediately wipe off splashes from walls, baseboards, glass partitions, etc. with a damp cloth. Allow solution to remain on the floor 5 to 10 minutes. Re-apply as necessary to keep the floor wet.
4. Scrub the floor with the rotary floor machine and stripping pad. Scrub in a circular motion, from side to side. Overlap the strokes made by the machine. Keep the floor wet. Re-apply solution as necessary.
5. Remove the stripping solution from the floor with the wet vacuum and floor squeegee tool. Examine the floor for complete finish removal. Re-strip any areas with residual gloss.
6. Rinse the floor. Apply rinse solution using the ***Rinse Mop*** and ***Rinse Bucket***. Apply sufficient water to thoroughly wet the floor, but DO NOT flood it. Remove the rinse solution from the floor using the wet vacuum and floor squeegee tool.
7. Damp mop the floor with clean water. Empty the ***Rinse Bucket*** and refill with clean water. Rinse the ***Rinse Mop*** with clean water. Damp mop the floor with clean water. Remove Floor hazard signs only when floor is completely dry.

FLOOR CARE - RESTORATION // BUFFING & BURNISHING

Action Items:

1. **Make sure that adequate floor finish exists. Determine if it is time for a scrub and recoat.**
2. **Select the appropriate restoration product. Water-based or low VOC products are recommended (see section on product selection).**
3. **Apply in a stream or coarse spray to minimize amount that gets in the air to breathe and overspray. Do not overapply.**

4. **Select the appropriate equipment (see section on product selection). If burnishing use a vacuum attachment. Use appropriate buffing/burnishing pads.**

Floor maintenance can make enormous impacts on health and the environment. The removing of floor finishes is perhaps one of the most labor intensive and hazardous of all major maintenance operations, placing both cleaning personnel and occupants at risk. Furthermore, frequent stripping introduces significant amounts of environmental impacts through both the use and disposal of products.

Thus, the objective of a green floor maintenance program is to minimize the frequency of stripping/removing and maximize the longevity of the coatings. The restoration process plays a huge factor in the longevity of the coating.

To maximize the longevity of a floor care program, make sure that there is a solid foundation of finish on the floor. Dry buffing and burnishing acts like sand paper on wood and increases the appearance by removing layer after layer to smooth out the surface - the smoother the surface, the shiner the appearance. However, if too much floor finish is removed, then dry buffing and burnishing can actually damage floor tile and increase particles into the air, which can harm health.

When selecting products for restoration, use those that are water-based or low in VOC's (see section on product selection). When applying the restorer from a spray bottle, use a stream or coarse spray. Do not use a fine mist as this increases the potential for fine particles to enter the breathing zone and minimizes over-spray on walls, furniture, carpets, etc.

Match the appropriate pad to the equipment and floor finish. Especially when using high-speed burnishers, it is important to use vacuum attachments to minimize particles in the air. Minimize the amount of finish that is being removed.

F. Carpet Care

CARPET CARE - GENERAL MAINTENANCE

Action Items:

1. **Ensure that vacuums are in good working order using appropriate bags and/or filters.**
2. **Vacuum bags should be emptied or replaced when half full. Dispose properly.**
3. **Clean up spills while they are still fresh.**
4. **Minimize the amount of moisture used during cleaning.**

The procedures for carpet care in a green maintenance program are similar in most instances with those of a traditional program. Beyond the traditional issues, carpet care in a green maintenance program addresses the selection of the appropriate products and equipment (see section on product selection), along with some minor modifications of the procedures themselves.

In a green maintenance program the primary effort should be a pollution prevention strategy, or one that minimizes the need to extract a carpet. Thus, a specific focus should be on preventative measures, such as

1. Keep outside/outdoors entryways clean to prevent soils from being tracked into the facility. This may include sweeping, use of a power sprayer, etc.
2. Use entry mats to capture soils and moisture from shoes. It is preferable that the mats be large enough for each shoe to hit the mat two times (approximately ten to twelve feet).
3. Frequent vacuuming of entryway mats and grating systems.
4. Frequent dust mopping of resilient tile floors, especially close to entryways and other sources of particulates (i.e. near copier rooms) to reduce soiling on surrounding carpeted areas.
5. Establish a specific daily routine for cleaning carpets.
6. Establish an interim cleaning process to address the needs of high traffic areas.
7. Minimize the need for large scale extraction cleaning.

When carpets need to be spot cleaned, solutions should be applied from a sprayer in a stream or coarse spray, as compared to a fine mist. This will minimize the amount of material that is atomized and potentially inhaled, as well as minimize over-spray. When carpets need to be extracted, it is important that occupants be notified. It is preferable to use the least toxic products possible. Use the least amount of water and ventilate the area with fans if necessary for rapid drying to minimize both the possibility of mold growth and slip-fall incidents.

It is preferable to conduct major cleaning activities on a weekend or some other extended time period when occupants will not be in the facility. This allows maximum time for the building to be ventilated (flushed with fresh air) prior to the return of the occupants.

CARPET CARE - EXTRACTION CLEANING

Action Items:

1. **Minimize the amount of cleaning chemicals. Excess chemicals result in rapid resoiling.**
2. **Use appropriate functioning equipment that will maximize the amount of water being extracted from the carpet to minimize moisture and potential for mold, mildew and bacterial growth.**
3. **After extraction of carpet areas that were flooded spray treat the area with a disinfectant solution (e.g., Micro-Ban) to prevent mold, mildew, and bacteria growth.**
4. **Increase ventilation, open windows if weather allows and use fans to dry carpets quickly. Carpets should be completely dry within 24 hours.**
5. **Dispose of cleaning solutions properly.**

Carpets can act as a "sink" that allows particles and other unwanted material to filter down into the backing of the carpets. Once deep down in the carpet the can lead to damage of the fibers and the need to ultimately replace the carpets. But from a health perspective, the biggest enemy of a healthy indoor environment is when moisture provides an opportunity for these unwanted contaminants to become

biologically active. Thus, extraction cleaning can get deep down into the carpets and remove the unwanted contaminants.

Unfortunately, extraction cleaning can also add large amounts of water to the carpet, especially if the equipment is not functioning properly. Select appropriate cleaning solutions (see section on product selection). Mix cleaning solution properly. Using too much concentrated cleaner not only wastes product, but also can lead to more rapid resoiling of the carpet. Do not apply too much solution.

Make sure that the vacuum pick-up is working properly and that there are no holes or leaks in wands or other attachments the decreases suction. When vacuuming up spent solution, repeat the process multiple times in both directions.

Use increased ventilation to help dry carpets. This can be accomplished by opening windows when weather permits, increasing building ventilation and using floor level drying fans. Carpets should dry within 24 hours to minimize the potential for bacteria and other potentially harmful organisms to grow.

Occupants should be notified before large-scale extraction procedures are used as this activity can affect more sensitive individuals. Proper scheduling is recommended when building is not to be occupied such as before weekends and holidays. Building should also be ventilated or flushed with fresh air prior to being reopened.

G. Food Areas: Cafeterias, Breakrooms, Etc.

Action Items:

1. **Clean and sanitize floors, tables, etc. See section on product selection for recommended products.**
2. **Separate recyclables from trash and makes sure recyclable areas are kept clean (i.e. rinse soda cans) not to attract pests.**
3. **Make sure that occupants understand how to properly separate trash and recyclables and proper disposal of each.**
4. **Make sure that waste containers are covered and emptied at least daily.**

Particular attention should be paid to food waste, trash receptacles containing food debris, recyclables such as soda cans, and other objects that contain food residues, which can attract pests. Making every effort to eliminate those things that attract pests is critical to protecting occupant health by reducing or eliminating the need for pesticides inside the building. Ask occupants to rinse out food and drink containers before placing in recyclable collection. Refrigerators used by occupants for their personal use should be emptied and cleaned periodically by the occupants. Integrated pest management (IPM) should be followed.

H. OSHA Blood-Borne Pathogen Standard

Action Items:

1. **Use safety cones or other means to make sure that occupants do not come in contact with spill.**
2. **Use proper personal protective equipment (i.e. gloves, goggles).**

3. **Disinfect area with appropriate solution.**
4. **Dispose properly in a red bag.**

While OSHA required training does not deviate in a green maintenance program, because the Blood-Borne Pathogen Standard requires among other things the use of an intermediate grade disinfectant that is tuberculocidal (kills TB), proven effective against the Hepatitis B Virus (HBV) or a specified dilution of chlorine bleach (sodium hypochlorite), special attention must be given under the green maintenance program.

Each of these disinfectant products is very effective at killing both HBV and HIV 1 (AIDS) the two target organisms of concern. However, these same products tend to have more health and environmental impacts then other possible disinfectant/sanitizers that may be desirable for general cleaning. However, because the OSHA Standard specifies the use of these more aggressive products, they must be used.

Thus, in a green maintenance program, it is recommended that a product specifically meeting OSHA's requirements be used along with all of the specified procedures, and this be clearly separate from the products and procedures used for general disinfecting/sanitizing. This separation will meet the OSHA requirements, clearly differentiate the procedures for the different types of disinfecting/sanitizing reducing the potential for confusion and reduce overall health and environmental impacts.

I. Measuring/Diluting Concentrated Cleaning Products

Action Items:

1. **Use appropriate protective equipment when mixing concentrated cleaning products.**
2. **Follow manufacturer's dilution directions. Do not under- or over-dilute concentrated cleaning products.**
3. **Make sure that spray bottles (secondary containers) have appropriate labels.**
4. **Never mix different cleaning products together.**

Highly concentrated cleaning products reduce environmental impacts from packaging and transportation, and typically reduce actual use cost compared to less concentrated alternatives. However, to gain the environmental benefits and to protect workers exposed to these more highly concentrated products during mixing, extra care should be used.

Products should always be diluted accurately according to manufacturers directions. This can be achieved through a variety of methods including measuring cups, simple dispensing pumps and more complicated automated dilution equipment. Dilution equipment should be periodically checked for accuracy.

Cleaning personnel should understand that adding extra concentrated cleaning product does not make the cleaner work better or faster, not only wastes products and the associated product expense, but also can result in longer times to do the job (i.e. removing residues), slippery floors and surfaces, and other complications. Finally, never mix cleaning products together.

J. Indoor Plants

Action Items:

1. **Educate occupants on appropriate care guidelines for indoor plants.**
2. **Ensure that plants are not in direct contact with carpets and unit ventilators.**

Indoor plants are a wonderful addition to any facility. While the cleaning contractor is typically not responsible for watering and caring for office plants, they frequently are called upon to address spills from watering, mold growth in carpets from dampness, aphids and other pests, and other problems. Furthermore, occupants use of with pesticides and fertilizers should be managed with care because these products can impact health. Thus, occupants should be educated on the proper and appropriate care for plants. This is an ideal communication issue for the Stewardship Task Force. If plants are on carpets they should be blocks underneath to keep moisture from building up in carpeting. Unit ventilators should not be used as plant stands.

K. Recycling

Action Items:

1. **Ensure that the building collection meets with the guidelines from the local recycling hauler and recycling facility.**
2. **Ensure that occupants understand what can be recycled and how it needs to be separated.**
3. **Food containers such as soda cans should be rinsed clean by occupants before placing in recycling containers so as to not attract pests.**
4. **Track recycling results.**

Recycling is a very important pollution prevention activity to reduce our burdens on the environment as a result of both solid waste disposal and the extraction of the natural raw materials. The recycling effort is guided by regulations and mandated including EPA's Comprehensive Procurement Guidelines. Check with local waste haulers and recyclers to determine what materials are picked-up and for the best sorting strategies. Currently, Commonwealth employees are asked to collect the following materials for recycling:

- Clear, green and brown glass bottles and jars
- White office paper (e.g., copier, bond, computer)
- Mixed office paper (e.g., ledger paper, folders, pamphlets, brochures, envelopes)
- Newspaper
- Cardboard
- Telephone and other books
- Scrap metal including steel containers
- Fluorescent lamps

- Toner and ink jet cartridges
- Batteries, floppy disks, compact discs (CDs)
- Microfilm and recording tape
- Carpet
- Ceiling tiles
- Computer equipment

One of the primary keys to making the recycling effort work, especially in a way that is efficient for both cleaning personnel and occupants is to develop some clear facility goals and procedures. To accomplish this, it is important to work with the Stewardship Task Force and facility management to support training and other efforts to engage the occupants in this effort.

It is important to enlist the occupants to sort their recyclables and it is clear what recyclables are to be collected and where they are to be placed. Recyclable that contained food such as soda or soup cans, should be rinsed out by the occupants prior to being placed in collection bins to minimize the potential for attracting pests (i.e. ants and cockroaches). Maintenance personnel should not be required to separate recyclables from trash. It is important that both the Stewardship Task Force and facility management work to support the recycling efforts and especially to address the issue of non-compliance by individual occupants or those that frequently contaminant the mix.

L. Restrooms

Action Items:

1. **Make sure sanitizing and disinfecting solutions are prepared and used properly (i.e. dwell time) and remix as required.**
2. **Frequently clean surfaces that hands touch to eliminate the spread of germs (i.e. door knobs, light switches, handles, etc.).**
3. **Frequently eliminate moisture.**
4. **Keep floors dry to eliminate slip falls and the build-up of bacteria, mold and mildew.**

While procedures for cleaning restrooms in a green maintenance program are similar to those in a traditional cleaning program, because of their heavy use and moisture, restrooms must be cleaning frequently using appropriate cleaning products (see section on product selection).

Make sure that cleaning is done thoroughly, including hard to reach areas such as behind toilets and around urinals. Periodically machine scrub restroom floors with a sanitizer or disinfectant (see section on product selection). Make sure that label directions for appropriate dilutions for necessary dwell times are followed to allow for germ-killing activities to be thorough. Dwell time for many sanitizers and disinfectants is ten minutes.

Many products used in the restroom can be quite hazardous, such as drain cleaners and toilet bowl cleaners (see section on product selection). Make sure that appropriate personal protective equipment is used. Never mix products.

Use large trash cans to minimize overflow and reduce the frequency for policing the area.

RESTROOM CLEANING -- Clean from high to low, towards the doorway, and do dry work before wet work.

1. Check supply cart for proper equipment and supplies.
2. Prepare the area. Place a Restroom Closed sign at the door, if applicable.
3. Clean the exterior of all dispensers and re-stock supplies, including paper towel dispensers, feminine hygiene dispensers, toilet tissue dispensers and hand soap dispensers.
4. Remove trash from all waste receptacles. Clean receptacles with a sanitizer cleaner. Replace liners.
5. Dust mop or sweep the floor, and pick up collected debris with dustpan.
6. Clean all sinks using sanitizer cleaner and abrasive sponge. Leave sanitizer on surfaces according to manufacturer's directions.
7. Clean all mirrors with glass cleaner and soft, clean cloths.
8. Clean and sanitize all toilets and/or urinals. Remove urinal screens from the urinals and using the bowl swab, push water level down in stools. Apply bowl cleaner to the exposed interior surfaces of the bowls and/or urinals, specifically under the rim. Allow time for the chemical to work, while cleaning partitions and showers (approximately 10 minutes - follow manufacturer's directions).
9. Remove graffiti from walls and stall partitions. Clean stall partitions and walls as needed with disinfectant cleaner.
10. Clean both sides of entrance/exit doors with a sanitizer cleaner, paying special attention to clean hand contact areas.
11. Scrub the inside of the bowls and urinals with a bowl swab. Use an abrasive sponge for difficult soils. Clean the exterior of the bowls and urinals with disinfectant cleaner. Clean both sides of the toilet seat. Clean the walls around the bowls or urinals with disinfectant cleaner. Flush bowls and urinals. Polish all chrome surfaces with a dry cloth (after cleaning with sanitizer cleaner).
12. Scrub the floor with a sanitizer cleaner using a wet mop, bucket and wringer. If needed, scrub floor grout with a tile and grout brush. Rinse with clear water. Squeegee or vacuum up water, if necessary.
13. Treat sink, shower or floor drains with drain maintainer, if necessary.
14. Inspect your work. If you are satisfied with your work, allow the floor to dry and re-open the restroom. Return cart to supply area and restock.

M. Spills

Action Items:

1. **Clean spills while still fresh.**
2. **Use the proper cleaning solutions and use only what is necessary.**

3. **Dispose properly.**
4. **Ensure that occupants know whom to contact in case of spills.**

Generally it is preferable to address spills as soon as possible to minimize impacts on both health and the environment. Work with building occupants to communicate quickly to address spills.

N. Trash

Action Items:

1. **Ensure that trash, especially that which contains food waste are removed frequently and are not left in buildings over an extended period of time (i.e. weekends or holidays).**
2. **Dispose properly and ensure that trash does not attract pests, birds, etc. nor create litter.**
3. **Make sure that trash and recyclables are being separated properly.**
4. **Make sure occupants know how to separate recyclables.**

Trash should be handled as with a traditional program. If it is not pulled and disposed everyday (in many cases totally unnecessary) it should be pulled and disposed before weekends and holidays to minimize the opportunity to attract pests.

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Cleaning Product Selection

A	Cleaning Product Consideration
1	All Purpose Cleaners
2	Bathroom Cleaners
3	Bathroom Disinfectants
4	Carpet Cleaners
5	Chrome Cleaners/Polish
6	Floor Finishes
7	Floor Strippers
8	Furniture Polish
9	General Degreasers
10	General Disinfectants
11	Glass Cleaners
12	Graffiti Remover
13	Gum Remover
14	Lime and Scale Remover
15	Solvent Spot Removers
16	Urinal Deodorizers
17	Wood Floor Finishes
B	Disposable Paper and Plastic Bags
C	Janitorial Equipment
D	Product Supplier Consideration

A. Cleaning Product Considerations

Each category of cleaning products has a limited number of health and environmental attributes that might differentiate one product from another. The following list of product issues are for 19 individual products that cover the majority of janitorial requirements. This list is not intended to be complete, but is only intended to serve to identify some of the typical issues for each product type.

1. ALL PURPOSE CLEANERS

All Purpose Cleaners consist of a broad array of possible formulations. The following are some of the specific issues to compare for this product category:

- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns (see ingredients to avoid).
- Dyes & Fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- More Preferable Ingredients: surfactants containing terms such as lauryl, amides, and glycosides.
- Less Preferable Ingredients: Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, phosphates.

2. BATHROOM CLEANERS

Bathroom Cleaners are often acids because of the need to remove mineral deposits from sinks, bowls and urinals. Frequently they are heavily dyed and strongly fragranced. The following are some of the specific issues to compare for this product category:

- pH: Prefer those with a more neutral pH as compared to those with extreme pH (closer to 1). Bathroom cleaners may fall more in the range of pH 4 as compared to traditional products that may have a pH below 1.
- Dyes & Fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns (see ingredients to avoid).

- More Preferable Ingredients: surfactants containing terms such as lauryl, amides, glycosides, citric or acetic acid.
- Less Preferable Ingredients: nonyl phenol ethoxylates, NTA, EDTA, hydrochloric acid, phosphoric acid.

3. BATHROOM DISINFECTANTS

Bathroom Disinfectants are similar to general disinfectants, but typically may have an acidic pH (closer to 1) to remove hard water deposits in sinks, bowls and urinals. The selection issues include both those under general disinfectants and bathroom cleaners. Care in selection and use is important. The following are some of the specific issues to compare for this product category:

- See Bathroom Cleaners for similar attributes.
- Antimicrobial Ingredients: Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and to accumulate in living tissue compared to those with a greater potential.
- More Preferable Active Ingredients: hydrogen peroxide.
- Less Preferable Active Ingredients: sodium hypochlorite (chlorine bleach), quaternary ammonium compounds, alcohols, phenolic compounds.

4. CARPET CLEANER

See All Purpose Cleaners. In addition, select carpet cleaners that when dry are not sticky or tacky. This minimizes resoiling and extends the time between cleaning.

5. CHROME CLEANER/POLISH

Chrome Cleaner/Polish frequently use petroleum distillates, which are poisonous and derived from a non-renewable resource. The following are some of the specific issues to compare for this product category:

- VOC: Prefer those that have no or low VOC as compared to alternatives with higher levels.
- Bio-Based / Renewable Resources: Prefer products that use oils derived from renewable resources as compared to oils from non-renewable resources.
- More Preferable Ingredients: (examples needed)
- Less Preferable Ingredients: petroleum distillates, ammonia.

6. FLOOR FINISHES

Floor Finishes must be durable and appropriate for the prescribed maintenance method, but they typical contain heavy metals. Importantly, floor finishes must be compatible with the stripping solution. The following are some of the specific issues to compare for this product category:

- Durability: Prefer finishes that are more durable (require less maintenance such as buffing, restoring and recoating) then less durable finishes that require more frequent maintenance.
- Heavy Metals: Prefer non-metal cross-linked polymers as compared to those containing heavy

metals. Another significant benefit of non-metal polymer formulas is that frequently they can be removed with less hazardous floor strippers.

- More Preferable Ingredients: metal-free polymers.
- Less Preferable Ingredients: metal-crosslinked polymers.

7. FLOOR STRIPPERS

Floor Strippers typically have extreme pH, solvents and ammoniated compounds necessary to remove metal cross-linked floor finishes. Floor strippers must be compatible with the floor finish. The following are some of the specific issues to compare for this product category:

- pH: Prefer those with a pH closer to neutral (in the range of 10 to 12) as compared to those with extreme pH (closer to 14).
- VOC: Prefer those that have no or low VOC as compared to alternatives with higher levels.
- Bio-Based / Renewable Resources: Prefer those that containing naturally derived solvents as compared to those containing non renewable derived solvents.
- More Preferable Ingredients: d-Limonene (citrus solvent) and methyl esters.
- Less Preferable Ingredients: ethylene glycol mono butyl ether (butyl cellusolve), 2-butoxyethanol, ammonia, and sodium hydroxide.

8. FURNITURE POLISH

Furniture Polishes frequently use petroleum distillates, which are poisonous and derived from a non-renewable resource. The following are some of the specific issues to compare for this product category:

- VOC: Prefer those that have no or low VOC as compared to alternatives with higher levels.
- Bio-Based / Renewable Resources: Prefer products that use oils derived from renewable resources as compared to oils from non-renewable resources.
- More Preferable Ingredients: citrus (lemon and orange) oils.
- Less Preferable Ingredients: petroleum distillates.

9. GENERAL DEGREASER

General Degreasers are typically heavy-duty cleaners that include solvents for removing oil-based soils. Traditional solvents are typically derived from a non-renewable sources (e.g., petroleum), can be flammable, have a high degree of VOCs which can cause respiratory irritation and contribute to environmental pollution and some have severe health impacts. The following are some of the specific issues to compare for this product category:

- See All-Purpose Cleaners
- VOC: Prefer those that have no or low VOC as compared to alternatives with higher levels.
- Bio-Based / Renewable Prefer products that use oils derived from renewable resources as compared to oils from non-renewable resources.

- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- More Preferable Ingredients: d-Limonene (derived from citrus fruits) and methyl esters from soy and corn.
- Less Preferable Ingredients: glycol ethers in general, ethylene glycol mono butyl ether (butyl cellusolve), and sodium hydroxide.

10. GENERAL DISINFECTANTS

General Disinfectants are similar to cleaners (see all-purpose cleaners) with additional ingredients added to kill bacteria and other unwanted organisms, and bathroom disinfectants. Because disinfectants kill organisms they are toxic by definition. Some are persistent in the environment and accumulate in living tissue. Care in selection and use is important. The following are some of the specific issues to compare for this product category:

- See Bathroom Disinfectants for similar attributes.
- Antimicrobial Ingredients: Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and to accumulate in living tissue compared to those with a greater potential.
- More Preferable Active Ingredients: hydrogen peroxide.
- Less Preferable Active Ingredients: sodium hypochlorite (chlorine bleach), quaternary ammonium compounds and phenolic compounds.

11. GLASS CLEANERS

Glass Cleaners are cleaners that have ingredients added to reduce streaking and to evaporate quickly. Traditional glass cleaners can contain alcohol and other solvents (typically glycol ethers) or ammonia. The following are some of the specific issues to compare for this product category:

- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns (see ingredients to avoid).
- Dyes & Fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- More Preferable Ingredients: surfactants containing terms such as lauryl, amides, and glycosides.
- Less Preferable Ingredients: ammonia, alcohols, propylene glycol, ethylene glycol and other glycol ethers.

12. GRAFFITI REMOVER

Graffiti Remover used to be formulated with chlorinated solvents (e.g., methylene chloride) before they were banned due to their environmental impact. Many graffiti removers are packaged in aerosol contains which often contain hydrocarbon propellants (e.g., propane, butane), which are highly flammable and can contribute to indoor air quality problems.

- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- More Preferable Ingredients: n-Methyl-2-Pyrolidone, d-Limonene.
- Less Preferable Ingredients: methylene chloride, petroleum distillates, propane, butane, isobutene, and sodium hydroxide.

13. GUM REMOVER

Gum Removers used to be formulated with chlorinated solvents (e.g., freon) before they were banned due to their environmental impact. Dry ice and carbon dioxide are preferable replacements. Degreasers can be used in some situations (see section on General Degreasers).

- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- More Preferable Ingredients: dry ice, carbon dioxide.
- Less Preferable Ingredients: freon, dichloro-difluoromethane, trichloro-fluoromethane.

14. LIME & SCALE REMOVER

Lime & Scale Removers are acids because of the need to remove mineral deposits from sinks, bowls and urinals.

- pH: Prefer those with a more neutral pH as compared to those with extreme pH (closer to 1). Environmentally preferable lime and scale removers may fall more in the range of pH 4 as compared to traditional products that may have a pH below 1.
- More Preferable Ingredients: citric or acetic acid.
- Less Preferable Ingredients: hydrochloric or phosphoric acid.

15. SOLVENT SPOT REMOVERS

Solvent Spot Removers are necessary for spot removal particularly on carpets. Use detergent based spotters if possible (must be followed with extraction or other method to remove/absorb the detergent).

- See All-Purpose Cleaners
- VOCs: Prefer products that have no or low VOC compared to those with higher VOC content.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- More Preferable Ingredients: d-Limonene (derived from citrus fruits) and methyl esters from soy and corn.
- Less Preferable Ingredients: mineral spirits, 2-butoxyethanol

16. URINAL DEODORIZERS

Urinal Deodorizers are traditionally blocks placed in urinals to reduce odors. Preferably these deodorizers should be eliminated altogether through more frequent cleaning and other methods of deodorizing. However, if urinal deodorizers are still required preference should be given to those with the safest ingredients.

- Biodegradability: Prefer detergents that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns (see ingredients to avoid).
- More Preferable Ingredients: surfactants containing terms such as lauryl, amides, glycosides,
- Less Preferable Ingredients: nonyl phenol ethoxylates, paradichlorobenzene

17. WOOD & STONE FLOOR COATINGS

Wood & stone floor coatings have traditionally been solvent-based products. While extremely durable to protect flooring materials that are very expensive to replace, these coatings can be quite hazardous during the drying and curing period. The two primary issues to consider during product selection is the use of zero or low-VOC containing materials which will reduce indoor air quality concerns and the products durability which is important to protect the flooring and due to the product and applications cost. One final note, many janitorial firms lack specific expertise in application for these types of finishes. Thus, supplier support (e.g., training) is very important.

- Durability: Prefer durable finishes that require less maintenance (e.g., recoating) then less durable finishes that require more frequent recoating.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- More Preferable Ingredients: water- or epoxy-based finishes.
- Less Preferable Ingredients: xylene, stoddard solvent

B. Disposable Paper and Plastic Bags

The issues associated with selecting paper products compared to cleaning products are significantly simpler. he issues of concern for paper are primarily focused at the manufacturing stage of the product. Whereas cleaners may have more then a dozen individual ingredients which can vary significantly from category to category and even amongst different products within the same category, paper is relatively similar. Paper has less emphasis on health issues during the products usage stage, or environmental impacts as a result of disposal.

The three basic issues of concern for paper include:

- Total recovered material (recycled content)
- Post-consumer recycled content
- Bleaching process

Environmentally preferable paper products recommended for use in the Commonwealth should meet the following standards for each of the following product categories:

- Bathroom tissue-minimum 100% recovered materials and 20% post-consumer content.
- Toilet seat covers-minimum 100% recovered materials and 40% post-consumer content.
- Paper towels and general-purpose industrial wipes-minimum 100% recovered materials and 40% post-consumer content.
- Plastic trash bags-minimum of 25% post-consumer content.

Two further recommendations for the paper include the following:

- No use of de-inking solvents containing chlorine or any other chemicals listed in the Toxics Release Inventory in the manufacture of paper products.
- No use of chlorine or chlorine derivatives in bleaching processes for paper products.

Paper dispensers, for example those used in restrooms to dispense paper hand towels should be "touch free", which reduces the potential for cross-contamination of bacteria and other potentially harmful pathogens.

C. Janitorial Equipment

Finally, some considerations for equipment selection include the following:

- Vacuums with High Efficiency Particulate Air (HEPA) filtration capable of trapping 99.97% of all airborne particles that are collected by the vacuum. It is preferable to use vacuums with a beater bar to increase the amount of soil removal.
- Floor Machines with guards and filters

In selection of all equipment it is preferable to select those that are durable, energy-efficient and quiet, as compared to less durable, less efficient and noisier alternatives.

D. Product Supplier Considerations

The final component in selecting products is consideration of the supplier. The product supplier will play an important role as part of the Stewardship Task Force and may be intimately involved in training. Furthermore, the standard operating practices of the supplier can impact inventory levels and thus the amount of materials, including those hazardous materials, which may be stored in the facility. Therefore, consideration should be given to suppliers' ability to train cleaning personnel, expertise with green janitorial products and cleaning, in addition to price and other traditional considerations.

Green Cleaning Appendix

1. SCOPE

As Stewards of the buildings and grounds within Pennsylvania, the Commonwealth recognizes the sizable impacts and opportunities to protect those properties in the public's interest. Commonwealth buildings have a huge impact on the health of the building occupants who spend substantial amounts of time within those buildings. In addition, those who maintain the buildings can be exposed to chemicals and other substances for many hours each day. Furthermore, the environmental impacts resulting from the cleaning chemicals and disposable paper and plastic products have huge impacts to the environment based on the manufacturing and disposal of those products. Thus, this guide is designed to reduce the health and environmental impacts resulting from the cleaning, landscaping and maintenance of those buildings.

This guide is not intended to suggest that current procedures are in anyway inadequate or has created a condition placing building occupants, cleaning personnel or the environment at imminent risk. Rather, the intent of this document is to go beyond traditional methods and to further reduce impacts while at the same time maintaining or improving the health, comfort and appearance of the Commonwealth's buildings.

This guide is designed for use by the maintenance staff for the Commonwealth of Pennsylvania in support of the established training programs and is not intended to replace existing federal or Commonwealth requirements for worker safety, environmental or other regulations.

2. INTRODUCTION

Cleaning is perhaps one of the least appreciated activities in America, if not the world. Just imagine where we would be today without the means to remove harmful and unwanted contaminants from our buildings. Contaminants like bacteria, viruses, molds and fungi can adversely affect human health. Even common dirt, dust and soils can be further contaminated with pesticides and other chemicals, and heavy metals such as lead and arsenic which can not only can harm our health, but can in addition damage the building, its mechanical systems and other materials costing huge sums of money to repair or replace. Without a doubt, cleaning is enormously important to protect our health, but also to protect our buildings.

Not only are janitorial activities in the United States important, they are also a huge industry. Today, billions of pounds of cleaning products, plastic and paper disposables are used to clean and maintain commercial buildings alone. Three and a half million people work as custodians in those buildings and due to the high turn-over of workers in some industry sectors the number of people working as custodians during the course of a year is much, much higher. In addition, tens of millions more work and visit those buildings each year further increasing the impacts.

Many organizations including the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the World Health Organization (WHO) and the Building Owners and Managers Association (BOMA) have all linked cleanings' impact on indoor air quality problems and the subsequent impacts on health and productivity. These numbers are startling and include the following:

- EPA has found that indoor air quality is 2 to 5 times worse then outdoor air and can be as much as 100 times worse.
- WHO states that 30% of buildings worldwide suffer from indoor air quality (IAQ) problems.
- DOE study found the productivity improvement to be at 6%
- EPA made the clear connection between IAQ and cleaning and quantified the impacts at $60 Billion of lost productivity, and perhaps in the hundreds of billions of dollars when the associated health care, litigation and other costs are included.

With impacts this large, the Commonwealth of Pennsylvania desires to be a leader and demonstrate the opportunities to both protect the health of custodians and building occupants, as well as reduce the overall impact on our environment.

Unlike a traditional cleaning program, a green janitorial program takes a holistic approach to facility cleaning. It goes far beyond simple appearances to focus on health and environmental impacts. Among the unique elements of the green cleaning program are the use of environmentally preferable products, and mobilizing human resources including cleaning personnel, facility occupants and suppliers to minimize impacts on health and the environment, while maximizing worker morale and productivity.

3. THE IMPACTS OF CLEANING

The impacts of cleaning can best be identified by several studies conducted over the recent past and which formed the foundation for green janitorial services. Each of the following studies established a baseline measuring contaminants, which can result in health impacts. Then using a pollution prevention

strategy they implemented a new cleaning products, which would reduce impacts on both health and the environment. The studies relied heavily on training and procedures to maximize the effectiveness of cleaning personnel and included active involvement with building occupants.

The first study was conducted at the Frank Porter Graham Child Development Center on the University of North Carolina, Chapel Hill Campus. The study was a collaborative effort between EPA's Environmental Criteria and Assessment Office under the direction of Dr. Michael Berry, Research Triangle Institute, the University of North Carolina, a building service contractor, commercial cleaning industries, and their suppliers.

Air Pollutant Category	**Routine Housekeeping 5 Months**	**Improved Housekeeping 7 Months**	**% Change**	**Most Probable Contributor To Improved Air Quality**
Airborne Dust (micrograms/m^3) Building means	11.9	5.7	-52	Efficient vacuum cleaners and bags Walk-off mats Damp dust cloths Frequent vacuuming and dusting Deep-cleaning of entire building Dust control on hard surfaces
Total VOC (micrograms/m^3) Building means	324	166	-49	Cleaning chemicals with less VOCs Extraction from carpets Balanced ventilation system
Biopollutants* Building CFM/m^3 Total Bacteria Gram-neg bacteria Endotoxin (surface) Bacillus Actinomycetes Total Fungi Penicillum Aspergillus Cladosporium	 395 17 352** 22 36 127 38 4 35	 237 2 100** 18 3 50 5 1 27	 -40 -88 -72 -18 -94 -61 -87 -75 -23	Rapid use of disinfectants after accidents Control of food and perishables New extraction equipment Hot water extraction of carpets Moisture control Removal of contaminated sources (wall, rotten tree stump) Walk-off mats
Days Absent from school)	0.75	0.40	-46	School buses were cleaned
*Andersen sampler data only **Endotoxin per gram of dust				

The deep-cleaning procedure, including new cleaning equipment and cleaning supplies, was found to decrease the levels of airborne dust inside the building by 52%. Total VOC concentrations decreased by 49%, total bacteria decreased by 40% and fungi colony-forming units decreased by 61%.

The researchers offered their conclusions as to the cause resulting in the improvement in the building's air quality. Generally, the improvements resulted from following sound cleaning practices including the use of the most appropriate chemicals and maintenance procedures.

Dr. Berry's ground breaking cleaning study quantified the reductions in contaminants. The reductions were dramatic, especially when considering that the study was done in a well-maintained building. With these results it can be concluded that by decreasing the hazards, health impacts will also be reduced.

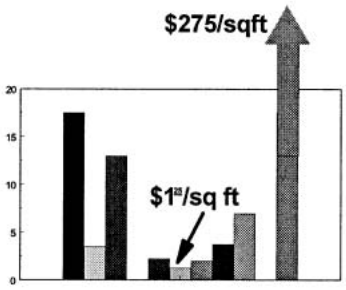
While Dr. Berry's study made a health impact assessment based on reducing hazards, Dr. Leonard Krilov with North Shore University Hospital - Cornell University Medical College took the next step. This study conducted at the Association for Children with Downs Syndrome School in Bellmore, New York looked at the health implications associated with improved cleaning. Rather than just focusing on the dust, VOCs and biologicals, Dr. Krilov tracked the health and attendance impacts after improved cleaning was implemented. \ The improved cleaning reduced total illnesses by 24%, doctor visits by 34%, courses of antibiotics by 24% and days absent from school by 46%.

Illness*	**Basline Year**	**Intervention Year**	**% Change**	**Most Probable Contributor To Improvement**
Total Illnesses Respiratory Gastrointes tinal Otitis media Sinusitis	0.70 0.80 0.67 0.08 0.00	0.53 0.42 0.00 0.08 0.00	-24% -37% # 0 #	Stressed proper use and dilution of cleaning products Cleaning procedures were modified Sequence of rooms cleaned was modified Frequency for changeing mop bucket water was increased Mops were disinfected routinely
Number of Visits to Doctor*	0.50	0.33	-34%	Reinforced handwashing procedures
Courses of Antibiotics[3]	0.33	0.25	-24%	Educated staff and parents about infection control Procedural posters strategically placed in classrooms Special attention paid to toys
Days Absent from School*	0.75	0.40	-46%	School buses were cleaned

4. GENERATING PRODUCTIVITY IMPROVEMENTS

While the studies mentioned earlier attempted to quantify health impacts our experience demonstrates that when building occupants suffers from health related symptoms such as respiratory illness, allergies and headaches their performance suffers. Symptoms relating directly to cleaning, such as dust from ineffective vacuuming can cause dry and scratchy eyes. VOCs from cleaning products can cause headaches and nausea. Bacterial contamination from molds and fungi can cause allergic reactions and flu symptoms. Even simple odors can cause "water cooler complaints" and low employee morale.

Beyond the health and environmental benefits for cleaning, a healthier indoor environment can have substantial financial benefits. According to BOMA the average costs for salaries and benefits in a Class A office building is $275.00 per square foot, while the average cost for cleaning is only $1.25 per square foot. Thus, each incremental increase of just 0.5% in worker productivity will result in an increase equal to $1.37 per square foot. In additional to improved productivity, the benefits of improved indoor environment as a result of green cleaning programs can also include reduced health care and insurance costs, recruiting and retaining top talent as part of the quality of life issues.



5. DEFINING GREEN

At times understanding what something is can be more easily defined by describing what it is not. Thus, the concept most essential to understanding green janitorial services is that it is not simply replacing one product with another. It is not just replacing a toxic product with a less toxic or non-toxic alternative. It is not just replacing a product made from non-renewable ingredients (i.e., derived from petroleum) with one made from renewable or bio-based alternatives (i.e., derived from vegetables). It is not just replacing disposable items made from 100% virgin materials with those made from recycled materials.

Rather, the essential concept is that the green janitorial service is a process that allows the reduction in the overall impacts on human health and the environment, and one that take a holistic view of a facility, its mission and the activities that take place within that facility. The success of a green janitorial program hinges not on the products, but a larger principle - stewardship. This notion of stewardship introduces the sense of caring. The expression of stewardship is unique based on the needs of an individual facility and is consistent with the vision and mission of the Commonwealth.

Because the product issue is such an important one, to further illustrate the point, consider the use of a traditional glass cleaner used to clean a restroom mirror. These products are typically made with alcohol and ammonia. These ingredients help remove fingerprints and other soils, and quickly evaporate to leave a streak-free surface even when over-applied or not wiped off thoroughly.

Unfortunately, when these ingredients evaporate they don't just magically disappear. When ingredients evaporate they first enter the breathing zone where cleaning personnel are exposed to their vapors. In the case of both the alcohol and especially the ammonia, these ingredients are known to cause respiratory irritation and can trigger asthmatic attacks and other breathing disorders.

The vapors then remain in the restroom to expose the users of the room and then are circulated throughout the building by the ventilation system to expose the building's occupants. Finally,

the vapors are exhausted to the outdoors where they can contribute to atmospheric smog and pollution.

While it sounds that the simple solution would be to just replace the traditional ammoniated and alcohol containing glass cleaner with one that has no solvents. After all, a non-solvent, detergent based glass cleaner will clean the mirror and will do so with less vapors that affect health and the environment. But because the goal of green janitorial services are to reduce the overall or total impact on health and the environment, we must also consider the process of how the glass cleaner is used.

Consider the same alcohol and ammoniated glass cleaner. Our goal is clearly to reduce the impacts to our cleaning personnel and others in the building, as well as the ultimate environmental impacts. But the amount of vapors that are released during the use of the product can vary enormously by how it is applied. For example, if the product is sprayed on the mirror with a trigger sprayer in a fine mist will cause more vapors then if the cleaner is applied in a stream. The vapors can be even further reduced if the cleaner is applied to a wiping cloth. Thus, the lesson to be learned is that we cannot separate the product from the process when considering how best to achieve our goals. Again, a green janitorial service is a process to achieve a specific goal. While it includes the consideration of environmentally preferable products, its success is dependant on numerous other factors.

6. HOW THE GREEN JANITORIAL PROCESS WAS DEVELOPED

During the mid-1990's, ASTM[1] (American Society for Testing and Materials) the largest and oldest standard writing organization in the United States, set out to write the specifications of an "environmentally preferable" cleaner/degreaser. This effort began in the sub-committee on Green Buildings because the owners and managers of buildings trying to maintain a green or healthy building desired a simple standard for products used by their janitorial services to insure that there was nothing being used inside their building that would compromise the indoor air and negatively affect the environment as a whole.

A task force of over 70 members was assembled from all areas including building service contractors, cleaning product manufacturers, building owners and managers, environmentalists, labor unions, plus numerous local, state and federal governmental agencies including the U.S. Environmental Protection Agency (EPA), General Services Agency (GSA), White House Office of the Federal Environmental Executive and the President's Council on Sustainable Development.

With a goal of developing a standard that would help the cleaning operations of buildings to reduce their impacts on building occupants, cleaning personnel and the environment, it quickly became apparent that focusing on products alone would not accomplish this goal. This is because while the selection of products is extremely important, but their use can significantly impact and even overshadow they impacts from the products themselves[2].

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[1] After almost five years of effort the standard was completed in 1998. It is titled the Standard Guide on Stewardship for Cleaning Commercial and Industrial Buildings. Its ASTM designator is E-1971-98 and can be obtained by contacting ASTM at 610/832-9500 or www.astm.org.

[2] It is important to point out that recognizing that the impact of the product usage is significant in relations to overall impact, is not intended to diminish the importance of selecting products with the least impacts.

7. STEWARDSHIP PRINCIPLES

Managing a building is a huge responsibility. As an asset it can be worth in the tens of millions of dollars and some historical buildings are irreplaceable. The materials of construction, energy and other products used in its operation make an enormous environmental impact. And the impact on the health and quality of life of the people that work, visit and live in the building makes an indelible impact on their lives. Thus, Stewardship is about "caring" for a building going far beyond the basic operations.

The 10 Stewardship Principles are the following:

1. Commit to people, education and communications. Buildings don't get dirty or get cleaned by themselves. These activities are dependent on people! A successful green janitorial program should involve both the cleaning personnel and building occupants. Get people involved, keep them involved by celebrating and communicating successes, and let them know the value/benefits that are in it for them.
2. Clean to protect health and the environment first, and appearance second. It is not what is seen that is the real area of concern. Even clean appearing buildings can be extremely unhealthy. Thus, focus on cleaning for health and the environment, and in most cases the appearance will be addressed at the same time.
3. Clean and maintain the building as a whole, not just as separate components. Cleaning and maintenance in one area of a building can have a major impact on other areas. For example, the fumes from the stripping and recoating of a floor in one area can contaminate adjacent areas or even the entire building via the HVAC system. Appropriate actions must take place to insure the health and safety throughout the entire building.
4. Scheduled routine maintenance. Scheduled maintenance that is frequent and thorough is the most efficient and effective method for building maintenance. Concise plans and records are a must.
5. Plan for accidents. Specific procedures need to be developed to address accidents. Plans should address weather related problems, as well as common spills (e.g., coffee), water leaks, smoke or air contamination by a noxious chemical reaction.
6. Minimize human exposure to harmful contaminants and cleaning residues. Workers should always use the appropriate personal protective equipment, areas where work is taking place should have adequate ventilation, work schedules should be established to minimize exposure to building occupants, and the products used should be the most benign to accomplish the task.
7. Minimize chemical, particle and moisture residue when cleaning. The products that are used for building maintenance due to their ability to quickly and efficiently remove oils, soils, living organisms, etc., can also contribute to a building's problem if used incorrectly.
8. Ensure worker and building occupant safety at all times.
9. Minimize the amount of pollutants entering the building, while maximizing the amount of pollutants extracted. It is significantly more effective in terms of both time and money to keep contaminants out of the building, then to try to remove them once they have entered.
10. Dispose of cleaning waste in environmentally safe ways.

8. JANITORIAL RESPONSIBILITY

The role that the janitorial workers play in a green janitorial service compared to a traditional cleaning program is very similar when we look at the day to day responsibility for keep the facility clean, removing trash, restocking restroom supplies, etc. But in a green janitorial program cleaning personnel are part of a stewardship team, as opposed to the individual group independently responsible for the building.

This in no way is to suggest that the role of cleaning personnel is diminished. Nor is this to suggest that building occupants or other group cleans or restocks bathrooms. Rather the intent is to elevate the importance to the rest of the facility of the role played by cleaning personnel in maintaining a healthy indoor environment. The result of this is improved communications, which in turn results in problems being solved more quickly and frequently with less aggressive or toxic materials.

9. OCCUPANT RESPONSIBILITY

Defining green janitorial services also identifies the critical role played by occupants. For example:

- cleaning of a simple coffee or beverage spill becomes more difficult as the spill dries over time. As the spill dries and seeps into a carpet it can require more aggressive and frequently more toxic cleaning agents to remove. Thus, the time it takes for an occupant to report a spill directly affects the type of cleaning product that is used for removal.
- occupants who eat in their work areas can leave food crumbs in and behind desks which can result in the need to use toxic pesticides if the crumbs attract insects.
- those who work in clutter, or who create excessive amounts of trash, or don't recycle each increase the amount of time custodial workers need to maintain the area, resulting in less time to perform other vital tasks.
- a more difficult and challenging personal impact on those who work nearby is the use of strong fragrances that can trigger allergic reactions in sensitive co-workers.

Because occupants significantly affect the building environment, we must all work together to reduce the impacts and create the safest and healthiest work environment.

10. SUPPLIER RESPONSIBILITY

But its not just the cleaning personnel and the occupants that affect the cleaning it is also the cleaning product suppliers who frequently participate in training on product usage and safety, waste management companies that haul away wastes and recyclables, contactors such as elevator, roof or HVAC repair, and others whose activities within a building can affect the overall impacts on health and the environment.

The participation in a green janitorial program by the occupants is perhaps the most unique aspect compared to traditional janitorial programs. By law, product suppliers have been required to provide training on new products used in the facility. Furthermore, other suppliers such as waste haulers and mechanical contractor have had direct financial incentives to increase their association with a facility. But the role of the occupant has not been addressed or fully appreciated in maintaining a healthy environment and minimizing impacts.

11. DEVELOPING A PURCHASING STRATEGY

Historically, the decision-making matrix for product selection was primarily limited to just two issues -- cost and performance. While health, safety and environmental concerns have always existed they played little or no role in the decision-making matrix. The traditional assumption was that all products met the minimum requirements, and thus were acceptable. Furthermore, it was the view of many procurement personnel that all products used for a specific task were essentially the same. Therefore, no additional consideration regarding health and environmental attributes was necessary.

While the traditional decision-making model was adequate in has failed to recognize the advances that have been made in many product categories. For example, the paper industry has developed processes for using high amounts of post-consumer content paper, a resource that was unavailable just 20 years ago.

Furthermore, purchasing was often done independent of other facility issues, such as age and materials of construction, flooring materials and other finishes, HVAC issues, geographical location, occupant make-up, cleaning personnel, facility mission, etc. This limited focus resulted in a "one size fits all" product solution which would be the appropriate decision if all facilities, occupants, cleaning personnel, etc., were the same. Environmentally preferable purchasing expands the decision-making model and takes advantage of new technologies to reduce health and environmental impacts.

12. DEFINING ENVIRONMENTALLY PREFERABLE PRODUCTS

Pennsylvania Executive Order 1998-1 (Governor's Green Government Council) charges Commonwealth agencies to focus on a variety of initiatives, including planning and operations, energy efficiency, especially in building design and management, procurement of environmentally friendly commodities and services, vehicle purchases and management, and recycling. Green building maintenance encompasses several of these areas.

Section 201 of Presidential Executive Order 13101 defines "environmentally preferable" products as "products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. his comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service." This definition of environmental preferability is consistent with the growing U.S. and international trend in this area, and as such an excellent conceptual definition of the term.

There are two critical elements in the definition of environmental preferability. The first critical element is that it defines the issue as a comparison. It does not suggest that some are "bad" and others are "good." It does not describe the issue as black and white. Rather it is a comparison in an effort towards the continual reduction of the impacts resulting from both products and services such as those provided by janitorial contractors.

The second critical element is the inclusion of human health, in addition to focusing on environmental impacts. It is also interesting that human health is presented before the environment as a whole. This is extremely important especially when working with a disabled workforce and those workers and occupants that may have pre-existing health conditions.

Thus, the concept of environmental preferability is not intended to suggest that traditional products are "bad" or have put our cleaning personnel, building occupants and visitors, or the environment at risk of harm or injury. Rather the concept of environmental preferability is simply a decision-making strategy which takes advantage of the opportunity to reduce impacts and perform tasks better. And considering the billions of pounds of chemicals (e.g., cleaner and floor coatings), paper (e.g., toilet tissue and hand towels) and plastic (e.g., trash can liners) used by the commercial janitorial industry to clean and maintain buildings, there exists an enormous opportunity to reduce impacts and have a positive influence on health and the environment.

13. THE RISK CONTINUUM[3]

There is no question that these attributes complicate the procurement effort. A basic concept that will assist in prioritizing and weighing the issues is called the "Risk Continuum". The underlying premise of the Risk Continuum begins with understanding that there is no such thing as zero risk. Life is full of risk. Even common products considered safe, including water can be deadly.

Thus, the Risk Continuum defines the issue of risk in terms of a continuum from a very low probability of harm to occur to ever increasing probability. Furthermore, the Risk Continuum requires the consideration of both the hazard of the products, plus the circumstances of the product users and the building occupants including their pre-existing health conditions, vulnerabilities (I.E., children and the elderly are more vulnerable than the middle aged), abilities of the janitorial personnel, etc.

To illustrate the Risk Continuum, consider two buildings. The first is a modern office building with excellent ventilation, cleaned by a healthy group of experienced, well-trained cleaning personnel and occupied by healthy building occupants. The second building has poor ventilation, cleaned by a workforce with numerous existing health problems and with high turn-over resulting in low levels of training/expertise and occupied by a tightly packed number of occupants with pre-existing health problems. In the first scenario, the risk of injury and unintended health impacts is lower then in the second building. Thus, more weight should be given to health related attributes during the selection of the products for the second building.

Incorporating environmental preferability into the purchasing decision-making matrix simply requires a comparison based on health and environmental factors on an equal bases to traditional factors, such as cost and performance. It also requires procurement personnel to become more knowledgeable about the products they are purchasing. For example, the issues associated with purchasing hand soaps are different then degreasers. This is because most hand soaps have similar attributes (e.g., detergent/ water-based, neutral pH), whereas solvents have attributes that are similar within the degreaser category (e.g., solvent-based, high pH), but which are very different from hand soaps.

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[3] Stephen P. Ashkin, “Selecting Environmentally Preferable Products”, MEHRC Conference on Cleaning and Restoration for a HEalthy Indoor Environment, Raleigh, NC, October 1997.

In the final analysis, procurement personnel must include more specific comparison information on a category-by-category bases into their decision-making. Once they understand the important attributes to be considered for each category, they will find this change to their procurement efforts to be relatively straightforward. The net result of their efforts can be reduce worker injury/compensation, a healthier workplace, less environmental impacts, and ultimately compliance with Commonwealth environmental and health goals.

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