ADDENDUM TO THE
B3 STATE OF MINNESOTA SUSTAINABLE BUILDING GUIDELINES (MSBG)
www.csbr.umn.edu/B3

Introduction

The original Version 1.0 of the B3 Minnesota Sustainable Building Guidelines was issued early in 2004 with Version 1.1 issued in July of 2004. Since that time that the guidelines have been applied to the early phases of several pilot projects funded with state bond proceeds. During the pilot project phase, several issues have emerged that are leading to clarifications and enhancements to the guidelines. These changes will be released as Version 2.0 on July 1, 2006. In the meantime, there are some important clarifications to the guidelines and required documentation that are explained in this Addendum. **Project teams can continue using the original version, however in most cases, the revised guidelines will require less work and produce clearer information.**

The intent of the revisions to come out in July is to meet three goals:

- To simplify and streamline the process for design teams by describing requirements more concisely and only asking for essential information .
- To provide better, easier–to-use tools to calculate the actual outcomes of the project.
- To reflect recent changes in ASHRAE Ventilation standards

The guidelines addressed in this Addendum are:

P.2 Planning for Conservation
P.6 Lowest Life Cycle Cost
I.2 Indoor Air Quality and Ventilation Baseline
I.4 Ventilation Based on Anticipated Pollutants
M.1 Evaluation of Design for Resource Use
M.2 Evaluation of Material Properties for Improved Performance

Consultants should submit the Outcome Documentation packets at the end of each phase to:

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P.2 Planning for Conservation

NOTE: In Version 1.1, this guideline required a narrative description of the process of Planning for Conservation. This aspect of P.2 has not changed. Another related guideline (M-1. Evaluation of Design for Resource Use) required documentation of the life cycle impacts of planning for conservation strategies. To simplify guideline M-1 and put the documentation of planning for conservation strategies in this guideline (P.2) where it belongs in the process, quantitative data is now required under P.2.

For now, design teams can fill out the tables shown below indicating the amount of space reduction or space reuse. When Version 2.0 is released in July, values for average cost, energy and material savings for each square foot of avoided new construction will be provided in a spreadsheet. Values will also be provided for the average cost and material savings for each square foot of reused or renovated space. In later phases of design, more precise costs, energy, and material savings can be inserted into the spreadsheet by the design team.

Intent (Proposed revision)

Maximize utilization of facilities and modify them less over time by careful analysis of needs and resources. Building less, remodeling existing facilities, and designing for flexibility lead to reductions in cost, energy, and environmental impacts of materials.

Required Performance Criteria (Proposed revision)

- Evaluate the assumptions to build, expand or remodel facilities using these questions.
    - Can the current facilities be shared or better utilized to reduce or eliminate the need for additional space?
    - Can the current facilities be used more hours of the day or more days of the week to reduce or eliminate the need for additional space?
    - Can the current space be reconfigured within its shell to meet the need?
    - If not, can an existing building be reconfigured within its shell to meet the need?
    - If not, would an addition to the current space or another existing building meet the need?
    - If not, how can new space be optimized (including shared use of some facilities) and the building footprint be minimized?
    - For all options, how can the space be configured best for future use and adaptability?
- Document the process in narrative showing that a thorough review of planning for conservation options was completed.
- Create and fill out tables as shown below and add narrative as appropriate.

Planning for Conservation Strategy Documentation Table
(with sample entries shown)

1. Reduce program needs

Strategy	Square footage avoided	Comment
Eliminate space 1	1000	Use neighboring facility
Reduce space 2	500	Share conference rooms
Reduce space 3	200	Unnecessarily large lobby
Eliminate space 4	1000	Use space 16 hours a day
Reduce space 5	2000	Telecommuting of staff
TOTAL	4700	

2. Reuse existing building

Strategy	Square footage reused	Comment
Reuse building 1	6000	Remodel for offices
TOTAL	6000	

3. Create flexible and adaptable space

Strategy	Square footage affected	Comment
High ceilings	10000	Adaptable to multiple uses
Raised floor	20000	Less costly to renovate

Option: For Item 3, use narrative in place of table if more appropriate.

P.6 Lowest Life Cycle Cost

NOTE: In its original form, this guideline required life cycle cost analysis but did not specify how to apply it to the project. In the proposed revision, life cycle cost analysis must be applied to three whole building energy use scenarios generated in guideline E.1. More extensive life cycle cost analysis is optional.

Intent
Determine the lowest life cycle cost when comparing design alternatives.

Required Performance Criteria (Proposed revision)

- Perform a life cycle cost on the energy strategies for the whole building based on three energy use scenarios generated in guideline E.1 using the life cycle cost calculation embedded in the Energy and Atmosphere Outcome Documentation spreadsheet (will be coming in Version 2.0.)

Recommended Performance Criteria (Proposed Revision)

- Include more extensive life cycle cost analysis of any design alternatives at the assembly, system or component scale.

I.2 Indoor Air Quality and Ventilation Baseline

NOTE: In Version 2.0, this guideline will be changed to adopt 62.1-2004 and associated revisions in 2007 and 2010as the basic reference.

I.# Ventilation Performance Validation

NOTE: This is a proposed new guideline for Version 2.0. The intention of this guideline is to promote good indoor air quality to be maintained over time by requiring that ventilation design intent be demonstrated on a regular basis to building owners and operators.

I.4 Ventilation Based on Anticipated Pollutants

NOTE: In Version 1.1, this guideline recommends calculation of ventilation based on pollutant concentrations. In Version 2.0, this guideline is eliminated.

M.1 Life Cycle Assessment of Building Assemblies
(Previous title: M.1 Evaluation of Design for Resource Use)

NOTE: In Version 1.1, this guideline required life cycle assessment of strategies ranging from reduced space needs to choice of building assembly materials. Tools for the analysis were suggested but no direct method was provided.

In Version 2.0, all calculations of the environmental impacts from strategies that reduce space, reuse buildings, or design for adaptability and flexibility are now determined in P.2 Planning for Conservation. In Version 2.0, a spreadsheet will be provided where the design team selects the assemblies and environmental impacts are calculated automatically. This new spreadsheet will replace Forms M-A, M-1, M-2A and M-2B. Teams may also perform their own customized comparisons using life cycle analysis software..

Until the next revision in July 2006, teams may do one of the following: 1) still use Version 1.1 documentation, 2) provide a narrative on how guidelines issues have been addressed, or 3) leave the documentation as "to be determined" and complete the documentation the guideline once Version 2.0 has been issued.

Intent (Proposed revision)

To perform a Life Cycle Assessment of alternatives for building assembly material choices during schematic design. Building assembly choices early in the process significantly affect global warming, air pollution, water pollution, energy use, and waste.

Required Performance Criteria (Proposed revision)

- Evaluate at least two alternative scenarios for building assembly material choices on the project. Assemblies to be documented are foundation, beams and columns, intermediate floors, roof, exterior walls, windows, and interior partitions. Outcomes are global warming potential, air pollution index, water pollution index, primary energy, and solid waste produced over the life cycle of the material. The analysis is calculated over a 60-year life cycle. The tool for these calculations is the spreadsheet provided which has pre-run assembly scenarios based on the Athena Environmental Impact Estimator software. Teams may alternately run the Athena Environmental Impact Estimator themselves for a more customized approach.

Recommended Performance Criteria (Proposed revision)

- Life Cycle Assessment of interior finish materials is not required in this guideline. Teams are encouraged to use BEES or other tools to perform similar types of analysis. This type of assessment usually occurs in the DD or CD phase.

M.2 Evaluation of Material Properties for Improved Performance

NOTE: In Version 1.1, this guideline requires documentation of material properties in the table in Appendix M-2A. It also requires a life cycle assessment of the materials in the table in Appendix M-2B. There is an option to provide narrative information where LCA is not available. In Version 2.0, Forms M-A, M-1, M-2A and M-2B will be replaced or eliminated. A narrative describing the type and extent of materials with certain properties is required. Further documentation of specific material properties is recommended. Until the next revision in July 2006, teams may do one of the following: 1) still use Version 1.1 documentation, or 2) provide a narrative on how guideline issues have been addressed.

Intent

To encourage the use of materials and products that meet specific prescriptive requirements understood to provide improved life cycle performance.

Required Performance Criteria (Proposed revision)

This guideline does not require implementation of any minimum level of materials or products meeting these criteria. However, it is required to document efforts to utilize these materials in narrative form indicating the specific properties and extent of the application.

Material properties to be documented in narrative form are listed below. Indicate specific property and extent of application.

- Salvaged or reused material
- High recycled content
- Locally/regionally produced and manufactured.
- Made from rapidly renewable agricultural byproducts
- Certified wood products
- Maximum durability
- Able to be reused, recycled, or that are biodegradable
- Designed for disassembly

Recommended Performance Criteria (Proposed revision)

Indicate detailed volume and cost information as required by LEED or other guidelines.

The State of Minnesota
Sustainable Building Guidelines (MSBG)

Buildings, Benchmarks and Beyond

www.msbg.umn.edu

[www. csbr.umn.edu/B3](www.csbr.umn.edu/B3)

Print Version for the
Minnesota Sustainable Building Guidelines
Version 1.1

Last Update 07/1/2004

THE STATE OF MINNESOTA
SUSTAINABLE BUILDING GUIDELINES
VERSION 1.1
Part of the Buildings, Benchmarks and Beyond (B3) Project

CONTENTS

Overview

An interdisciplinary team of local and national experts has developed sustainable building guidelines for the State of Minnesota Departments of Administration and Commerce that will be used on all new state buildings. This is Version 1.1 of The State of Minnesota Sustainable Building Guidelines. It will be tested during 2004-5 and subsequent revisions will be published on at least an annual basis.

The guidelines are a part of the Buildings, Benchmarks & Beyond (B3) Project consisting of three components. Project management and delivery is led by LHB, Inc.; the guideline development process is led by the Center for Sustainable Building Research (CSBR); and public building benchmarking is led by The Weidt Group. The management component of the B3 project facilitates integration of the guideline and benchmarking efforts, and coordinates public input. The guidelines component is described above and is the subject of this document. Benchmarking will identify the energy performance of existing public buildings in order to direct energy conservation improvements where they are most needed and most cost-beneficial. As new state-funded projects are constructed and operated in accordance with the new sustainable guidelines, more detailed information on energy and other sustainable performance factors will also be tracked.

Background

Applicable Legislation

The departments of Administration and Commerce, with the assistance of other agencies, must develop sustainable building design guidelines for all new state buildings funded by bond money after January 15, 2004. According to the legislation, the guidelines must:

- Exceed existing energy code by at least 30 percent
- Achieve lowest possible lifetime costs for new buildings
- Encourage continual energy conservation improvements in new buildings
- Ensure good indoor air quality
- Create and maintain a healthy environment
- Facilitate productivity improvements
- Specify ways to reduce material costs
- Consider the long-term operating costs of the building including the use of renewable energy sources and distributed electric energy generation that uses a renewable source of natural gas or a fuel that is as clean or cleaner than natural gas.

The State has further clarified the scope of the Version 1.1 of the guidelines to focus on new office and higher education classroom facilities, although many of the guidelines are suitable for other building types and renovation projects.

Existing Guidelines

The Minnesota Sustainable Design Guide (MSDG) was initiated in 1997 by Hennepin County with a grant from the Minnesota Office of Environmental Assistance (OEA) and is currently maintained by the University of Minnesota. It embodies many regionally specific strategies in an open framework. The guide is a management tool with interconnected sets of information on design process, strategies, and case studies with a flexible scorekeeping system. It will be replaced by the Minnesota Sustainable Building Guidelines.

The LEED™ Rating System (Leadership in Energy and Environmental Development) developed by the U.S. Green Building Council (USGBC) has emerged in recent years as a national standard with a high level of visibility and increasing market acceptance. Other prominent guidelines and assessment tools that form the foundation for LEED™ and MSDG are BREEAM™[1] and GBTool . LEED™ has been adapted for use in many regions of the U.S. and Canada. Some of these efforts include guidelines for New York City, North Carolina, Pennsylvania, and LEED Canada

Key Problems and Issues
In spite of the many models of existing guidelines, there are some fundamental problems that have not yet been addressed adequately. For example:

Current guidelines, like LEED™ use prescriptive, point-based, and proxy measures that simplify both compliance and enforcement but in many cases do not connect to real human, community, environmental, and life-cycle economic outcomes and in some cases may lead away from desired results.

- The life cycle costs and benefits of sustainable design strategies are not well documented or available early enough in the process to effect significant improvements.
- There is no planning framework or process that allows managers to actually make sustainable choices during project initiation and capital budget planning.
- National guidelines such as LEED™ are not always regionally appropriate and are not applicable to all project types in all cases.
- Fixed standards are rarely right for every building in every location.

Vision
Based on experience and analysis of other systems as well as the direction of the client, the desired attributes of The State of Minnesota Sustainable Building Guidelines are listed below.

- Performance-based, moving from proxies to real performance indicators related to cost, people, community and, eventually, environment. These true outcomes become the inputs for a complete life cycle analysis tool for decision makers.
- Clear, simple and easily monitored or calculated.
- Explicit documentation to hold agencies and designers accountable.
- Self-improving, with project documentation informing further guideline development and the State's benchmarking activities.
- Compatible with national models such as LEED™ while maintaining regional values, priorities and requirements.

To address these challenges the first phases of the project attempt to do the most important things first and do them well. The framework for performance accounting is established in early phases; the tools to confirm that desired outcomes are achieved and verify performance accountability are developed in following phases. Ultimately, outcomes will be incorporated into a complete life cycle cost analysis whenever possible. The short- and long-term vision includes:

Early Phases:

- A set of clear goals, objectives, guidelines, and performance criteria for state funded buildings in Minnesota (correlated to LEED™ and MSDG.)
- Wherever possible, move from proxy measures to actual performance-based outcomes in these areas- human, community, environmental, and lifecycle cost.
- A step-by-step process that assists in implementing the guidelines.

[1] BREEAM™ (Building Research Establishment Ltd.'s Environmental Assessment Method); GBTool (Green Building Assessment Tool)

Following Phases:

- A comprehensive, integrated set of decision support tools to assist public agencies in facility planning and design, capital budget planning, cost/benefit analysis, environmental assessment, worker productivity impact, and community impact.
- An evolving knowledge base with information fed back from benchmarking, project experience and post occupancy evaluations.
- A publicly maintained one-stop source of information on sustainable buildings in Minnesota.

Key Guideline Concepts

1. **Reduction in Guidelines**
   Guidelines have been eliminated that are either already required by code or do not apply in this region.

2. **Required Guidelines**
   Guidelines are required when they clearly contribute to the desired life cycle cost, human, community or environmental outcomes. Guidelines are sometimes recommended rather than required until their benefits to the State can be clearly demonstrated. In some of these cases, however, the team is required to evaluate implementing the guideline to calculate the costs and benefits for their particular project. Where any inconsistencies may appear as to the extent of performance required or whether an item is recommended or required, the more strict (higher performing) case shall apply.

3. **Connection to Real Outcomes**
   Performance-based guidelines replace prescriptive measures wherever appropriate. Because it is not possible to make a complete transition to a system with performance-based outcomes at this time, each section includes a required Outcome Documentation guideline for submitting information related to human, community, environmental, and life-cycle costs and benefits. The purpose is to collect data on outcomes wherever possible and educate all participants in the process of determining outcomes. The performance indicators of real outcomes to be calculated in applying these guidelines (to be further developed in following phases) include the following:

   Project Lifecycle Costs
   - Project capital costs
   - Operation and maintenance costs

   Human Impacts and Related Cost
   - Health and Well-being
   - Productivity
   - Absenteeism
   - Employee turnover
   - Health care costs

   Environmental Impacts
   - Primary energy
   - Global warming potential
   - Air pollution index
   - Water pollution index
   - Resource depletion
   - Waste production

Community Impacts and Related Cost
- Community infrastructure demand and associated costs
- Community assets contributed by project
- Economic impacts
- Social impacts

4. **Relationship to LEED™ and the existing Minnesota Sustainable Design Guide (MSDG)**
   It is envisioned these guidelines will replace the current Minnesota Sustainable Design Guide; however, versions of both systems will be posted on the internet during the transition period.

   The guidelines contained in this document do not require any connection to LEED™ guidelines. There is a clear correspondence, however, that allows owners and designers to seek LEED™ certification if they desire. Compared to LEED™, these guidelines have, in effect, made a number of credits into prerequisites, removed credits that are required by code, and added some guidelines including Outcome Documentation. The correspondence between The State of Minnesota Sustainable Building Guidelines and LEED™ is shown in the Guideline Summary Table.

   Effort will be made to indicate where these guidelines meet or exceed requirements for compliance with LEED™ Credits, as well as where guidelines may need further enhancements to comply with LEED™ requirements. (See the Guideline Summary Table.) It is not the purpose of The State of Minnesota Sustainable Building Guidelines to follow LEED™ requirements specifically, but wherever requirements are the same or similar, documentation required for these guidelines may be useful in achieving LEED™ credit. There is no guarantee, however, that compliance with these guidelines will result in a LEED™ credit. Refer to LEED™ sources for specific requirements and documentation required for certification.

   One benefit of making The State of Minnesota Sustainable Building Guidelines transparent to LEED™ is that LEED™ certification serves as one incentive to achieve higher performance than the basic requirements of these guidelines. (Once it is possible to determine the true lifecycle cost impacts of higher performance buildings, the benefits accrued to the project and the State will be another effective incentive.)

How to Use the Guidelines
The guidelines are organized into the following topic categories. (See Guideline Summary Table):

- Performance Management
- Site and Water
- Energy and Atmosphere
- Indoor Environmental Quality
- Materials and Waste

At the beginning of each section, there is an overview, goals, objectives, and a list of guidelines for that topic. Most guidelines are required although parts or all of some guidelines are noted as recommended. This is followed by documentation for each guideline that states the intent, performance criteria, suggested implementation steps, tools and resources. The suggested implementation steps are not the only way to achieve the performance criteria, but the team should read the suggested implementation steps, even if they use a different process as a check of progress when they complete the compliance summary form at the end of each phase. Also note, the suggested implementation steps are not intended to be a complete list of all that needs to be done to achieve performance criteria, but instead provide some of the key steps for a typical process. A glossary is included at the end of the guidelines. The process for implementing the guidelines is explained in the Performance Management section. Each section includes an Outcome Documentation guideline where the key performance indicators are determined as much as possible at this time. These outcomes will be inputs for the total lifecycle analysis tool to be developed in subsequent versions of the guidelines and also used in benchmarking.

Credits

Phase I Team (Completed 1/15/03)

Phase I State of Minnesota Team

Executive Team	Agency
Wes Chapman	Department of Administration
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Laura Millberg	Office of Environmental Assistance (OEA)
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Phase II Team (Completed 7/1/04)

State of Minnesota Team

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Executive Summary

The Minnesota Legislature required the Departments of Administration and Commerce, with the assistance of other agencies, to develop sustainable building design guidelines for all new state buildings by January 15, 2003. According to the legislation, the guidelines must:

- Exceed existing energy code by at least 30 percent
- Achieve lowest possible lifetime costs for new buildings
- Encourage continual energy conservation improvements in new buildings
- Ensure good indoor air quality
- Create and maintain a healthy environment
- Facilitate productivity improvements
- Specify ways to reduce material costs
- Consider the long-term operating costs of the building including the use of renewable energy sources and distributed electric energy generation that uses a renewable source of natural gas or a fuel that is as clean or cleaner than natural gas.
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To achieve these goals, The State of Minnesota Sustainable Building Guidelines (MSBG) build on previous local and national efforts. The guidelines are designed to be clear, simple and easily monitored with explicit documentation that will record progress. They are designed to be compatible with national guidelines such as LEED™ while maintaining regional values, priorities and requirements. Most importantly, the guidelines set up a process that will eventually lead to a full accounting of the actual human, community, environmental, and life-cycle economic costs and benefits of sustainable building design.

The guidelines are organized into the following categories: Performance Management, Site and Water, Energy and Atmosphere, Indoor Environmental Quality, and Materials and Waste. Guidelines are required when they clearly contribute to the desired human, community, environmental, and life-cycle economic outcomes. Some guidelines are recommended rather than required until their direct financial benefits to the State can be clearly demonstrated. However, in some of these cases, the team is required to evaluate implementing the guideline.
Sustainable design is a means to reduce energy expenditures, enhance the health, well-being and productivity of the building occupants, and improve the quality of the natural environment. All of these can contribute to high-performance State buildings with lower life cycle costs. To move toward ensuring these outcomes, the guidelines attempt to quantify the human, community, environmental, and life-cycle economic costs and benefits for each project.

This version of The State of Minnesota Sustainable Building Guidelines is referred to as Version 1.1. It will be tested on pilot projects during its initial use and refined based on that experience.

THE STATE OF MINNESOTA SUSTAINABLE BUILDING GUIDELINE SUMMARY

Version 1.1 7/1/04 **Part of the Buildings, Benchmarks, and Beyond (B3) Project**

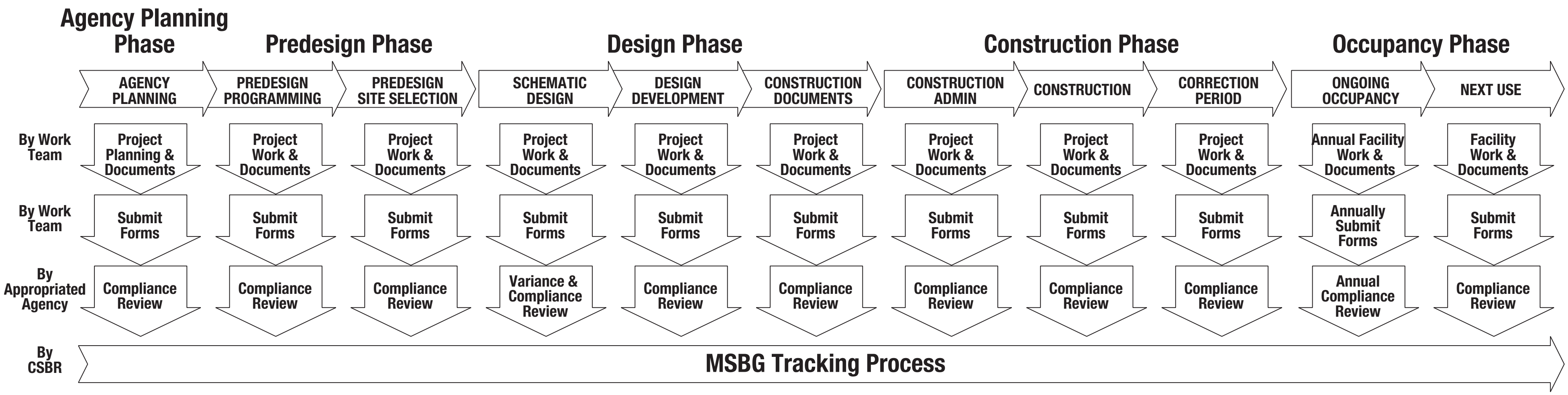
MSBG GUIDELINES (Required except as noted by * which indicates recommended.)		COMPARISON TO LEED™ ** Potential LEED™ Credits		Potential LEED™ Points For MSBG Requirements	For MSBG Requirements & Recommendations
	PERFORMANCE MANAGEMENT				
P.1	Guideline Management				
P.2	Planning for Conservation				
P.3	Integrated Design Process				
P.4	Design and Construction Commissioning	EA EQ	Prereq 1, Credit 3 Credits 3.1, 3.2	3	3
P.5	Operations Commissioning	EA EQ	Credit 5 Credit 1	2	2
P.6	Lowest Life Cycle Cost				
P.7	Process Documentation for Performance Management				
	SITE AND WATER				
S.1	Avoid Critical Sites	SS	Credit 1	1	1
S.2	Appropriate Location and Density	SS	Credit 2	0	1
S.3	* Brownfield Redevelopment	SS	Credit 3	0	1
S.4	Erosion and Sedimentation Control	SS	Prereq 1	0	0
S.5	Stormwater Management	SS	Credit 6.1, 6.2	2	2
S.6	Reduce Site Disturbance and Restore Site	SS	Credit 5.1, 5.2	2	2
S.7	* Restorative Design				
S.8	Reduce Site Water Use for Plant Materials	WE	Credit 1.1. 1.2	1	2
S.9	Reduce Light Pollution	SS	Credit 8	1	1
S.10	* Reduce Heat Island Effect	SS	Credit 7.1-7.2	0	2
S.11	* Encourage Efficient Transportation Alternatives	SS	Credit 4.1—4.4	0	4
S.12	Building Water Efficiency	WE	Credit 3.1, 3.2	2	2
S.13	* Use Gray Water to Reduce Wastewater Treatment Impacts				
S.14	* Use Biological Wastewater Treatment System	WE	Credit 2	0	1
S.15	Outcome Documentation for Site and Water				
	ENERGY AND ATMOSPHERE				
E.1	Reduce Energy Use by at least 30%	EA	Prereq 1, Credit 1.1—1.5	4	10
E.2	Efficient Equipment and Appliances				
E.3	Evaluate Renewable and Distributed Energy Generation	EA	Credit 2.1—2.3, 6	0	4
E.4	* Atmospheric Protection	EA	Prereq 3, Credit 4	0	1
E.5	Outcome Documentation for Energy and Atmosphere				
	INDOOR ENVIRONMENTAL QUALITY				
I.1	Restrict Environmental Tobacco Smoke	EQ	Prereq 2	0	0
I.2	Indoor Air Quality and Ventilation Baseline				
I.3	Specify Low-emitting Materials	EQ	Credit 4.1—4.4	4	4
I.4	Ventilation Based on Anticipated Pollutants	EQ	Credit 5	1	1
I.5	Ventilation Based on Carbon Dioxide Limits				
I.6	Moisture Control	EQ	Prereq 1, Credit 2	1	1
I.7	Thermal Comfort	EQ	Credit 7.1	1	1
I.8	* Daylight	EQ	Credit 8.1	0	1
I.9	Quality Lighting				
I.10	* View Space and Window Access	EQ	Credit 8.2	0	1
I.11	Eliminate Whole Body Vibration in Buildings				
I.12	Effective Acoustics & Positive Soundscapes				
I.13	* Personal Control of IEQ Conditions & Impacts	EQ	Credit 6.1, 6.2	0	2
I.14	* Encouraging Healthful Physical Activity				
I.15	Outcome Documentation for Indoor Environmental Quality				
	MATERIALS AND WASTE				
M.1	Evaluation of Design for Minimum Resource Use	MR	Credits 1, 3	0	5
M.2	Evaluation of Material Properties for Improved Performance	MR	Credits 4—7	0	6
M.3	Waste Reduction and Management	MR	Credit 2.1, 2.2	1	2
M.4	Outcome Documentation for Materials and Waste				
**Comparison to LEED™ points is estimated. MSBG requirements overlap with LEED™ credits, however, following MSBG does not require, nor automatically result in LEED™ certification.			TOTALS	26	63
			Corresponding LEED™ Certification Level	(Certified)	(Platinum)

Process

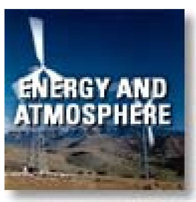
Refer to Performance Management Guideline P.1 for comprehensive explanations and requirements for the guideline management process.

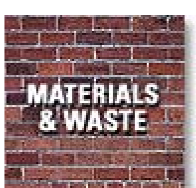
Guideline Management Process

- At the start of each phase (or year of operation), the Guideline Leader reviews the MSBG guidelines and associated Outcome Documentation Forms, plans the tasks to be done for that phase to keep on track for meeting the guidelines, and communicates this with the work team.
- If exceptions to the MSBG guidelines are sought, the Guideline Leader (whether from the agency/owner in early phases or from the design team in later phases) shall request the variance in writing to the Appropriated Agency for Variance Review before the completion of the schematic design phase. For each guideline for which variance is requested, the request for variance shall include the name of the guideline, an explanation of why variance is requested, and supporting information demonstrating the reason whether it be for financial hardship or other reasons.
- The Work Team for the responsible organization (planning team, design team, construction team, or operations team depending on phase) works towards the MSBG requirements. At the end of the phase, the work team completes the Outcome Documentation Forms and Compliance Summary Form and gives them to the Guideline Leader.
- The Guideline Leader collects the Compliance Summary Form and Outcome Documentation Forms for each topic area at the end of each phase (or annually during facility operation.)
- Optionally, in addition, the Guideline Leader summarizes the extent of compliance and the progress towards outcomes for the whole project and organizes all of this into a cohesive, end-of-phase Guideline Report.
- The Guideline Leader submits the Guideline Report (even if it only contains the required forms) to the Appropriated Agency for Compliance Review, and archives relevant documentation for that phase (or year) that supports the Guideline Report in the project files, for future reference.


Agency Planning Phase
Predesign Phase
Design Phase
Construction Phase
Occupancy Phase
AGENCY PLANNING
PREDESIGN PROGRAMMING
PREDESIGN SITE SELECTION
SCHEMATIC DESIGN
DESIGN DEVELOPMENT
CONSTRUCTION DOCUMENTS
CONSTRUCTION ADMIN
CONSTRUCTION
CORRECTION PERIOD
ONGOING OCCUPANCY
NEXT USE
By Work Team
Project Planning & Documents
Project Work & Documents
Annual Facility Work & Documents
Facility Work & Documents
By Work Team
Submit Forms
Annually Submit Forms
By Appropriated Agency
Compliance Review
Variance & Compliance Review
Annual Compliance Review
By CSBR
MSBG Tracking Process

Minnesota Sustainable Building Guidelines (Required except where noted with *)





Guidelines: Performance Management

Guidelines (Required)

Forms

Overview

Too often, goals for long term savings, improved occupant health and reduced impact to the environment are not realized due to problems with the implementation process. In the complex sequence of planning, design, construction, and operation it is not enough to set a goal for improved performance - there needs to be a process followed to avoid missing the biggest opportunities early on and to prevent well-intended approaches failing in operation.

The Performance Management section outlines the processes to support successful performance improvements intended by *The State of Minnesota Sustainable Building Guidelines (MSBG)* by documenting progress towards performance criteria throughout the planning, design, and construction phases. Monitoring of key systems continues throughout occupancy and provides information on an ongoing basis, which will provide information for planning and constructing future State projects.

In addition, the Performance Management guidelines address the creation and use of the team necessary for a well-integrated solution, and the thorough evaluation of current and future needs so that all facilities are well-utilized and represent a responsible use of economic and natural resources over time. While the Performance Management section supports the actions defined in other sections, there may be specific actions and benefits that come out of the processes in this section. The documentation that is filed under this section is limited to process and reference information.

Goal

To employ processes that improve the ongoing performance of facilities towards the lowest lifetime costs, and to promote design and operational decisions based on improving environmental, human, and economic outcomes.

Objectives

- Define a simple process for tracking progress towards guideline compliance throughout the project development and operation.
- Document information that captures design intent and actual performance to track progress towards desired guideline outcomes and to facilitate guideline improvement.
- Define a quality planning, control and tracking process to ensure that specific steps take place that are needed to support the operational achievement of performance criteria.
- Initiate and utilize an integrated team approach to produce integrated solutions.
- Review needs and resources thoroughly so as to maximize utilization of space.
- Provide guidance on determining the lowest life cycle cost for project alternatives.

Guidelines: Performance Management

P.1 Guideline Management

Intent
Track compliance, define a method of variances and collect information to measure outcomes leading to continual improvement of the Guidelines.

Required Performance Criteria
- Follow Agency process for guideline management. In lieu of specific agency process, see Guideline Management Process. (See Supporting Information.) In either case, the following elements are required at the end of each phase and annually during operations:
  - Complete forms verifying compliance (for required guidelines) and indicate use of guidelines that are being used voluntarily. (See P-A.) Submit them to the Appropriated Agency for Compliance Review and to CSBR.
  - Complete (update) outcome documentation (P-B.) Submit them to the Appropriated Agency for Compliance Review and to CSBR.
- Use Agency variance process or follow Variance Review Process, when appropriate (see Supporting Information.) The agency variance process must include at least the elements shown in the Variance Review Process.

Supporting Information

Guideline Process Descriptions
Guideline Management Process
- At the start of each phase (or year of operation), the Guideline Leader reviews the MSBG guidelines and associated Outcome Documentation Forms, plans the tasks to be done for that phase to keep on track for meeting the guidelines, and communicates this with the work team.
- If exceptions to the MSBG guidelines are sought, the Guideline Leader (whether from the agency/owner in early phases or from the design team in later phases) shall request the variance in writing to the Appropriated Agency for Variance Review before the completion of the schematic design phase. For each guideline for which variance is requested, the request for variance shall include the name of the guideline, an explanation of why variance is requested, and supporting information demonstrating the reason whether it be for financial hardship or other reasons.
- The Work Team for the responsible organization (planning team, design team, construction team, or operations team depending on phase) works towards the MSBG requirements. At the end of the phase, the work team completes the Outcome Documentation Forms and Compliance Summary Form and gives them to the Guideline Leader.
- The Guideline Leader collects the Compliance Summary Form and Outcome Documentation Forms for each topic area at the end of each phase (or annually during facility operation.)
- Optionally, in addition, the Guideline Leader summarizes the extent of compliance and the progress towards outcomes for the whole project and organizes all of this into a cohesive, end-of-phase Guideline Report.
- The Guideline Leader submits the Guideline Report (even if it only contains the required forms) to the Appropriated Agency for Compliance Review, and archives relevant documentation for that phase (or year) that supports the Guideline Report in the project files, for future reference.

Variance Review Process

The Variance Review Process defines the steps for reviewing a request to not adhere to a portion of the guideline as written. This is intended to be used very sparingly, for issues such as non-applicability to a building type or scale. It is led by the Appropriated Agency and consists of the following key steps:

- The Work Team (or Guideline Leader if applicable) submits a variance request in writing to the Appropriated Agency before the completion of the schematic design phase. The request shall document the reasons for each variance request.
- After review, the Appropriated Agency either accepts or rejects the request for variance, or may specify a compromise equivalency or conditions for the variance.
- The Appropriated Agency sends a copy of the variance request and extent approved to CSBR

Compliance Review Process

The Compliance Review Process is designed to provide checkpoints for regularly reviewing compliance with the guidelines over time from initial phases through ongoing occupancy. The Appropriated Agency leads the Compliance Review Process which consists of the following key components:

- The Appropriated Agency receives the end-of-phase Compliance Summary Form and Outcome Documentation Forms (and optionally Guideline Report) from the Guideline Leader.
- The Appropriated Agency reviews the extent and nature of compliance as documented by the Guideline Leader and decides if the extent of compliance is acceptable. (The Appropriated Agency, is not responsible for determining compliance, but may question if compliance is achieved if in doubt.)
- The Appropriated Agency then either approves the extent of compliance for that phase, or directs the Guideline Leader to revisit compliance measures with the work team.
- After successful completion of the correction period or the first year of operation, whichever is longer, the Appropriated Agency may end its role in Compliance Review. In any case, the annual reporting will continue to be sent to CSBR throughout the life of the project's operation. (See MSBG Tracking Process.)

MSBG Tracking Process

This consists primarily of updating and maintaining the project information. Related activities may include posting data from the project on an informational MSBG web site, using project information to improve the usability and effectiveness of the MSBG guidelines, and translating reported building performance into economic, human, and environmental outcomes for use by the State of Minnesota This process consists of the following elements:

- Agency sends Compliance Summary form and all Outcome Documentation Forms (and Guideline Reports if applicable), at the end of each phase, and annually during operations to CSBR for use in the MSBG Tracking Process. Depending on the phase, Outcome Documentation may also call for Commissioning or other reports to be attached.
- CSBR receives Compliance and Outcome forms from the Agency.
- CSBR uses the information received to update and maintain project information.
- CSBR uses project information at the direction of the State of Minnesota.

Guideline Management Roles

Work Team: The Work Team is responsible for the facility performance progress in a particular phase. Depending on the phase, this may be the planning team, predesign team, design team, construction team, or operations team. This team works towards the guideline performance criteria appropriate to their phase, and completes Compliance Summary and Outcome Documentation Forms at the end of each phase (or annually during Ongoing Occupancy.)

Guideline Leader: The Guideline Leader is the person who coordinates the completion, and documentation of tasks to comply with the sustainable guidelines. They shall work within the organization contractually responsible for a phase (or be a consultant hired by that organization), thus the role may be filled by different people for each phase. They are the contact person for guideline compliance. . Some Agency processes, may have a different name for this role, or not designate this role, leaving it up to a representative from the Work Team to coordinate the tasks of the Guideline Leader. The person and organization mostly likely to play the role of the Guideline Leader in each phase is as follows:

Phase:	**Recommended Guideline Leader**:
Agency Planning	Facility Project Manager
Predesign-Programming	Facility Project Manager or Predesign Consultant
Predesign-Site Selection	Facility Project Manager or Predesign Consultant
Schematic Design	Design Team Project Manager or Sustainable Consultant
Design Development	Design Team Project Manager or Sustainable Consultant
Construction Documents	Design Team Project Manager or Sustainable Consultant
Construction Administration	Design Team Project Manager or Sustainable Consultant
Construction	Construction Supervisor
Correction Period	Commissioning Team Leader/ Coordinator
Ongoing Occupancy	Facility Operations Manager
Next Use	Facility Project Manager for Next Use

The Guideline Leader's duties include:

- Coordinate and Support the Guideline Management Process
- Maintain continuity as Guideline leader position transfers across phases and responsible organizations
- Support an interdisciplinary, participatory team approach. (See Guideline P.3 Integrated Design and Construction Process for details.)

The Guideline Leader should possess the following qualities:

- Familiar with MSBG guidelines and generally with sustainable practices
- Good facilitation and communications skills (verbal and written)

Appropriated Agency: The Appropriated Agency is the agency that received funding from the capital bond proceeds on behalf of the project and is responsible for compliance review. The role includes the following:

- The appropriated agency is responsible for reviewing, (but not necessarily determining), compliance with the guidelines according to the Compliance Review Process based on the extent of compliance represented and documented in the Outcome Documentation and Compliance Summary Forms (and optional Guideline Report.)
- The Appropriated Agency also reviews and decides whether to accept applications for variance from the guidelines according to the Variance Review Process.
- The Appropriated Agency may choose to cease involvement in project compliance monitoring after successful completion of the correction period or 1 year of operation, which ever is longer.

CSBR: The Center for Sustainable Building Research (CSBR) at the University of Minnesota acts as the MSBG tracking team. CSBR leads the MSBG Tracking Process, updates and maintains project information with required forms and optional Guideline Reports from each phase of project development and each year of operational data. This data may be posted on an MSBG informational web site. It may also be used for selected audits, to improve the usability and effectiveness of the MSBG guidelines, and to translate building performance in to state economic, human, and environmental outcomes. CSBR tracks the MSBG on direction of the State.

Guideline Management Reporting

Compliance Summary Form: A Compliance Summary Form is filled out for the project at the end of each phase or annually during Ongoing Occupancy. It includes statements of compliance, or progress towards compliance appropriate to the phase signed by the responsible party for each guideline. See Form P-A.

Outcome Documentation Forms: An Outcome Documentation Form is filled out for each topic (Site, Energy, etc.) indicating key documentation of performance and outcome results for each guideline within a topic. The Outcome Documentation Form and attachments are completed at the end of each phase (or annually during Ongoing Occupancy.) See Process Documentation and Outcome Documentation Guidelines and forms for further description and sample templates.

Guideline Report (Optional): The Guideline Report provides information to the Compliance Review Process, and the MSBG Tracking Process. Guideline Reports are submitted for compliance review at the end of each phase (or annually during operations.) They are phase-specific and compare the state of design documentation or facility operation at a specific time or time period to the guideline requirements for that phase. In addition to the required forms, the Guideline Report provides a narrative of progress, and may discuss issues to be resolved or lessons learned along the way.
The Guideline Report consists of:

- Required compliance summary forms and outcome documentation forms for the phase.
- Executive summary of the extent of guideline compliance for that phase.
- Executive summary of performance achieved (or estimated progress towards that performance in planning and design phases.)

Project Archive (Optional): The Project Archive is the performance planning, design, and ongoing maintenance history of the project. This body of information should include: performance parameters and basis for design, design actions taken towards MSBG criteria, ongoing monitoring, measurement and verification over time, actions to resolve problems over time, and results of those actions. It includes each released version of the Guideline Reports and Commissioning Reports. The Guideline Leader and Work Team maintain the Project Archive each phase and facilitate its transition to leaders of following phases.

Recognition Award Programs

The Minnesota Office of Environmental Assistance offers environmental awards and recognition programs, including the coveted Governors Awards for Excellence in Waste and Pollution Prevention, the MNGreat Awards, and Minnesota Waste Wise Leaders Awards. www.moea.state.mn.us/P2/awards.cfm

The United States Green Building Web Site: "The LEED (Leadership in Energy and Environmental Design) Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings." Buildings can be rated as Certified, Silver, Gold or Platinum. www.usgbc.org

Suggested Implementation

The **Guideline Management Process** is outlined in the Supporting Information Section. A diagram of major roles and the flow of documentation for each phase is indicated on the MSBG Process Diagram. (See Page Section 1.12.) Features of this process include:

- Project Work to meet the Guidelines: The Work Team responsible for compliance shifts to correspond with the organization responsible for project work in a particular phase. For Example, during design phases, the design team (and their consultants) are the Work Team. During Ongoing Occupance, the Work Team resides with the facility operations group who are responsible for maintaining and operating the facility.
- Guideline reporting: Forms submitted each phase include Compliance Summary Forms and Outcome Documentation. Forms for each topic (Site, Energy, etc.) are submitted for review at the end of each phase per the Compliance Review Process.
- The Appropriated Agency Reviews the forms submitted in each phase that state the level of compliance and after approval, forwards them on to CSBR for use in the MSBG Tracking Process.

Agency Planning

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Educate planning team so that Agency agrees to importance of:
  - A performance oriented planning, design and construction process.
  - An on-going evaluation of performance, implementation of preventive maintenance, and logging of occupant complaints and resolutions.
- Include the Guideline Management Process in budget plans. This includes long range implications for active management of performance during the Ongoing Occupancy phase.
- Education and Recognition: (Recommended) Plan ahead for ways to educate the public and the design and construction industry about the techniques and performance levels the facility will achieve. See Supporting Information section for samples of award recognition programs.[1]
- Submit Outcome Documentation

Predesign-Programming

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Guideline Leader shall document guideline tasks to perform in this phase.
- Submit Outcome Documentation

Predesign-Site Selection

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Guideline Leader shall document guideline tasks to perform in this phase.
- Submit Outcome Documentation

Schematic Design

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Guideline Leader shall highlight guideline tasks to be performed in this phase, and document details of performance goals and criteria as they develop.

[1] Some recognition programs such as LEED™ take advance planning and specific steps throughout the design process, and so are best planned for early.

- Variance Review: Analyze guidelines to determine if any variances are appropriate, and apply for variances before the end of schematic design.
- Submit Outcome Documentation

Design Development

- Guideline Leader shall highlight guideline tasks to be performed in this phase, and document details of performance goals and criteria as they develop.
- Performance Check: Guideline Leader shall review design as documented to check that it supports the physical outcomes and operational performance desired.
- Submit Outcome Documentation

Construction Documents

- Guideline Leader shall highlight guideline tasks to be performed in this phase, and document details of performance goals and criteria as they develop.
- Performance Check: Guideline Leader shall review design as documented to check that it supports the physical outcomes and operational performance desired.
- Submit Outcome Documentation

Construction Administration

- Guideline Leader (with Design Team) shall identify guideline tasks to be performed by the design team in this phase.
- Performance Verification: Guideline Leader shall verify performance that is not covered under the Commissioning Section. This includes reviewing submittal information to verify its compliance with performance criteria as incorporated in the construction documents.
- Submit Outcome Documentation

Construction

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Construction Guideline Leader (with Construction Team) shall identify and document guideline Construction tasks (as represented in construction documents.)
- Contractor shall comply with guidelines to the extent these are incorporated in the construction documents.
- Submit Outcome Documentation

Correction Period

- Identify the Guideline Leader appropriate to the phase to fulfill the role leading the Guideline Management Process. (See Supporting Information.)
- Education and Recognition: Explore ways to educate the public and the design and construction industry about the performance levels achieved. See Supporting Information section for samples of award recognition programs.
- Submit Outcome Documentation

Ongoing Occupancy

- Identify the Guideline Leader for the ongoing occupancy phase. The Guideline Leader role during operations may be filled by the Facility Operations Manager.
- Guideline Leader shall complete annual Compliance Summary and Outcome Documentation Forms (and optionally Guideline Report), demonstrating guideline compliance, and provide an executive summary of significant facility changes, actions taken to change performance level and measured or estimated results demonstrating performance level.
- The required forms and Guideline Report shall be submitted for Compliance Review and for Benchmarking.

- Guideline Leader shall give written feedback to inform the guideline development process.

Next Use
- Guideline Leader and Facility Operations Manager shall advise in facility planning process and review, and aid in transfer of planning, design, construction, and operations performance history as documented in the Project Archive.

P.2 Planning for Conservation

Intent
Maximize utilization of facilities and modify them less over time by careful analysis of needs and resources.

Required Performance Criteria
- Evaluate the assumptions to build, expand or remodel facilities based on these questions.
  - Can the current facilities be shared or better utilized to reduce or eliminate the need for additional space?
  - Can the current space be reconfigured within its shell to meet the need?
  - If not, can an existing building be reconfigured within its shell to meet the need?
  - If not, would an addition to the current space or another existing building meet the need?
  - If not, how can new space be optimized (including shared use of some facilities) and the building footprint be minimized?
  - For all options, how can the space be configured best for future use and adaptability?
- Document process showing that a thorough review of "building less" (or "utilize more") options was completed with explanation of how the project is proceeding and why this path was chosen. Refer to Materials and Waste[2] and Energy[3] for calculation tools.
  - The analysis requires that the design team evaluate the environmental and economic impacts regarding reuse of an existing building versus building a new building as well as an analysis of how the space use needs could be most efficient.
  - Measure the resource reuse gained when reusing a building against the materials needed to build a new building. Also measure the savings gained because less energy is used in a smaller building. Base the energy savings on typical energy usage for the building type and base on total building square footage.
- Establish sq.ft. areas for the various baselines used to calculated the above: Planning Baseline, Programming Baseline, and Design Baseline. (See P.4 Supporting Information for more on these baselines.)

Tools
These documents will be provided in a supplementary publication.
- Open Ended Questionnaires
- Rating Scales
- Evaluating Current and Predicting Future Environmental Conditions
- Space Program Data Sheet

[2] Building less is a critical component of the Planning for Conservation guideline. It is important that the ideas for building less are discussed in every phase of the project. It is also important that a measuring tool be used to determine what the environmental and economic benefits are for building less. The measuring tool for using fewer resources can be found in Materials and Waste, M.4.
[3] Building less most likely will reduce the amount of energy needed. The designer should calculate typical energy usage for the original programmed building and subsequent buildings that would have less programmed space.

- Functional Adjacency Analysis
- Orientation/Daylighting Requirements
- Occupancy Analysis

Resources
Kensington Library - Environmental Matrix
www.ci.nyc.ny.us/html/ddc/pdf/appf.pdf
Building Green in PA videos
www.greenworks.tv/green_building/archives.htm
WMEP Interdistrict Downtown School Minneapolis Case Study link
www.sustainabledesignguide.umn.edu/MSDG/case/downtown/downtown.html

Suggested Implementation

Agency Planning
- Select an agency person to lead this guideline.
- Determine the area of the Planning Baseline scenario based on typical industry data and first understanding of facility needs and operating parameters. More information under Design and Construction Commissioning, Supporting Information.
- Project organizational needs into the future. Create a document that states space, technology, and systems needs for the next 5-10 years at the beginning of a new project's inception.
- Evaluate the existing building's space utilization, opportunities, and limitations. Agency planning shall consider whether or not their needs can be met without building anything new.
- Determine if all spaces are being used to their capacity during facility use times. The measurement of success of this process will be based on whether or not the perceived facility need was resolved without new construction.
- Review space-sharing options with other state agencies or within the community. As needs are assessed, look to neighboring facilities to determine if spaces could be shared.[4]

Predesign-Programming / Predesign-Site Selection
- Project organizational needs into the future. Review the Agency Planning document that projects Agency space needs for the next 5-10 years. The programming information created in the Agency Planning phase shall be considered the Planning Baseline.
- Evaluate Agency requirements through thorough use of surveys, interviews, questionnaires, and specific system analyses; compile information using tools available in a supplementary publication.
- Analyze Program Utilization
    - Every square foot of new construction has significant economic, environmental impacts, and so to achieve the most sustainable design, it is important to do a careful program analysis in order to build no more than is needed or will be well utilized.
    - Analyze space utilization by comparing recognized standards, existing facility, and proposed program spaces (SF/person-hour)
    - The design team and agency shall work together to create a program that focuses on overall space utilization. This is measured against standard space use standards.
    - Look for opportunities to reduce the number of duplicate spaces (i.e. consider a manager's office as a conference room if that person is out of the office more than 50% of the time.)
    - Develop a space program data sheet.
- Analyze potential future uses and building lifespan. Create multiple planning schemes for projected agency needs and building's next use

[4] The WMEP Interdistrict Downtown School in Minneapolis is a good example of how space sharing with neighbors can effectively reduce the amount of new construction required. Refer to the Resources section for a link to the project case study.

- Create a new program document incorporating changes to the space needs based on the analysis outlined above. Include square footage for spaces that may be located outside the facility as a separate subtotal. Spatial information from this guideline in this phase will contribute to the establishment of the "Programming Baseline." This revised program for new built space can be compared to the Planning Baseline to determine space, energy, and material savings from this phase. (See Design and Construction Commissioning Supporting Information.)
- Tabulate the environmental and economic savings. Refer to Process Documentation for Performance Management P-7.

Schematic Design

- Analyze spatial utilization for program area.
  Determine net program to gross area and net program to gross volume. Excerpt from source of accepted space standards showing recommended SF/program unit ranges. Create a proposed SF/program unit and if the proposed exceeds minimum recommended, then provide an explanation.
- Analyze spatial utilization based on time.
  - For a given building area the justification for the environmental and economic demands, has most meaning when it is a well-utilized space. In a sense, all the embodied cost, and operating costs of a space is wasted for every hour it is not used for its intended purpose. This measure serves to increase awareness for all involved of the amount of "program benefit" achieved for an investment in a space. It is also a way to highlight opportunities for shared spaces between functions that have different scheduling. This can highlight under-utilized spaces that could be borrowed from adjacent facilities. It can also be a way to make more use of tax dollars to construct a building, by identifying underutilized spaces that might be shared with the community to add amenity and create interaction within the community. Each space as well as the whole facility should be analyzed for proposed annual percent utilization based on current program needs. If additional space is being rationalized by future needs the projected percent utilization should also be shown for the time frame scenario being considered.
  - In columns next to each programmed space, identify its annual % utilization based on current program needs. Add columns as needed if it is seasonally based, or if there are areas with low utilization to be examined in more detail for opportunities for space sharing.
  - Tally the total % utilization for all annual hours of all the net program area (not halls, toilets, janitor's closets, etc.)
  - Tally the % utilization for just the primary operating hours as a benchmark.
  - Report the total utilization, the operation hours to total hours, and the utilization within the operating hours.
- Analyze spatial utilization based on volume.
  - Two-dimensional spatial efficiency is a result of the layout of a building and grouping of functions which can affect the overall net to gross area ratio, which affects the environmental and economic impacts of building. Three-dimensional spatial efficiency for a given square foot area, aims at building as high and with as much plenum space as is needed. This is not to say that ample plenum space is not beneficial for future adaptability and maintenance, but that if the designer aims at minimizing wasted height, creative solutions can occur. Nor is it to say that tall spaces whether for daylight access or for design objectives are not important, but they should be compared to the impact of added cubic feet and vertical feet of envelope to put the costs and the benefits in perspective.

- Consider impact of design configuration and system selection on projected building lifecycle scenarios.
    - Evaluate design against needs for adaptability, durability and disassembly. Refer to Materials and Waste for calculation methods and tasks.
    - Confirm life expectancy for building design and design systems accordingly.
- Spatial information from this guideline in this phase will contribute to the establishment of the "Design Baseline" (Covered under Design and Construction Commissioning. See P.4 Supporting Information.) This can be compared to the Programming Baseline from prior phase to see the spatial and associated economic, energy and material savings from the spatial optimization strategies in this phase.

Design Development
- Evaluate design and systems development in relationship to Client needs.
- Evaluate design for building lifecycle scenarios.

Construction Documents
- Ensure efficient detailing for lifecycle scenarios. Refer to Materials and Waste for tasks.

Construction Administration
- Meet with Project Manager, Site Supervisor, and representatives from all of the sub-contractors prior to construction start. Provide information to the contractors related to the MSBG goals, the intent of MSBG and specific information for the project under construction.

Correction Period
- Communicate intent/outcome, benefits of strategies to owner/operator to enhance operation

Ongoing Occupancy
- Analyze ongoing program and schedule optimization
- Review maintenance and operation of facility in relation to building lifecycle scenarios

Next Use
- Refer to documentation of prior scenario planning and actions taken to make use of opportunities designed into the facility

P.3 Integrated Design Process

Intent
Create an integrated approach to the design process by involving key design team members, users, occupants and operators. This approach is associated with successful outcomes on lower cost buildings with improved occupant productivity.

Required Performance Criteria
- Facilitate communication and the process for an interdisciplinary design and stakeholder team as outlined in the Integrated Design Process Overview. (See Supporting Information.)
- Conduct an organization/kick-off meeting including the team.
- Create a plan of meetings and team updates at each phase indicating who will attend, performance responsibilities, and submit documentation of decisions.

Tools

Provided in a supplementary publication:

- PLADEW: Four Factor Sustainable Building Checklist: A Walking Tour in a Learning Environment.
- Visioning Work Meeting/Client Awareness Checklist Form.

Resources

General:

Building Green in PA videos www.greenworks.tv/green_building/archives.htm
The MOEA web site of Resources on Sustainability is an excellent source of information about community benefits from sustainable design. Includes the Neighborhood Sustainability Indicators Guide, Thinking Like a Sustainable Community: A Workbook for Applying a Sustainability Framework to Community Challenges, and more. www.moea.state.mn.us/sc/resources.cfm

Supporting Information

Integrated Design Process Overview

- Assemble appropriate stakeholder team
  Include representation from every discipline that will be involved in the project: Owner's decision-making team, users, occupants, operations and maintenance representatives, at least one representative from the community, and at least one agency "client" or visitor representative. Also include Owner Representative and commissioning agent if applicable. Choose members who can make a commitment through post-occupancy review phase.
- Establish a Team Roster and Communication Plan outlining who gets copied on what, distributed to all team members. Update each phase and redistribute.
- Conduct planning/ review workshops at each phase with all team members. The goal is exchange between team members, with broad-based input and understanding of the goals and approaches the project will take.
  - Comprehensive Business Planning Workshop at Agency planning phase
  - Programming Workshop during Predesign Programming
  - Facility Performance Workshop within the first 2-3 weeks of the schematic design phase
- Convene multi-disciplinary team at least once per design phase for integrated progress review towards guidelines
- Convene stakeholder team regularly for integrated progress review. Stakeholder team to meet a minimum of once per phase.
- Convene General Contractor and Sub-contractors for pre-construction kick-off meeting to review the MSBG goals and objectives.
- Incorporate discussion about the progress toward project outcomes during every construction meeting.
- Recommended: After occupancy, Facility Operations Manager, Human Resources Manager and others that offer cross disciplinary points of view on Facility Operations shall meet annually to review operation practices, complaints, and building maintenance issues.

Suggested Implementation

Agency Planning

- Create and distribute to all stakeholders a communication plan and a team roster with all contact information included.

- Hold comprehensive Business Planning Workshop.
  The Guideline Leader for the Agency is responsible for introducing the MSBG Guidelines to the agency at the initial discussion of a new project. The early planning of the project generally includes a group discussion about the needs of the agency and requirements for a project. The MSBG Guidelines shall be incorporated into the Comprehensive Business Plan and Strategic Plan for each Agency.
- Conduct sustainability awareness surveys for all employees using the recommendations in the PLADEW, provided in a supplementary publication.

Predesign-Programming / Predesign-Site Selection

- Create or update and distribute to all stakeholders a communication plan and a team roster with all contact information included.
- Hold Programming Workshop.
  The programming workshop is to be expanded to include discussion about the MSBG Guidelines. The workshop will include MSBG education for the design team and the stakeholders. The intent is to incorporate the MSBG Guidelines into the programming discussion. An example of a format for this workshop can be found under tools: "Visioning Work Meeting/Client Awareness", provided in a supplementary publication:
- Conduct a second round of sustainability awareness surveys for all employees using the recommendations in the PLADEW, provided in a supplementary publication.

Schematic Design

- Create or update and distribute to all stakeholders a communication plan and a team roster with all contact information included.
- Assemble appropriate stakeholder team.
  Include representation from every discipline that will be involved in the project, Owner's decision making designate, user, occupant, operations and maintenance representatives, at least one representative from the community, and at least one agency "client" or visitor representative. Also include owner representative and commissioning agent if applicable. Choose members who can make a commitment through post-occupancy review phase.
- Hold Facility Performance Workshop.
  Schedule a Workshop within the first 2-3 weeks of the project. Include the stakeholder team. If some cannot attend a common date, include a representative on their behalf. Review programming document from Pre-Design and update as required. Review MSBG Guidelines and revise project goals as required. Provide MSBG education for the team as required during this workshop.
- Convene multi-disciplinary team regularly for integrated progress review.
- Convene stakeholder team at least once during this phase for integrated progress review

Design Development

- Create or update and distribute to all stakeholders a communication plan and a team roster with all contact information included.
- Convene multi-disciplinary team regularly for integrated progress review
- Convene stakeholder team at least once during this phase for integrated progress review

Construction Documents

- Create or update and distribute to all stakeholders a communication plan and a team roster with all contact information included.
- Convene multi-disciplinary team regularly for integrated progress review
- Convene stakeholder team at least once during this phase for integrated progress review

Construction Administration

- Create or update and distribute to all stakeholders a communication plan and a team roster with all contact information included.
- Convene multi-disciplinary team regularly for integrated progress review
- Convene stakeholder team at least once during this phase for integrated progress review
- Convene general contractor and subcontractors for pre-construction kick-off meeting to review the MSBG goals and objectives.
- Incorporate discussion about the progress toward project outcomes during every construction meeting.

P.4 Design and Construction Commissioning

Intent
Ensure and verify that the building is constructed and calibrated to meet the design intent as represented in contract documents (which includes meeting performance criteria of the Agency, including MSBG as represented in the contract documents.)

Required Performance Criteria
- Provide funding to a minimum of 1.5% of the total construction cost for verification prior to and through the end of the correction period.
- Verify that the design is compatible with the Operations Commissioning Plan. (See P.5 Operations Commissioning.)
- Use Agency Commissioning Process. If no Agency Commissioning Process exists, use Design and Construction Commissioning Process Summary (see Supporting Information.) In either case, the elements in the Design and Construction Commissioning Process Summary must be included as well as the following elements:
- Scope of items to be commissioned
    - Systems Commissioning: Mechanical HVAC system including testing, adjusting and balance, energy, (including renewable) systems, power and electrical systems, including lighting and daylighting controls; indoor air quality elements and systems. See Supporting Information for more details on requirements under Design and Construction Commissioning Plan.
    - Indoor air quality procedures during construction and correction period According to Construction Air Quality Management Plan and Correction Period Air Quality Management Plan. (See Supporting Information.)
    - Construction waste management procedures during construction according to the Construction Waste Management Plan. See Supporting Information and Guideline M.3 Waste Reduction and Management for criteria that the plan must meet.
    - User Comfort and Satisfaction Assessment as one indicator of overall IEQ performance. See details under Supporting Information.
- Design elements for measurement and verification:
    - Provide separate circuits and panels for power, lighting, HVAC and plumbing systems and equipment with high power and/or water use to facilitate monitoring.
    - Provide separate energy (electric, gas, other) meters for each building and sub-meters depending on project size to meet requirements of P.5 Operations Commissioning.
    - Provide separate water meters for each building, and separately meter building water use for irrigation and process water uses.
    - Include design elements needed to enable measurement and verification for site, water, energy, IEQ, materials, and waste sections of P.5.

Recommended Performance Criteria
Additional scope of Commissioning:
- Plumbing Systems (In addition to required flow rate commissioning above.)

- Interior materials (specification, installation);
- Envelope integrity (In addition to required water infiltration commissioning above.)
- Physical measurement of vibrations/acoustics/noise (In addition to occupant surveys above.)

Tools

IAQ Practices
SMACNA, IAQ Guidelines for Occupied Buildings Under Construction, 1st Edition, 1995.
www.smacna.org

Measurement and Verification
US DOE's International Performance Measurement and Verification Protocol (IPMVP): www.ipmvp.org
Volume I - Concepts and Options for Determining Savings
Volume II -Concepts and Practices for Improving Indoor Environmental Quality Volume III - Applications

Indoor Air Quality Operations, Measurement and Verification
EPA's Building Air Quality can be found at
www.epa.gov/iaq/largebldgs/baq_page
EPA's I-BEAM can be found at
www.epa.gov/iaq/largebldgs/ibeam_page

Resources

Commissioning
ASHRAE Guideline 1-1996, The HVAC Commissioning Process www.ashrae.org. See website for new guidelines for building commissioning
Building Commissioning Association www.bcxa.org
Designing Tools for Schools: Commissioning www.epa.gov/iaq/schooldesign/commissioning.html
Federal Energy Management Program Building Commissioning Guide www.eren.doe.gov/femp/techassist/bldgcomgd.html
LEED Green Building Reference Guide™ 2.0, United States Green Building Council
National Strategy for Building Commissioning website www.peci.org/cx/natstrat.html
State of Florida references NIBS program: www.state.fl.us/fdi/edesign/news/9811/total.htm
Total Building Commissioning sustainable.state.fl.us/fdi/edesign/resource/totalbcx/index.html
Stum, Karl The Importance of Commissioning Green Buildings, P.E. Portland Energy Conservation, Inc. (PECI) 921 SW Washington, Suite 312, Portland, OR 97205 Tel: 503-248-4636 Fax 503-295-0820)

P.4 Design and Construction Commissioning

Supporting Information

Design and Construction Commissioning Process Summary
Design and Construction Commissioning refers to the commissioning process that shall begin in schematic design and conclude after the correction period or after completion of a full year of operation, which ever is last. The Design and Construction Commissioning process is the means to verify and document that the systems of a facility operate in accordance with their design intent and that the operations staff fully understands the system operational procedures. This includes documenting system operational goals and design parameters, planning for verification and testing in the design and specifications, confirming the successful completion of the verification process, documenting the system operational procedures and training the operations staff. The Design and Construction Commissioning Process is coordinated by the Commissioning Leader and executed by the Commissioning Team.

Key components of the Design and Construction Commissioning Process include:

- Establish Planning Baseline, Programming Baseline, and before the end of schematic design phase, establish the Design Baseline.
- Before the end of the Schematic Design phase, engage a Commissioning Team and establish the role of Commissioning Leader. [5]
- Before the end of the Schematic Design phase, review the design intent and basis of design documentation, incorporating this into a Design and Construction Commissioning Plan that includes the required Commissioning Scope defined in the MSBG Guidelines.
- Update the Commissioning Plan in each phase with increasing detail, and noting the characteristics upon which design and demonstration of performance will be based as they become more defined each phase.
- At least once during each of Design Development and Construction Documents phases, evaluate progress of work towards the Commissioning Plan, documenting the progress and recommendations into a Commissioning Report before the end of each phase so that the design may be adjusted in response to the findings.
- Submit a list of I/O data points as part of outcome documentation before the end of Design Development
- Incorporate commissioning criteria and scope into the Construction Documents.
- Review contractor submittals for commissioned equipment and other design elements during the Construction Administration phase.
- Verify installation, functional performance, training, and operation and maintenance documentation during construction and correction period.
- After construction, complete an initial Commissioning Report comparing work completed to the Commissioning Plan and identifying outstanding items or seasonally-deferred items to be completed later.
- At 10 months into the correction period, review building operation with Operations and maintenance staff, and create a plan for resolution of outstanding commissioning-related issues.
- After the 10 month correction period review, or after seasonally deferred commissioning work, whichever is longer, complete a Commissioning Report, confirming that the tasks for the Design and Construction Commissioning Plan are complete and design intent has been achieved.

Commissioning Roles

Commissioning Leader: The person who coordinates efforts of commissioning team and assembles commissioning design reviews and final Commissioning Report. For Design and Construction Commissioning, the commissioning leader shall have a distinct role from the design team, but may be employed within the same firms providing design services. In Operations Commissioning, the Facility Operations Manager could play the role of the Commissioning Leader, although it could also be played by an outside consultant.

Commissioning Team: Assists in planning, reviewing and coordination of commission process with all disciplines involved in the building project. The team will complement skills of commissioning leader and shall include:

- Commissioning Leader
- Representative of owner's facilities operations team, preferably Facility Operations Manager who will operate the facility
- Current Guideline Leader for the phase
- Commissioning Consultants as needed to cover other commissioning expertise

[5] It is recommended to engage the Commissioning Leader and Team as early as possible, ideally in Predesign phase.

- For Design and Construction Commissioning, the team shall also include:
    - Architect and Engineers of multiple disciplines as needed to cover the expertise to plan and execute commissioning of selected systems.
    - Contractor, and appropriate subcontractors

Facility Operations Manager (FOM): Facility Operations Manager is accountable for facility performance during ongoing occupancy and manages or performs ongoing operational practices, maintenance and corrective actions. The FOM is responsible for understanding Operations and Maintenance manuals, and monitors and reports on ongoing performance of the facility. This person is available for participation throughout the design process for continuity into final operation. The FOM or their representative shall be part of the Design and Construction Commissioning Team. After occupancy, the Facility Operations Manager leads the work team responsible for facility maintenance, and corrective measures. The FOM may also be Guideline Leader during the occupancy phase, confirming compliance with MSBG guidelines and sending annual reports to CSBR. Additionally, they may also act as Operations Commissioning Leader, verifying that the building is maintained and is operated according to the Operations Commissioning Plan.

Commissioning Reporting

Commissioning Plan: The Commissioning Plan identifies systems with specific performance criteria, establishes documentation, and identifies specific test and verification procedures for installed equipment to confirm operation according to commissioning plan. The Design and Construction Commissioning Plan is a living document that grows in detail over time, as systems are specified and design parameters become refined. After the correction period, the Operations Commissioning Plan defines systems to be monitored, regularly scheduled actions to be taken, and procedures for responding to problems and aberrations in performance. The Operations Commissioning Plan is drafted during design phases so that it can be used to ensure that the design accommodates planned operational maintenance and testing.

Design and Construction Commissioning Plan: The Design and Construction Commissioning Plan shall include directly, or by reference, provision for all items required in the Commissioning Guideline for activities through the Correction Period or successful completion of the Design and Construction Commissioning Plan, which ever comes first.
Systems to be commissioned include:

- Mechanical HVAC Comfort, Energy, and Renewable Energy Systems, Testing Adjusting and Balancing: And other elements related to performance of Guidelines: E.1, E.2, E.3, E.4, I.2, I.4, I.5, I.6, I.7
- Electrical Systems, including Lighting and Daylighting Controls: And other elements related to performance of Guidelines: S.7, E.1, E.2, E.3, I.8, I.9
- Indoor Air Quality Elements and Systems: And other elements related to performance of Guidelines: I.1, I.2, I.3, I.4, I.5, I.6
- Plumbing Systems: Flow Rate
- Envelope Integrity: Test Building Envelope for Water Infiltration

Recommended additional scope of Commissioning:

- Plumbing Systems : In addition to required flow rate commissioning above as needed to support operational achievement of guidelines: S.11, S.12, S.13
- Interior materials (specification, installation): As needed to support operational achievement of guidelines: I.3, M.1, M.2
- Envelope integrity: In addition to required water infiltration commissioning above as needed to support operational achievement of guidelines: I.6, I.7, M.1, M.2
- IEQ: Vibrations/acoustics/noise: In addition to occupant surveys above, perform physical measurements as needed to support operational achievement of guidelines: I.11, I.12

The Design and Construction Commissioning Plan includes by reference the following documents that may be packaged separately but shall be coordinated with all other parts of the Design and Construction Commissioning Plan.

- Construction Air Quality Management Plan
- Correction Period Air Quality Management Plan
- Construction Waste Management Plan
- Correction Period User Comfort and Satisfaction Assessment

Construction Air Quality Management Plan: The Construction Air Quality Management Plan is part of the Design and Construction Commissioning Plan and shall cover practices to prevent introduction of air quality problems as a result of the construction process.
Meet construction air quality requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction
Protect stored on-site or installed absorptive materials from moisture damage, and replace all filtration media immediately prior to occupancy.
Complete minimum two-week building "flush-out" prior to occupancy (One month is preferred)
Required Elements for IAQ protection during construction. (From CHPS section 01350, 1.6)

- Construction Ventilation and Preconditioning:
    - Temporary Construction Ventilation: Maintain sufficient temporary ventilation of areas where materials are being used that emit VOCs. Maintain ventilation continuously during installation, and until emissions dissipate after installation. If continuous ventilation is not possible via building's HVAC system(s) then ventilation shall be supplied via open windows and temporary fans, sufficient to provide no less than three air changes per hour.
        - Period after installation shall be sufficient to dissipate odors and elevated concentrations of VOCs. Where no specific period is stated in these Specifications, a time period of 72 hours shall be used.
        - Ventilate areas directly to outside; ventilation to other enclosed areas is not acceptable.
    - Dust producing activities (e.g. drywall installation and finishing): Turn ventilation system off and protect openings in supply and return HVAC system from dust infiltration. Provide temporary ventilation as required.
    - Preconditioning: Prior to installation, allow products which have odors and significant VOC emissions to off-gas in dry, well-ventilated space for 14 calendar days to allow for reasonable dissipation of odors and emissions prior to delivery to Project site.
        - Condition products without containers and packaging to maximize off-gassing of VOCs
        - Condition products in ventilated warehouse or other building. Comply with substitution requirements for consideration of other locations.
- Protection:
    - Moisture Stains: Materials with evidence of moisture damage, including stains, are not acceptable, including both stored and installed materials: immediately remove from site and properly dispose. Take special care to prevent accumulation of moisture on installed materials and within packaging during delivery, storage, and handling to prevent development of molds and mildew on packaging and on products.
        - Immediately remove from site and properly dispose of materials showing signs of mold and signs of mildew, including materials with moisture stains.
        - Replace moldy materials with new, undamaged materials.
    - Ducts: Seal ducts during transportation, delivery, and construction to prevent accumulation of construction dust and construction debris inside ducts.

- Environmental Issues:
    - On-Site Application: Where odorous and/or high VOC emitting products are applied on-site, apply prior to installation of porous and fibrous materials. Where this is not possible, protect porous materials with polyethylene vapor retarders.
    - Complete interior finish material installation no less than fourteen (14) days prior to Substantial Completion to allow for building flush out.

Correction Period Air Quality Management Plan: Indoor Air Quality Testing: Evaluate building air quality three months, six months, and ten months after occupancy with testing that verifies ventilation system is better than or within design guidelines.[6] Measure key factor that determines ventilation rate for building (major pollutant or CO2) in building occupied zones. Pollutant concentrations measured should be within guideline range and CO2 levels should be at or below 450 ppm over outdoor levels. If pollutant concentrations exceed action level or CO2 levels are above 450 ppm over outdoor levels, excess ventilation must be provided or sources eliminated until concentrations fall below action levels. Action values for each pollutant are given in Appendix I-1.[7]

Construction Waste Management Plan: The Construction Waste Management Plan is part of the Design and Construction Commissioning Plan and shall cover practices to minimize waste of the construction process. See Guideline M.3 Waste Reduction and Management for criteria.

Correction Period User Comfort and Satisfaction Assessment: User Comfort and Satisfaction Assessment as one indicator of overall IEQ performance: Assess User Comfort and Satisfaction via occupant surveys, three months and ten months after occupancy. Areas for assessment include the following areas outlined in IEQ Guidelines:

- Air Quality (I.4, I.5 and integrated effect of I.6)
- Thermal Comfort (I.7)
- Access to Daylight, Quality of lighting, View space and window access (I.8,I.9,I.10)
- Vibrations, Acoustics and Noise (I.11, I.12)
- Personal Control of IEQ conditions and impacts (I.13)
- Opportunities and encouragement for healthful physical activity (I.14.)

Commissioning Report: The Commissioning Report is an evaluation of work at a particular point in time in comparison with a particular version of the Commissioning Plan. Early Commissioning Reports during design phases may be simple design reviews to determine if steps needed to lead to an operating performance level are being taken. Construction Documents shall include Commissioning Plan, verification procedures, responsibilities, and reporting requirements. An end-of-correction-period Commissioning Report is the final deliverable of the Design and Construction Commissioning Process. The Report states that the Design and Construction Commissioning Plan has been completed and design intent has been achieved. Refer to P.5 for Operations Commissioning review and the Operations Commissioning Report.

Commissioning Baselines

Baseline: Baselines demark a reference case for comparison and are used to determine performance improvements for compliance with guidelines throughout this document. Members of the Commissioning Team determine project baselines.

Planning Baseline: During Agency Planning determine the characteristics of the Planning Baseline scenario. The Planning Baseline is the initial space program document, construction type, and cost

[6] Consider (recommended, not required), monitoring three months, six months, and ten months after occupancy of other pollutants on I.4 guideline list which are not pollutants that determine the ventilation rate. Concentrations should be in guideline range and below action value for each pollutant. Sample pollutant action levels are given in Appendix I-1

[7] Contaminant Testing: (Recommended) Measured values of pollutants and CO2 concentrations in occupied zones of building,

assumptions based on typical industry data and first understanding of facility needs and operating parameters. The Planning Baseline is needed to measure the environmental and economic advantages of Planning for Conservation approaches such as building less and/or reusing existing buildings studied in Predesign Programming and Predesign Site Selection phases. (See P.2 Planning for Conservation, and first part of M.1 Evaluate Design for Resource Use.)

Programming Baseline: During the Predesign Programming phase, the predesign team evaluates initial general assumptions of program needs and further develops program document to reflect Agency needs in concert with lifecycle performance goals. At the end of Predesign, determine characteristics of the Programming Baseline based on Planning for Conservation approaches chosen and other changes made during Predesign Programming and Site Selection phases. The Programming Baseline is needed to measure environmental and economic advantages of alternate construction for various building systems, evaluated and chosen during schematic design. (See second part of M.1 Evaluate Design for Resource Use.)

Design Baseline: During schematic design after a basic building concept and outline of construction types for each building system is chosen, determine characteristics of the Design Baseline scenario. The Design Baseline defines project parameters that will be used as the baseline for all guidelines to be measured against. For example, additional savings gained through improved material properties shall be measured against the Design Baseline, and the area, configuration, construction/ and system parameters will be used as a baseline for energy analysis.

Measurement and Verification Baseline(s): Measurement and Verification Baseline(s) are used to calculate savings as part of the Measurement and Verification Process. They should be coordinated with other baselines but may have other requirements per IPMVP reference standard. See details of Measurement and Verification under P.4 Operations Commissioning under Supporting Information.

Suggested Implementation

Agency Planning

- Identify a Facility Operations Manager (FOM) who will manage maintenance and operations of the facility, be responsible for understanding Operations and Maintenance manuals, and monitor and report ongoing performance of the facility. The FOM should participate throughout the design process for continuity into final operation. This person shall be part of the Commissioning Team and work closely with the Guideline Leader.
- Evaluate existing facility operations to provide a reference point of performance for improvements and the goal setting process. Include performance issues specific to the activities of the organization to set performance goals.
- Include the Commissioning processes in project budget.
- Establish the Planning Baseline.
- Submit Outcome Documentation.

Predesign-Programming

- Establish an acting Commissioning Team and Commissioning Leader for this phase that may or may not be the Commissioning Team and Leader for Schematic Design and later phases.
- Create a Predesign-Programming phase Commissioning Plan that includes:
    - Facility performance goals in accordance with the Guidelines
    - Basis of design documents
    - Systems to be commissioned and activities to plan for commissioning scope in the next phases
- Establish the Programming Baseline

- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation

Predesign-Site Selection

- Update Commissioning Plan with more detail, noting basis of design and demonstration of performance as they are more defined in this phase.
- Review site alternatives for ability to achieve performance goals in the commissioning plan. (For example, good indoor environmental quality is easier to achieve on a "clean" site over one with high levels of air pollution.)
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation

Schematic Design

- Establish the Commissioning Team and Leader for the Design through Correction Period Phases if different than the team created in Predesign-Programming phase.
- Update Commissioning Plan with more detail, as it becomes more defined in this phase. Clarify systems to be commissioned, basis of design, design intent, and design review points.
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings. Review schematic design for compatibility with performance goals in Commissioning Plan.
- Submit a list of systems that will be commissioned.
- Establish the Design Baseline.
- Submit Outcome Documentation.

Design Development

- Update Commissioning Plan with more detail, noting basis of design and demonstration of performance as they are more defined in this phase. Further develop Commissioning Plan to include roles, responsibilities, and schedules to verify completion of performance goals.
- Performance Check: Commissioning Team shall review design as documented to ensure it meets the physical outcomes and operational performance defined in prior and subsequent phases. Performance areas include but are not limited to:
    - Performance Criteria for all required or additional pursued guidelines
    - Requirements for specific operational scenarios of the building
    - Regular maintenance, cleaning, and servicing (including ISO 14000 cleaning materials)
- Measurability/ Testability Check: Commissioning Team shall review design as documented to ensure that it meets criteria for testing and verification of performance for both Design and Construction Commissioning as well as Operations Commissioning monitoring during Ongoing Occupancy. (See details under Construction Documents phase below.) Performance areas include but are not limited to:
    - Measurements and testing required during all phases of Design and Construction Commissioning.
    - Measurement, monitoring, and control of energy, water, indoor environmental quality during ongoing occupancy.
- Submit a list of I/O data points.
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation and update Commissioning Plan.

Construction Documents

- Commissioning Leader and Team shall finalize commissioning plan and ensure that specific required construction practices, reporting on those practices, commissioning activities, and reporting of those activities are included in the construction documents. (See construction and correction period phases for detail on activities to be included.)

- Commissioning Leader and Team shall write a Construction Air Quality Management Plan and Correction Period Air Quality Management Plan and indicate in bid documents that both of these are required. (See Supporting Information for details of requirements.)
- Performance Check:
    - Finalize the list of systems to be commissioned.
    - Commissioning Team shall review design as documented to ensure it meets the physical outcomes and operational performance defined in prior and subsequent phases for performance criteria for all required guidelines and other guidelines that are pursued.
    - Commissioning Team shall review specifications to ensure that it includes criteria for testing and verification of performance as per the requirements of the Design and Construction Commissioning Guideline.
- Measurability/ Testability Check: Commissioning team shall confirm that the Construction Documents:
    - Indicate separate circuits and panels for power, lighting, HVAC and plumbing systems and equipment with high power and/or water use to facilitate monitoring.
    - Include a summary schedule of instrumentation and controls for the required monitoring categories, highlighting I/O data points to be collected.
    - Include cut sheets of sensors and data collection system for continuous metering per IPMVP standards. (See Resources.)
- Final coordination with Operations Commissioning Plan
    - Confirm that the design of the building as represented in the construction documents is compatible with the requirements of the Operations Commissioning Plan. (See P.5 Operations Commissioning)
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation

Construction Administration

- Review contractor submittals for commissioned equipment and other commissioned design elements.
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation

Construction

- Contractor complies with commissioning incorporated in construction documents. Specific commissioning guideline provisions relating to the construction process itself include:
    - Construction Air Quality Management Plan. (See Supporting Information.)
    - Construction Waste Management Plan. (See Supporting Information.)
- Commissioning Leader and Team execute commissioning activities during construction under the Commissioning Plan as included in construction documents, including:
    - Review selected contractor submittals for commissioned systems and equipment
    - Require contractor to create Operations and Maintenance manual for Owner at construction completion.
- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation and an initial Commissioning Report.

Correction Period
Construction Team

- Construction Guideline Leader with Construction Team shall identify and document Guideline Commissioning and Training tasks (as represented in construction documents) to be performed by the construction team in this phase.
- Construction Air Quality: Complete minimum two-week building "flush-out" prior to occupancy (One month is preferred.)
- Arrange for testing, adjusting, and calibration of facility systems to meet performance goals as specified in Construction Documents.
- Indoor Air Quality Testing:
    - Perform an evaluation of building performance three months, six months, and ten months after occupancy. Measure key factor that determines ventilation rate for the building (major pollutant or CO_2) in the building occupied zones.
    - Pollutant concentrations measured should be within the guideline range and CO_2 levels should be at or below 450 ppm over outdoor levels.
    - If pollutant concentrations exceed action level or CO_2 levels are above 450 ppm over outdoor levels, excess ventilation must be provided or sources eliminated until concentrations fall below action levels. Action values for each pollutant are given in IEQ Guidelines.

Commissioning Team
Commissioning Leader and Team executes commissioning activities under the Commissioning Plan as included in construction documents, including:

- Verify installation, functional performance, training, and operation and maintenance documentation.
- After construction, complete an initial Commissioning Report comparing work completed to the Commissioning Plan and identifying outstanding items or seasonally deferred items to be completed later.
- At 10 months into the correction period, review building operation with Operations and maintenance staff, and create a plan for resolution of outstanding commissioning-related issues.
- After the 10 month correction period or after seasonally deferred commissioning work, whichever is longer, complete a Commissioning Report, confirming that all tasks required by the Design and Construction Commissioning Plan are complete and design intent has been achieved. Include : design criteria, intent, other requirements and parameters, specifics of equipment and operations, test procedures and records, participants, and schedule.
- Coordinate training for Owner's Operations staff
- Review Operations and Maintenance Manual, coordinate with content of Commissioning Report, and combine into a cohesive Operations Manual to be delivered to the Owner.
- At the end of this phase, Commissioning Leader and Team shall advise and assist the Operations Commissioning Team to revise and complete Operations Commissioning Plan to comply with Guidelines.

Occupant Survey Leader (Owner or depends on contract.)
Execute commissioning activities assigned under the Commissioning Plan as included in construction documents, including:

- Conduct Occupant Surveys
    - During the move-in process (recommended)
    - Three months after occupancy (required)
    - Ten months after occupancy (required)

- Document progress and recommendations in Commissioning Report before the end of phase so that the work may be adjusted in response to findings.
- Submit Outcome Documentation

Ongoing Occupancy
Commissioning actions after the correction period are part of Operations Commissioning. (See Guideline P.5)

P.5 Operations Commissioning

Intent
Ensure (verify) the building is operated to meet the design intent as represented in contract documents (which includes meeting performance criteria of the Agency, including MSBG.)

Required Performance Criteria
Use Agency Operations Management Process. If there is no established Agency Operations Management Process, use Operations Commissioning Process Summary. (See Supporting Information.) In either case, the elements of the Operations Commissioning Process Summary must be included as well as the following:

- Evaluate performance over time according to the Measurement and Verification Plan for the following scope: (More detail on requirements is under Supporting Information.)
  - Water device and system level measurement and verification
  - Water whole building measurement and verification
  - Energy device and system level measurement and verification
  - Energy whole building measurement and verification based on metering and calibrated energy simulation:

Size (sq.ft.)	Metering	with Submetering	Calibrated Simulation (annual Energy Use)
<10,000	Required	Recommended	Recommended
10-50,000	Required	Required	Recommended
>50,000	Required	Required	Required

  - Indoor environmental quality (IEQ) measurement and verification: Air quality, thermal comfort, quality of lighting
  - Waste measurement and verification
  - User complaint/ work request logs related to user comfort and satisfaction as an indicator of ongoing IEQ performance
- Implement Operations and Maintenance Practices and annual evaluation according to the Maintenance Plan: (More detail on requirements is under Supporting Information.)

Recommended Performance Criteria
- Perform Measurement and Verification of the following additional areas of building performance over time according to the Measurement and Verification Plan. (See Supporting Information for more detail.)
  - Vibrations, acoustics, and noise verification
  - Access to daylight
  - View space and window access evaluation
  - Personal control of IEQ conditions and impacts
  - Opportunities and encouragement for healthful physical activity

    - Materials measurement and verification
    - User Comfort and Satisfaction Assessment surveys as an indicator of ongoing IEQ performance
- Perform Systems Recommissioning: At least annually or in response to events or triggers at the discretion of owner (see Supporting Information for more detail.)

Tools

IAQ Practices
SMACNA, IAQ Guidelines for Occupied Buildings Under Construction, 1st Edition, 1995.
www.smacna.org

Measurement and Verification
US DOE's International Performance Measurement and Verification Protocol (IPMVP): www.ipmvp.org
Volume I - Concepts and Options for Determining Savings
Volume II -Concepts and Practices for Improving Indoor Environmental Quality Volume III - Applications

Indoor Air Quality Operations, Measurement and Verification
EPA's Building Air Quality can be found at www.epa.gov/iaq/largebldgs/baq_page
EPA's I-BEAM can be found at www.epa.gov/iaq/largebldgs/ibeam_page

Resources

ASHRAE Guideline 1-1996, The HVAC Commissioning Process www.ashrae.org. See website for new guidelines for building commissioning
Building Commissioning Association www.bcxa.org

Designing Tools for Schools:
Commissioning www.epa.gov/iaq/schooldesign/commissioning.html
Federal Energy Management Program Building Commissioning Guide
www.eren.doe.gov/femp/techassist/bldgcomgd.html
LEED Green Building Reference Guide™ 2.0, United States Green Building Council
National Strategy for Building Commissioning website
www.peci.org/cx/natstrat.html
State of Florida references NIBS program:
www.state.fl.us/fdi/edesign/news/9811/total.htm

Total Building Commissioning
sustainable.state.fl.us/fdi/edesign/resource/totalbcx/index.html
Stum, Karl The Importance of Commissioning Green Buildings, P.E. Portland Energy Conservation, Inc. (PECI) 921 SW Washington, Suite 312, Portland, OR 97205 Tel: 503-248-4636 Fax 503-295-0820)

Supporting Information

Operations Commissioning Process Summary
Operations Commissioning shall be planned for during design, but focuses on the operations of the facility after construction through the next use of the facility. The Operations Commissioning process is the means to verify and document that the systems of a facility and the facility as a whole continue to operate in accordance with their design intent overtime. This includes planning, implementation, and documentation for regular preventative maintenance, Measurement and Verification of system and whole building performance, and improvement and correction of that performance. The Operations

Commissioning process is coordinated by the Operations Commissioning Leader and executed by the Operations Commissioning Team. Initial operations input is provided by the participation of the Facility Operations Manager on the Design and Construction Commissioning Team.
Later in design, the Operations Commissioning Team is formed and leads the planning for Operations Commissioning after occupancy.

Key components of the Operations Commissioning Process include:

- Include the Facility Operations Manager or their representatives as part of the initial Design and Construction Commissioning Team for the new facility in order to represent operations issues from the beginning of the Design and Construction Commissioning Process.
- Identify the Operations Commissioning Leader and Commissioning Team during the Design Development phase.
- Draft the Operations Commissioning Plan during the Design Development phase and coordinate operations issues with design and construction issues before construction documents are complete. (See section detailing required elements of the Operations Commissioning Plan.)
- Refine or create Measurement and Verification Baseline(s.)
- During the Correction Period, refine and complete the Operations Commissioning Plan.
- During occupancy, implement the Operations Commissioning Plan acting on findings according to the plan if covered in the plan, or according to the judgment of the Facility Operations Manager.
- At the end of each year of operations, complete an Operations Commissioning Report. (See section detailing Operations Commissioning Report for those items required to be reported annually.)
- Review the Operations Commissioning Plan at least annually updating it as needed to reflect changes in equipment or practices.

Commissioning Roles

Definitions for Commissioning Leader, Commissioning Team, Facility Operations Manager (FOM): Refer to P.4 Supporting Information.

Commissioning Reporting

Operations Commissioning Plan: The Operations Commissioning Plan shall include directly or by reference provision for all items required in the Commissioning Guideline P.5 for planning, implementing, or documenting activities from Correction Period through the life of the project. The Operations Commissioning Plan includes by reference the following documents that may be packaged separately but shall be coordinated with all other parts of the Operations Commissioning Plan.

- Operations and Maintenance Manuals (O&M Manuals as per conventional contracts)
- Problem Response Plan (See details below.)
- Maintenance Plan (See details below.)
- Measurement and Verification Plan (See details below.)
- Systems Recommissioning Manual (See details below.)

Operations Commissioning Report: The Operations Commissioning Report is an evaluation of work at a particular point in time in comparison with a particular version of the Commissioning Plan. After the correction period, complete an annual Operations Commissioning review and Operations Commissioning Report that documents monitored usage and other data, and log of actions taken to address aberrations or problems.

Problem Response Plan: The Problem Response Plan is part of the Operation Commissioning Plan and shall cover the systems and materials commissioned under Operations Commissioning Scope.

- Incorporate a planned response to anticipated feedback or triggers indicating potential performance problems such as increase in IEQ complaints, or aberrations in monitored resource use. Indicate diagnostic or corrective actions such as recommissioning of systems or user comfort and satisfaction assessments.

Maintenance Plan: The Maintenance Plan is part of the Ongoing Operation Commissioning Plan and shall cover the following for the systems and materials commissioned under the Operations Commissioning Scope.

- Cleaning products and practices
- Moisture prevention and moisture response practices
- Preventative Maintenance Practices, such as refinishing, or replacement of parts

Annually, evaluate the following Systems Operations and Maintenance Practices in comparison to the Operations Commissioning Plan for Maintenance and Operation. Document Findings and Correct Maintenance and Operations Practices, or update the plan to reflect changes in practices.

- Site Systems
- Water Systems
- Energy Systems
- IEQ Systems (note related items on moisture response in the IEQ section of the Measurement and Verification Plan below.)
- Materials and Waste Systems (Note issues relating to Material VOC and cleaning IAQ issues are found under IAQ portion of IEQ sections. Cross reference between sections in all documentation.)

Measurement and Verification Plan: The Measurement and Verification Plan is part of the Ongoing Operation Commissioning Plan. It is aimed at monitoring performance over time, and measuring savings. The Measurement and Verification Plan shall cover the following.

- Frequency of user comfort and satisfaction assessments
- Format and procedures for user complaint and work request logs
- Schedule regular checks to verify ongoing performance, and prevention of failures of facility and its systems.
- Procedures to compare to weather normalized expectations, track trends in usage, and identify aberrations in use patterns
- Method of quantifying savings
- Procedures for reporting potential problems to Facilities Operations Manager for possible corrective action.
- Method to verify complete installation and proper operation of new equipment and systems specified in contract documents

It shall also include these Measurement and Verification Plan Components excerpted from USGBC LEED page 158 of reference package version 2.0, June 2001.

1. IPMVP standard language and terminology should be employed.
2. State which options and method from the IPMVP document will be used.
3. Indicate who will conduct the Measurement and Verification.
4. State key assumptions about significant variables of unknowns.
5. Create an accurate baseline using techniques appropriate to the project.
6. Describe the method of ensuring accurate savings determination.
7. Define a post installation inspection plan.
8. Specify criteria for equipment metering, calibration, and measurement period.
9. Define level of accuracy to be achieved for all key components.

10. Indicate quality assurance measures.
11. Describe contents of reports to be prepared, along with a schedule.

Measurement and Verification Reference Standard: For details on Measurement and Verification based on US DOE's International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org The following summarizes several of the types of Measurement and Verification defined by this standard that are used in the Measurement and Verification Scope Detail below.
Option B: After project completion, savings are determined by short term or continuous measurements taken throughout term of the contract at device or system level. Both performance and operations factors are monitored. Savings calculations are based on engineering calculations using metered data.
Option C: After project completion, savings are determined at "whole building" or facility level using current year and historical utility meter (gas or electricity or other) or sub-meter data. Savings are based on analysis of meter or sub meter data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.
Option D: Savings are determined through simulation of facility components and/or the whole facility. Savings are based on calibrated energy simulation and modeling; calibrated with hourly or monthly utility billing data and /or end use metering.

<u>Measurement and Verification Scope Details:</u>

Construction Documents Energy Measurement and Verification Details: Based on the Measurement and Verification Plan, check that the following are included in construction documents:

- Provide separate circuits and panels for power, lighting, HVAC and plumbing systems and equipment with high power and/or water use to facilitate monitoring.
- Provide separate energy (electric, gas, other) meters for each building and sub-meters depending on project size to meet requirements of P.5 Operations Commissioning.
- Provide separate water meters for each building, and separately meter building water use for irrigation and process water uses.
- Include design elements needed to enable measurement and verification for site, water, energy, IEQ, materials, and waste sections of P.5.
- Include a summary schedule of instrumentation and controls for required monitoring categories, highlighting I/O data points to be collected.
- Include cut sheets of sensors and data collection system used to provide continuous metering per IPMVP standards.

Water Device and System Level Measurement and Verification: Comply with a long-term continuous measurement of performance as stated in Option B: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:

- Indoor water risers
- Outdoor irrigation systems

Water Whole Building Measurement and Verification: Comply with a long-term continuous measurement of performance as stated in Option C: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following

- Indoor water usage
- Outdoor irrigation usage
- Every 5 years- Testing of water infiltration rate and quantity
- (Recommended) Biannual (Spring/Fall) testing of water quality (TSS measurements)
- (Recommended) Biannual (Spring/Fall) testing of water quality (Phosphorus measurements)

Energy Device and System Level Measurement and Verification: Comply with a long-term continuous measurement of performance as stated in Option B: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:

- Lighting systems and controls
- Constant and variable motor loads
- Variable frequency drive (VFD) operation
- Chiller efficiency at variable loads (kW/ton)
- Cooling load
- Air and water economizer and heat recovery cycles
- Air distribution static pressures and ventilation air volumes
- Boiler efficiencies
- Buildings specific process energy-efficiency systems and equipment

Energy Whole Building Measurement and Verification based on Metering and Calibrated Energy Simulation: Depending on size of project, comply with additional long-term continuous measurement of performance as stated in Options C and D: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:

IPMVP Option

	C	**C**	**D**
Size (sq.ft.)	Metering	with Submetering	Calibrated Simulation (annual Energy Use)
>10,000	Required	Recommended	Recommended
10-50,000	Required	Required	Recommended
>50,000	Required	Required	Required

Indoor Environmental Quality (IEQ) Measurement and Verification: Comply with a long-term continuous measurement of performance as stated in Volume II of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following

- Air Quality (I.4, I.5 and integrated effect of I.6)
  - Perform an evaluation of the building indoor air quality performance annually. This shall be a measurement of the key factor that determines the ventilation rate for the building (major pollutant or CO_2) in the occupied zones of the building. The pollutant concentrations measured should be within the guideline range and CO_2 levels should be below 450 ppm over the outdoor levels. If the pollutant concentrations exceed the action level or CO_2 levels are above 450 ppm over the outdoor levels, additional ventilation must be provided or sources eliminated until the concentrations fall below the action levels. Action values for each pollutant are given in Appendix I-A.
  - When exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water occurs, the intrusion, leakage or accumulation shall be corrected because of the potential for these conditions to cause the growth of mold. (Title 8, Chapter 4, Section 3362(g) of California Occupational Safety and Health Standards, Sept. 2002.) Establish maintenance procedures that will identify unintended water intrusion, leakage or accumulation quickly and provide drying or removal of building structure elements within 48 hours of the unintended event.
  - Use ISO 14000 requirements for cleaning supplies in standard maintenance after building occupancy.
  - IAQ is part of the IEQ User Complaint Logging procedures described below. The portion of data logging that relates to IAQ can be modeled after EPA's Building Air

Quality Program (1991) or their newer web-based system called I-BEAM (IAQ building education and assessment.)

- Thermal Comfort (I.7) For details on Measurement and Verification based on US DOE's International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org
- Quality of Lighting, (I.9) For details on Measurement and Verification based on US DOE's International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org
- Other Recommended IEQ Measurement and Verification
    - Access to Daylight, (I.8)
    - View space and window access (I.10)
    - Vibrations, Acoustics and Noise (I.11, I.12)
    - Personal Control of IEQ conditions and impacts (I.13)
    - Opportunities and encouragement for healthful physical activity(I.14.)

Overall IEQ Assessments:

- User Complaint/ Work Request Logs related to User Comfort and Satisfaction as an indicator of ongoing IEQ performance: Record and maintain a log of User Complaints and Work Requests related to User Comfort and Satisfaction as an indicator of ongoing IEQ performance. Flag each IEQ-related complaint or work request for which guideline categories(s) they relate to.
- (Recommended) User Comfort and Satisfaction Assessment as an indicator of ongoing IEQ performance:
    - Initial Required Assessments during first year of occupancy are part of Design and Construction Commissioning Scope, see Guideline P.4
    - Recommended: During Ongoing Occupancy after Correction Period, assess User Comfort and Satisfaction via occupant surveys at regular intervals or in response to other events or triggers at the discretion of the owner.

(Recommended) Materials Measurement and Verification: Annually evaluate the wear and durability of materials compared to expectations.

Waste Measurement and Verification: Annually evaluate waste and recycling generated compared to expectations and baseline.

Systems Recommissioning Manual (Recommended): The Systems Recommissioning Manual is part of the Ongoing Operation Commissioning Plan and documents important reference information for operating or recommissioning building systems as follows:
Include Recommissioning Management Manual Components excerpted from LEED page 147 of reference package version 2.0, June 2001.

- Final version of the owner's requirements and design basis narratives, including brief descriptions of each system.
- As-built sequences of operation for all equipment; control drawings.
- List of time of day schedules and schedule frequency to review them for relevance and efficiency.
- Seasonal start-up and shutdown, manual and restart operation procedures, recommendations regarding seasonal operational issues that affect energy use.
- Recommendations for recalibration frequency of sensors and actuators by type and use.
- List of user adjustable set points and reset schedules with a brief discussion of purpose of each and range of reasonable adjustments with energy implications.
- Schedule frequency to review various set points and reset schedules to ensure they are at current relevant and efficient values.

- Guidelines for energy accounting including assurance that renovations and equipment upgrades will not decrease energy efficiency and will maintain owner's requirements.
- List of diagnostic tools with use descriptions to assist facility staff.

Recommended Scope of Systems Recommissioning: At regular intervals or in response to other events or triggers at the discretion of the owner, evaluate the following:

- Mechanical HVAC Comfort and Renewable Energy Systems: As needed to support performance of Guidelines: E.1, E.2, E.3, E.4, I.2, I.4, I.5, I.6, I.7
- Electrical Systems, including Lighting and Daylighting Controls: As needed to support performance of Guidelines: S.7, E.1, E.2, E.3, I.8, I.9
- Indoor Air Quality Elements and Systems: As needed to support performance of Guidelines: I.1, I.2, I.3, I.4, I.5, I.6
- Plumbing Systems: As needed to support operational achievement of guidelines: S.11, S.12, S.13
- Interior Materials (specification, installation as finishes and furnishings are replaced or reconfigured): As needed to support operational achievement of guidelines: I.3, M.1, M.2
- Envelope Integrity: As needed to support operational achievement of guidelines: I.6, I.7, M.1, M.2

Suggested Implementation

Agency Planning

- Identify a Facility Operations Manager (FOM) who will manage maintenance and operations of the facility, be responsible for understanding Operations and Maintenance manuals, and monitor and report ongoing performance of the facility. The FOM should participate throughout the design process for continuity into final operation. This person shall be part of the Design and Construction Commissioning Team and work closely with the Guideline Leader during design phases. This person will be part of the Operations Commissioning Team once it is formed later in the design process.
- Evaluate existing facility operations to provide a reference point of operating issues for use in planning operation of the future facility.
- Include the Operations Commissioning processes in planning for future operating budgets
- Submit Information for Outcome Documentation (P.7)

Predesign-Programming - Schematic Design

- Facility Operations Manager or their representatives are part of Design and Construction Commissioning Team for the new facility to represent operations issues from the beginning of the Design and Construction Commissioning Process.
- Submit Information for Outcome Documentation (P.7)

Design Development

- Identify Leader and Members of the Operations Commissioning Team: This should include the following, plus any other added expertise needed depending on the building systems.
    - Facilities Operations Manager (FOM) is accountable for facility performance and manages or performs ongoing operational practices, maintenance and corrective actions. FOM may also fill the role of Guideline Leader during ongoing occupancy phases.
    - The person from the Operations Work Team who will be in charge of compliance with the Guidelines during Ongoing Occupancy (Guideline Leader if applicable to Agency Process.) This person will document ongoing management, maintenance and correction actions, and complete annual and interim reporting as per the Outcome Documentation Forms.

- Draft Operations Commissioning Plan and coordinate operations issues with design and construction issues. Review and participate in coordination of Operations Commissioning Plan and the Design and Construction Commissioning Plan
- Refine or create Measurement and Verification Baseline(s.)
- Submit Information for Outcome Documentation (P.7)

Construction Documents

- Prepare for Operations: Operations Commissioning Leader and Team shall draft documents in preparation for transition into Operations including:
    - Revised Operations Commissioning Plan
    - Systems Recommissioning Manual
    - Measurement and Verification Plan. (See Supporting information - Reporting for details of these plans.)
- Submit Information for Outcome Documentation (P.7)

Correction Period

- Confirm or transfer roles as necessary of the Operations Commissioning Team, including FOM and Guideline Leader for Ongoing Occupancy. Orient any new members of the Operations Commissioning Team to the project documentation and the Operations Commissioning Plan Both the Guideline Leader (ongoing occupancy phase) and FOM are to be familiar with history and upkeep of project records and their contents from review of prior phases of the Operations Commissioning Plan and its supporting documents:
  - Operations Commissioning Plan (See "Supporting Information - Reporting" for details)
  - Operations Manual
  - Measurement and Verification Plan (See "Supporting Information - Reporting" for details)
  - Systems Recommissioning Manual (See "Supporting Information - Reporting" for details)
  - Guideline Management Process and its reporting requirements during ongoing occupancy (See P.1 Guideline Management)
  - Refine and complete Operations Commissioning Plan.
  - Submit Information for Outcome Documentation (P.7)

Ongoing Occupancy

During occupancy, implement the Operations Commissioning Plan acting on findings according to the plan if covered in the plan, or according to the judgment of the Facility Operations Manager.
The plan includes, but is not limited to the following activities:

- Resource Use Management:
    - Guideline Leader shall monitor energy and water-related items defined in Measurement and Verification Plan and compare to weather normalized expectations, track trends in usage, and identify aberrations in use patterns, reporting them to Facilities Operations Manager for potential corrective action.
    - Facilities Operations Manager will take action on aberrations in resource use as they deem appropriate.
    - Guideline Leader shall document investigation of cause for resource use aberrations. They shall keep an annual log of actions taken to address aberrations or problems, and monitored usage data.
- Indoor Environmental Quality Management (according to the Measurement and Verification Plan):
    - Perform an evaluation of building IAQ performance annually. Measure key factor that determines ventilation rate for the building (major pollutant or CO_2) in the building occupied zones. Pollutant concentrations measured should be within the

guideline range and CO_2 levels should be at or below 450 ppm over outdoor levels. If not, additional ventilation must be provided or sources eliminated until concentrations fall below action levels. Action values for each pollutant are given in Appendix I-1.[8]
  - When exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water occurs, the intrusion, leakage or accumulation shall be corrected because of potential for these conditions to cause the growth of mold. (Title 8, Chapter 4, Section 3362(g) of California Occupational Safety and Health Standards, Sept. 2002.)
  - Establish maintenance procedures that will identify unintended water intrusion, leakage or accumulation quickly and provide drying or removal of building structure elements within 48 hours of the unintended event.
  - Use ISO 14000 requirements for cleaning supplies in standard maintenance after building occupancy.
  - Implement a preventive maintenance program for IAQ and other Indoor Environmental Quality factors in the building. Initiate data logging procedure to track occupant complaints and their resolution. This can be modeled after EPA's Building Air Quality Program (1991) or their web-based system called I-BEAM (IAQ building education and assessment)
  - After the required surveys during the correction period, Guideline Leader shall perform or coordinate completion of occupant comfort and satisfaction surveys when organizational or productivity issues arise, or optionally at regular intervals as stated in the Measurement and Verification Plan.
  - Review annually the results of Indoor Environmental Quality management practices with Facilities Operations Manager and highlight any aberrations.
  - If, in the judgment of the Facilities Operations Manager, a severe or repeated complaint occurs, the Facilities Operations Manager will arrange for an investigation of the situation, and recommend corrective action if appropriate.
- Maintenance Management:
  - Guideline Leader shall implement the Maintenance Plan covering major building systems (structural, envelope, lighting, safety, etc.) See Maintenance Plan under Supporting Information for details. Some of the elements of the plan shall include:
    - Regularly scheduled checks to verify ongoing performance, and prevention of failures of facility and its systems.
    - Review of items under Indoor Environmental Quality Management section above regarding
      - Cleaning products and practices
      - Moisture Response Practices
      - Preventative Maintenance Practices
  - Review the Operations Commissioning Plan at least annually updating it as needed to reflect changes in equipment or practices.
  - Once per year of operations, complete an Operations Commissioning Report. (See section detailing Operations Commissioning Report for those items required to be reported annually.)
  - Submit Information for Outcome Documentation (P.7) annually attaching revisions to the Operations Commissioning Plan, and the annual Operations Commissioning Report and associated reports (also see Guideline P.1 Guideline Management which covers the submittal of outcome documentation and compliance summary form annually.)

[8] Consider (recommended, not required), annual monitoring of other pollutants on the I.4 guideline list which are not the pollutants that determine the ventilation rate. Concentrations should be in the guideline range and below the action value for each pollutant. Sample pollutant action levels are given in Appendix I-1.

Next Use

- Provide transition data, history, requirements and Guideline plans and reports to new owner and facility manager
- Encourage the new owner to proactively support the Guidelines.

P.6 Lowest Life Cycle Cost

Intent

Determine the lowest life cycle cost when comparing design alternatives.

Required Performance Criteria

- Apply Life Cycle Cost methods to compare at least three alternatives for "lowest possible lifetime cost." either through use of the NIST's BLCC computer model or comparable discounted cash flow analysis. Perform this analysis at least twice in the design process: once before the end of Schematic Design Phase and once before the end of the Construction Document Phase.

Tools

A discounted cash flow analysis of each project alternative under review is required. These analyses can be accomplished through use of a custom designed discounted cash flow model or through use of the NIST's BLCC computer model. In either case, refer to the discussion of other considerations related to modeling in the "Supporting Information" section that follows.

Custom Designed Model

- It is very likely that any entity proposing a significant state funded project will have the resources needed to prepare a discounted cash flow analysis of the project. Such an analysis, typically prepared using Excel, will detail all of the initial costs of design and construction and then project future annual operating and maintenance costs, utility costs, replacement costs, and the residual value of the building and equipment. If these future costs are presented in current dollars in each year (showing the impact of inflation), they are then discounted back to the present using a nominal discount rate (a discount rate that recognizes inflation.) If future costs are expressed in constant dollars (not adjusted for inflation), then they are discounted back to the present using a real discount rate. (For example, FEMP discount and inflation rates, valid for energy and water conservation and renewable energy analyses conducted between 4/1/2004 and 3/31/2005 are: 3% Real Discount Rate, 4.8% Nominal Discount Rate, and a 1.75% Inflation Rate.) The initial costs and the discounted future costs are the summed to provide the discounted present value (discounted cost) of the proposed project over its life cycle. By completing a life cycle cost analysis of different options under consideration and then comparing the discounted present value of each, it is possible to work towards identifying the building option that has the lowest possible lifetime cost.

The BLCC Model

- The NIST Office of Applied Economics has produced, and annually updates, a Building Life-Cycle Cost (BLCC) computer model that is available at no charge from NIST and that can also be downloaded from their web site. The annual update of the BLCC is released each April and contains the federal government's latest estimates for inflation, energy price escalation by state, and federal discount rates (Nominal and Real.) This model is designed specifically to help the user identify building options that result in the lowest life cycle cost with particular attention paid to energy use and water consumption. The user of this model is expected to enter a base case (typically for a code-compliant basic building), one or more alternative designs, and then compare the results.

- While the BLCC model is focused on energy and water, with a little imagination it can be used to complete a comprehensive analysis of a project. The model allows the user to add new categories for initial capital expenditures, on going recurring charges, one time future charges, etc., so it is possible to build a comprehensive model of the life cycle costs of a proposed building. Numerous different building configurations can then be defined and evaluated and predefined reports can be used for easy comparisons of alternatives. The BLCC model has a module that compares the base case project to the alternative under review and calculates energy savings and emission reductions (CO_2, SO_2, NO_x) achieved by the alternative.

Resources

Life-Cycle Costing Manual for the Federal Energy Management Program published by National Institute of Standards and Technology (NIST Handbook 135) (222 pages) A comprehensive manual containing a thorough discussion of both the concepts and underlying math of life cycle costing with numerous examples demonstrating the value of this approach. This publication can be ordered at no cost from NIST (301-975-6478) or the EERE Info Center (1-800-363-3732.) It can also be downloaded from the EERE web site: www.eere.energy.gov/femp/program/lifecycle.cfm

Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123, January 8, 2003 (27 pages) A brief but solid discussion of Life Cycle Cost Analysis concepts and definitions with some examples. Published by FEMP and available through the EERE web site: www.eere.energy.gov/femp/program/lifecycle.cfm

2003 Facilities Standards (P100), Section 1.8 Life Cycle Costing (5 pages) This section of the GSA's Facility Standards manual discusses Life Cycle Costing and contains a table summarizing key LCC formulas and their use. Available through GSA: www.gsa.gov (search for "P100", then go to section 1.8 "General Requirements; Life Cycle Costing")

OMB Circular A-94 - Guidelines for Benefit-Cost Analysis of Federal Programs Presents guidance for the analysis of projects other than those that are primarily energy related. Broadens the discussion beyond just costs and cost-avoidance to include benefits. Available for download at: www.whitehouse.gov/omb/circulars/a094/a094.html

Whole Building Design Guide is a web based resource containing extensive background information, research reports and references relating to the design, analysis, and construction of "Whole Buildings". Includes information on life cycle analysis, productivity, energy conservation and other topics pertinent to sustainable design. www.wbdg.org

Supporting Information

State legislation identifies two different measures for evaluating the performance of new and existing buildings:

1. Section 16B.325 requires in part that the guidelines "focus on achieving the lowest possible lifetime cost for new buildings...";
2. Minnesota Laws 2001, Article 1, Ch 212,Sec.3. Benchmarks for Existing Public Buildings requires a comprehensive plan to maximize energy efficiency in existing public buildings "through conservation measures having a simple payback within ten to 15 years."

How are proposed projects to be evaluated in order to best ensure compliance with these requirements?

- The first requirement references a more comprehensive analysis, an analysis that strives to achieve the lowest possible lifetime cost for a proposed new building. This lifetime cost analysis requirement can be the source of some confusion because of varying definitions and interpretations and the math needed to complete the calculations. The materials in the following section are intended to serve as an introduction to this type of comprehensive analysis.

- The second requirement for energy efficient projects in existing buildings with a simple payback within ten to 15 years is simple enough, but in its simplicity it fails to recognize some important considerations. Some alternative measures that can be used in addition to the simple payback calculation are discussed below.

Why Discounting?

The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. If the costs and the benefits (i.e. energy cost savings) of a particular proposal occur in the same time period the analysis is quite simple. If you were trying to pick the most cost effective choice between 2 rental cars for a weekend the analysis would be quite straightforward. If a hybrid rents for $50 a day and gets 50 MPG and a more traditional compact rents for $40 a day and gets 22 MPG, it is easy to envision the analysis. The most cost effective choice will depend on how many miles you expect to drive and the cost of gasoline. You might have some difficulty quantifying other considerations (i.e. you like or don't like the looks of the hybrid), but you could weigh such preferences against the least costly alternative. Does it make the choice easier or harder? How big a economic penalty are you willing to pay to support your styling preference?

But what if the costs and benefits are spread out over time? The same simple calculations don't work very well since we all have a "time value of money". If you are deciding which car to buy and the hybrid costs $24,000 and the traditional compact costs $21,000, how do you compare them? The extra $3,000 is a current expenditure while the gas savings will be spread over the years. Most people would not consider the hybrid to be the same cost as the traditional car if it saved exactly $3,000 in gasoline costs over 10 years. You would require more future savings than that to compensate for the fact that the benefits are spread over so many years. And what about maintenance and repairs? How will they compare? To properly compare these two alternatives you would need to convert costs and benefits to comparable Present Values and complete a "life-cycle cost analysis".

Discounting and Present Values

Discounting and Present Values are perhaps best understood as the reverse of compound interest. If you have $100 and invest it at 5% interest compounded annually for 10 years, it will grow by more than $50 over 10 years because of compounding. It will grow to $105.00 at the end of year 1, $110.25 in year 2, $115.76 in year 3, and so forth until in totals $162.89 at the end of year 10. Calculating a Present Value amounts to reversing the compounding process in order to answer the question, "What amount received today would have the same utility to me as $162.89 received ten years from now?" If my discount rate is 5%, the answer will be calculated to be $100.

Just as the interest rate is central to determining the total amount accumulated over the investment period, so the choice of discount rates drives the Present Value calculation. In the above example, if my discount rate were 8% instead of 5%, the $162.89 received in year 10 would have a Present Value of only $75.45. The choice of discount rates is very important to the validity of an analysis, overshadowed only by the critical importance of being consistent with the choice of discount rates throughout an analysis.

Federal Energy Management Program Guidance

The Federal Energy Management Program's Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123 provides some useful definitions and guidance. "Section 707 of Executive Order 13123 defines life-cycle costs as *"...the sum of present values of investment costs, capital costs, installation costs, energy costs, operating costs, maintenance costs, and disposal costs over the life-time of the project, product, or measure."*

"Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and disposing of a project are considered important to the decision. LCCA is particularly suited to the evaluation of design alternatives that satisfy a required performance

level, but that may have differing investment, operating, maintenance, or repair costs; and possibly different life spans. LCCA can be applied to any capital investment decision, and is particularly relevant when high initial costs are traded for reduced future cost obligations."
The FEMP guidance goes on to explain the need for time adjustments , defines the life cycle cost formula, and discusses application of life cycle cost analysis. Included in the FEMP guidance are some important comments on the shortcomings of a simple payback analysis. These sections of the FEMP guidance are quoted below.

Time Adjustments
Adjustments to place all dollar values expended or received over time on a comparable basis are necessary for the valid assessment of a project's life-cycle costs and benefits. Time adjustment is necessary because a dollar today does not have equivalent value to a dollar in the future. There are two reasons for this disparity in value. First, money has real earning potential over time among alternative investment opportunities, and future revenues or savings always carry some risk. Thus an investor will require a premium or extra return for postponing to the future the spending of that dollar. Second, in an inflationary economy, purchasing power of money erodes over time. Thus a person would demand more than a dollar at some future time to obtain equivalent purchasing power to a dollar held today.
The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. A discount rate is used in special formulas to convert future values. When future values are expressed in current (nominal) dollars, where inflation is included in the future values, a market (nominal) discount rate is used. It takes into account both inflation and the earning potential of money over time. When future values are expressed in real (constant dollar) terms, where general price inflation has been stripped out, a real discount rate is used. It takes into account only the earning potential of money over time. Both approaches yield identical results as long as you use real discount rates in discounting constant-dollar future amounts and market discount rates in discounting current-dollar future amounts.

Choices among energy-savings projects can be made either by estimating for each alternative project a stream of life-cycle costs and savings relative to a "base case," and computing the net present value (NPV) of that stream (looking for the maximum NPV), or by calculating the present value of each project's life-cycle cost, and choosing the alternative (including "do nothing") that yields the minimum present value life-cycle cost (PVLCC.)

Life-Cycle Cost Formula
To find the total LCC of a project, sum the present values of each kind of cost and subtract the present values of any positive cash flows such as a resale value. Thus, where all dollar amounts are converted to present value by discounting, the following formula applies:
Life-cycle cost = first cost + maintenance and repair + energy + water+ replacement - salvage value.
Eventually, when additional considerations for values such as worker or occupant productivity and community or social values can be assessed and calculate with more certainty, they will be incorporated in the model as well. At this time, however, there are too many variables and little conclusive data associated with these topics to make them part of the standard calculations. However, Appropriated Agencies may want to consider the cost benefits of worker productivity improvements within their own models and use those as additional factors when considering the overall outcomes for net present value.

Applications of LCCA
Projects may be compared by computing the LCC for each project, using the formula above and seeing which is lower. The alternative with the lowest LCC is the one chosen for implementation, other things being equal.

The LCC method can be applied to many different kinds of decisions when the focus is on determining the least-cost alternative for achieving a given level of performance. For example, it can be used to compare the long-term costs of two building designs; to determine the expected savings of retrofitting a building for energy or water conservation, whether financed or agency-funded; to determine the least expensive way of reaching a targeted energy use for a building; or to determine the optimal size of a building system.

In addition to the LCC formula shown above, there are other methods for combining present values to measure a project's economic performance over time, such as Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return or Discounted Payback.

Note on Discounted Payback (DPB) and Simple Payback (SPB)
Discounted Payback (DPB) and Simple Payback (SPB) measure the time required to recover initial investment costs. The payback period of a project is expressed as the number of years just sufficient for initial investment costs to be offset by cumulative annual savings. DPB is the preferred method of computing the payback period for a project because it requires that cash flows occurring each year be discounted to present value to adjust for the effect of inflation and the opportunity cost of money. The SPB does not use discounted cash flows and therefore ignores the time value of money, making it a less accurate measure than the DPB. In practice, the DPB or SPB is used to measure the time period required for accumulated savings to offset initial investment costs. Any costs or savings incurred during the remainder of the project life-cycle are ignored. The DPB and the SPB are therefore not appropriate measures of life-cycle cost effectiveness and should be used only as screening tools for qualifying projects for further economic evaluation.

Suggested Implementation

Agency Planning - Schematic Design

- Evaluate at least three alternatives at least once before the end of the schematic design phase.

Design Development - Construction Documents

- Evaluate at least three alternatives at least once more before the end of the Construction Documents phase.

Ongoing Occupancy

- It is recommended a comparison to the final project model be run at least every 5 years to capture experiences during construction and operations and compare them with assumptions made in the final project model.

P.7 Process Documentation for Performance Management

Intent
Document compliance with Guidelines and process of integrated design and to calculate outcomes of Planning for Conservation and Commissioning in order to improve Guidelines over time.

Required Performance Criteria

- Complete P-A Compliance Summary Form at the end of each phase to document progress towards compliance for those portions of the guidelines required or recommended but being pursued.
- Complete Process Documentation Forms at the end of each phase to document key process and project reference information relevant to the reported phase of the project. See Form P-B.

FORM P-B: PERFORMANCE MANAGEMENT —PROCESS DOCUMENTATION

For work through phase: ________________________ as of the date:__________________

P.1 PROJECT DATA

- Client, and Work Team List with contact information (attach)*
- Project Master Schedule (attach)*
- Building Operating Hours (by season if varies)
  ____
- Estimated Years of planned use by Owner______ Est. Years between major reconfigurations_____
- Estimated life of the building _______
- Project Budget (attach) $/sq.ft. construction cost________*
- Outline of construction types for each building system (attach)*
- Space Program with Building Function Narrative (attach)*

P.2 SPACE UTILIZATION DATA

- Building Area: Gross sq.ft. __________ Net sq.ft._________,*
- Net to Gross Sq.Ft. Ratio _____________
- Average Full Time Equivalent (FTE) Employees + other occupants (40 Hr/Wk basis) _______ Peak Number of Occupants (based on code capacity)_________
- Net Area per Average FTE Occupants ____________
- Gross Building Volume cu.ft. _____________
- Gross Volume to Gross Floor Area Ratio:_____________
- Answer questions in Performance Criteria of P.2. Include brief explanation of how the project is proceeding (attach)
- Estimated Total Construction Cost Savings from Reused/Remodeled/Reduced Area versus New Construction $__________(Programming Baseline vs. Design Baseline Area)
- Estimated Total Annual Energy Cost Savings from Reduced Area of New Construction $________

P.3 INTEGRATED DESIGN PROCESS DATA

- Stakeholder team list (attach)*
- Brief description of process conducted to achieve integrated design.
- Identify Agenda, Attendees, and Key results from stakeholder planning/ review workshops held in the current phase. (attach Agenda and Meeting Minutes)

P.4 DESIGN AND CONSTRUCTION COMMISSIONING DATA

- Brief description of scope of commissioning determined.
- Attach Design and Construction Commissioning Plan and Report (and referenced related reports) for the current phase if applicable. (If Plan is same as prior submission, note this, - do not resubmit same plan.)

P.5 OPERATIONS COMMISSIONING DATA

- Brief description of scope of Operations Commissioning determined.
- Attach Operations Commissioning Plan and Report (and referenced related reports) for the current phase or reported year of operation. (If Plan is same as prior submission, note this, - do not resubmit same plan.)

P.6 LIFE CYCLE COST ANALYSIS

- Brief description of life cycle cost determined for alternatives considered; indicate chosen alternative.
- Attach Lifecycle Model Report (and referenced related reports) for this phase.

**Note: Information included in State Required Predesign Document can be used.*

Form P-A: Compliance Summary Form - PAGE 1 OF 2

Project Name: **Project Address:**

CHECK LIST

- [ ] **Attach Process/Outcome Documentation Forms for Each Section:** (P, S, E, I, M)
- [ ] **Enter Date of Submittal:**
- [ ] **Name of Phase being Completed and Submitted for Compliance:** **(See list e.g.. "Schematic Design")**
- [ ] **Complete the following Table for the phase being completed**

Guidelines are required except those with * which are Recommended

	Guideline # and Name	Responsible Role Name: (Example Role Names listed below for design phase.)	PURSUED	ACHIEVED	VARIANCE	COMMENTS
	PERFORMANCE MANAGEMENT					
P.1	Guideline Management	Guideline Leader (Coordinator of Work Team Compliance)				
P.2	Planning for Conservation	Appropriated Agency				
P.3	Integrated Design Process	Architect				
P.4	Design and Construction Commissioning	Design and Construction Commissioning Leader				
P.5	Operations Commissioning	Operations Commissioning Leader				
P.6	Lowest Life Cycle Cost	Architect				
P.7	Process Documentation for Performance Management	Guideline Leader (Coordinator of Work Team Compliance)				
	SITE AND WATER					
S.1	Avoid Critical Sites	Appropriated Agency				
S.2	Appropriate Location and Density	Appropriated Agency				
S.3	* Brownfield Redevelopment	Appropriated Agency				
S.4	Erosion and Sedimentation Control	Architect				
S.5	Stormwater Management	Civil Engineer				
S.6	Reduce Site Disturbance and Restore Site	Landscape Architect				
S.7	* Restorative Design	Landscape Architect				
S.8	Reduce Site Water Use for Plant Materials	Landscape Architect				
S.9	Reduce Light Pollution	Electrical Engineer				
S.10	* Reduce Heat Island Effect	Architect				
S.11	* Encourage Efficient Transportation Alternatives	Architect				
S.12	Building Water Efficiency	Mechanical Engineer				
S.13	* Use Gray Water to Reduce Wastewater Treatment Impacts	Mechanical Engineer				
S.14	* Use Biological Wastewater Treatment System	Mechanical Engineer/ Civil Engineer				
S.15	Outcome Documentation for Site and Water	Guideline Leader (Coordinator of Work Team Compliance)				
	ENERGY AND ATMOSPHERE					
E.1	Reduce Energy Use by at least 30%	Mechanical Engineer (or Energy Consultant)				
E.2	Efficient Equipment and Appliances	Appropriated Agency				
E.3	Evaluate Renewable and Distributed Energy Generation	Mechanical Engineer				
E.4	* Atmospheric Protection	Mechanical Engineer				
E.5	Outcome Documentation for Energy and Atmosphere	Guideline Leader (Coordinator of Work Team Compliance)				
	INDOOR ENVIRONMENTAL QUALITY					
I.1	Restrict Environmental Tobacco Smoke	Appropriated Agency				
I.2	Indoor Air Quality and Ventilation Baseline	Mechanical Engineer				
I.3	Specify Low-emitting Materials	Architect				
I.4	Ventilation Based on Anticipated Pollutants	Mechanical Engineer				
I.5	Ventilation Based on Carbon Dioxide Limits	Mechanical Engineer				
I.6	Moisture Control	Mechanical Engineer				
I.7	Thermal Comfort	Mechanical Engineer				
I.8	* Daylight	Architect				
I.9	Quality Lighting	Electrical Engineer				
I.10	* View Space and Window Access	Architect				
I.11	Eliminate Whole Body Vibration in Buildings	Structural Engineer				
I.12	Effective Acoustics & Positive Soundscapes	Architect (or Acoustical Consultant)				
I.13	* Personal Control of IEQ Conditions & Impacts	Mechanical/ Electrical Engineer				
I.14	* Encouraging Healthful Physical Activity	Architect				
I.15	Outcome Documentation for Indoor Environmental Quality	Guideline Leader (Coordinator of Work Team Compliance)				
	MATERIALS AND WASTE					
M.1	Evaluation of Design for Minimum Resource Use	Architect				
M.2	Evaluation of Material Properties for Improved Performance	Architect				
M.3	Waste Reduction and Management	Architect				
M.4	Outcome Documentation for Materials and Waste	Guideline Leader (Coordinator of Work Team Compliance)				

Form P-A: Compliance Summary Form - PAGE 2 OF 2

☐ **Complete the Signatures for each responsible party in the table below:**

By signing this you indicate the project is on track towards compliance with the guidelines for which you are responsible as listed above, and that related documentation to these guidelines is accurate to the best of your knowledge.		
Role Name responsible for selected guidelines as indicated above	Signature and Printed Name of Responsible Party and Firm	Date
Guideline Leader (Coordinator of Work Team Compliance)		
Agency Contact		
Architect		
Civil Engineer		
Landscape Architect		
Structural Engineer		
Mechanical Engineer		
Electrical Engineer		
Interior Designer		
Energy Consultant		
Acoustic Consultant		
Construction Contractor		
Facilities Operations Manager		
Design and Construction Commissioning Leader		
Operations Commissioning Leader		
Other: List		

	Agency Approval		

FORM P-B: PERFORMANCE MANAGEMENT —PROCESS DOCUMENTATION

For work through phase: _________________________as of the date:___________________

P.1 PROJECT DATA

- Client, and Work Team List with contact information (attach)*
- Project Master Schedule (attach)*
- Building Operating Hours (by season if varies)
  ____
- Estimated Years of planned use by Owner______ Est. Years between major reconfigurations_____
- Estimated life of the building _______
- Project Budget (attach) $/sq.ft. construction cost________*
- Outline of construction types for each building system (attach)*
- Space Program with Building Function Narrative (attach)*

P.2 SPACE UTILIZATION DATA

- Building Area: Gross sq.ft. __________ Net sq.ft._________,*
- Net to Gross Sq.Ft. Ratio _____________
- Average Full Time Equivalent (FTE) Employees + other occupants (40 Hr/Wk basis) _______ Peak Number of Occupants (based on code capacity)_________
- Net Area per Average FTE Occupants ____________
- Gross Building Volume cu.ft. _____________
- Gross Volume to Gross Floor Area Ratio:_____________
- Answer questions in Performance Criteria of P.2. Include brief explanation of how the project is proceeding (attach)
- Estimated Total Construction Cost Savings from Reused/Remodeled/Reduced Area versus New Construction $__________(Programming Baseline vs. Design Baseline Area)
- Estimated Total Annual Energy Cost Savings from Reduced Area of New Construction $________

P.3 INTEGRATED DESIGN PROCESS DATA

- Stakeholder team list (attach)*
- Brief description of process conducted to achieve integrated design.
- Identify Agenda, Attendees, and Key results from stakeholder planning/ review workshops held in the current phase. (attach Agenda and Meeting Minutes)

P.4 DESIGN AND CONSTRUCTION COMMISSIONING DATA

- Brief description of scope of commissioning determined.
- Attach Design and Construction Commissioning Plan and Report (and referenced related reports) for the current phase if applicable. (If Plan is same as prior submission, note this, - do not resubmit same plan.)

P.5 OPERATIONS COMMISSIONING DATA

- Brief description of scope of Operations Commissioning determined.
- Attach Operations Commissioning Plan and Report (and referenced related reports) for the current phase or reported year of operation. (If Plan is same as prior submission, note this, - do not resubmit same plan.)

P.6 LIFE CYCLE COST ANALYSIS

- Brief description of life cycle cost determined for alternatives considered; indicate chosen alternative.
- Attach Lifecycle Model Report (and referenced related reports) for this phase.

**Note: Information included in State Required Predesign Document can be used.*

Guidelines: Site and Water

Guidelines (Required except where noted with * which indicates recommended)

Forms

Overview

Building construction transforms land that provides valuable ecological services. Society has only recently begun to understand that these services have a quantifiable economic value. Site selection and design affect transportation and energy use which leads to ground-level ozone, acid rain, smog, and global climate change. Current development practices on the land can lead to uncontrolled stormwater runoff, degraded water and soil quality, and destruction of habitat. The State of Minnesota Sustainable Building Guidelines (MSBG) seek to restore and improve site water and soil quality, and to reduce negative impacts associated with site selection and design.

Goal

To design and maintain sites which have soil and water quality capable of supporting healthy, bio-diverse plant, animal, and human communities, which reduce water and energy consumption, and which minimize pollutant contributions related to transportation requirements.

Objectives

- Maintain and improve the ability of the soil to maintain its structure against adverse impacts.
- Restore/improve the hydrologic cycle of water on the site to avoid adverse impacts on the site and downstream of the site.
- Reduce consumption of potable water.
- Improve the biodiversity of the site by introducing flora/fauna which will help contribute to the sustainability of the site over time.

- Reduce energy consumption and pollution contributions to air and water related to site location and associated transportation requirements.
- Restore/improve the outdoor environmental quality (OEQ) of the site to enhance occupant productivity, building performance, and community benefits.

Guidelines: Site and Water

S.1 Avoid Critical Sites

Intent
Avoid development or minimize the impacts of development on portions of sites whose natural features and functions are particularly valuable to the larger community; avoid development on sites where soil, water, and flora/fauna indicators are in a fragile condition because of surrounding development or the natural state of the site.

Required Performance Criteria
Avoid or minimize the impact of development on portions of sites that meet any one of the following criteria:

- Land of state, regional, or local natural resource and biological/ecological significance as identified in state, regional, or local natural resources inventories, assessments and biological surveys.
- Prime farmland as defined by the American Farmland Trust.
- Land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by the Federal Emergency Management Agency (FEMA)
- Land which provides habitat for any animal or plant species on the Federal or State threatened or endangered list.
- Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt.)

Tools
Maps:

- Comprehensive County "Critical Natural Resources" map and assessments such as County Biological Surveys, DNR Natural Resources Inventory and Assessment (NRI/A) (in 7 county Metro Area), local NRI/A's
- Comprehensive Municipal land use map
- Prime Farmland as defined by state statute/rules and identified in County Soil Surveys and/or County/regional farmland and natural areas conservation/preservation programs
- FEMA Flood Insurance Maps and/or natural resource agency information identifying 100 year flood elevations
- National, state, or county databases and maps identifying habitat with identified or potential threatened or endangered flora/fauna

Other:

- Minnesota Rules; Board of Soil and Water Resources, Chapters 8400-8420
- Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources
Websites:

- www.swcs.org/t_resources_critical_adults.htm

Suggested Implementation

Agency Planning

- Determine ideal spatial needs for existing or new development.

Predesign-Programming

- Determine what type of infrastructure, constructed or natural, will be needed or desired to support the proposed development.

Predesign-Site Selection

- Determine how the proposed site soil, water and flora/fauna will be affected by the proposed development. This will be determined by looking at the carrying capacity standards of soil, water and flora/fauna and the ability of these elements to sustain themselves and flourish after development

S.2 Appropriate Location and Density

Intent

Direct development, where appropriate, to existing urban, suburban, or rural areas with in-place infrastructure to reduce development pressure on undeveloped land or Greenfield sites; to conserve natural resources, reduce energy use and pollution contributions related to transportation requirements; and to promote a sense of increased community interaction.

Required Performance Criteria

Avoid low density, undeveloped sites, unless no other site is available. If no appropriate site is available, then compare existing and planned land use and zoning requirements for specific site types. Select a site which presents the most comprehensively positive impact for environmental, economic, community, and human benefits.

In this analysis consider the following scenarios:

- Urban and suburban locations: Select sites which reuse existing urban/suburban and industrial sites; are located near mass transit and public amenities to encourage walking to services instead of driving; and can utilize existing infrastructure such as utilities, roadways, services, etc. Select sites that support Regional Development Strategies and Local Comprehensive Plans.
- Urban and suburban locations: Increase localized density to conform to existing or desired density goals as listed in Minnesota's Community-Based Planning Act.
- Rural locations: Avoid Greenfield sites which may not meet the threshold for a potentially significant environmental impact under Minnesota Statute CH. 116D, but which negatively impact green space and soil and water conditions.

Tools

The density calculation process is described in the following steps:

1. Determine the total area of the project site and the total square footage of the building. For projects that are part of a larger property (such as a campus), define the project area as that which is defined in the project's scope. The project area must be defined consistently throughout the project documentation.
2. Calculate the development density for the project by dividing the total square footage of the building by the total site area in acres. This development density
3. Convert the total site area from acres to square feet and calculate the square root of this number. Then multiply the square root by three to determine the appropriate density radius.

(Note: the square root function is used to normalize the calculation by removing effects of site shape.) (See Equation 2.)

4. Overlay the density radius on a map that includes the project site and surrounding areas, originating from the center of the site. This is the density boundary. Include a scale on the map.
5. For each property within the density boundary and for those properties that intersect the density boundary, create a table with the building square footage and site area of each property. Include all properties in the density calculations except for undeveloped public areas such parks and water bodies. Do not include public roads and right-of-way areas. Information on neighboring properties can be obtained from your city or county zoning department.
6. Add all the square footage values and site areas. Divide the total square footage by the total site area to obtain the average property density within the density boundary. The average property density of the properties within the density boundary must be equal to or greater than 60,000 square feet per acre.

Equation S-1

Development Density	(SF) (Acre)	=	Building Square Foot (SF) Property Area (Acres)

Equation S-2

Density Radius (LF)	=	3 X	-- √Property Area (Acres) x 43,560 [SF/Acre]

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources

Websites

- www.pca.state.mn.us/water/pubs/sw-bmpmanual
- www.dot.state.mn.us/engserv/tecsup/index

Suggested Implementation

Predesign-Site Selection

- Seek out and evaluate opportunities to locate in areas where existing infrastructure will support increased densities, and where additional development can improve site use.
- Work with local governing units and community representatives to inventory potential sites that will enhance environmental and economic performance for communities and agencies alike.

Schematic Design

- Choose to develop a site where a community revitalization is occurring provided the required development density is achieved by the project's completion.
- For example: Utilize site located within an existing minimum development density of 60,000 square feet per acre (two story downtown development)

Design Development

- Integrate community feedback into density development proposals, working closely with municipality to coordinate development efforts.
- Document development density.

Construction Administration

- Make bidders aware of specific requirements for sustainable development.

S.3 Brownfield Redevelopment

Intent

Redevelop damaged or contaminated sites to reduce development pressure on undeveloped land and utilize existing investments in infrastructure, conserve natural resources, and promote new sense of community renewal, identity, and revitalization.

Recommended Performance Criteria

This criterion is recommended but not required by these guidelines.

- Redevelop Brownfield sites to support Minnesota's Community-Based Planning Act.
- Provide remediation as required for EPA's Sustainable Redevelopment of Brownfields Program and enroll site in the Minnesota Pollution Control Agency's Voluntary Investigation and Cleanup Program.
- Develop a site classified as a Brownfield into a Greenspace (B2-G), for park or open space connected to building development.

Tools

www.pca.state.mn.us/cleanup/brownfields.html

County comprehensive development plan

Municipal land use plan

County Brownfield map listing contamination source and degree of contamination

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources

Websites

- www.epa.gov/swerosps/bf/index
- www.brownfields2002.org

Suggested Implementation

Agency Planning

- In planning for new facilities, include the Brownfield redevelopment option, based on its ability to meet expectations of key locations, appropriate size, and sufficient infrastructure to support planning goals.

Predesign-Programming

- Select a building approach that is adaptable to Brownfield redevelopment.

Predesign-Site Selection

- Preferably, select a site that is eligible for the EPA's Brownfield Redevelopment program.

- Select a site where the development has the ability to benefit both owner and user; to provide tax credits and purchase incentives for the owner and to create an improved economic and social environment for the neighborhood.

S.4 Erosion and Sedimentation Control

Intent
Reduce the loss of soil and sediment during construction and occupancy by reducing the impacts of wind and water on the soil and to reduce the amount of soil and sediment entering streams causing downstream impacts.

Required Performance Criteria
- Design, specific to site, a sediment and erosion control plan than conforms to "Urban Small Sites Best Management Practices" (Metropolitan Council), prevents sedimentation within acceptable limits as set by local authority or watershed district having jurisdiction, whichever is more stringent.
- The plan shall meet the following objectives:
    - Prevent sedimentation of storm sewer.
    - Prevent soil erosion before, during, and after construction by controlling stormwater runoff and wind erosion.[1]
    - Protect hillsides using erosion control measures.[2]
    - Prevent air pollution due to dust and particulate matter.

Tools
Best management practices for erosion and sedimentation control authored by the Environmental Protection Agency (EPA), Minnesota Pollution Control Agency (MPCA), MetCouncil, or Local Governing Unit (LGU), whichever is most stringent.

MetCouncil Small Sites BMP Manual
www.metrocouncil.org/environment/Watershed/BMP/manual.htm

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources
Websites
- www.pca.state.mn.us/water/pubs/sw-bmpmanual
- www.dot.state.mn.us/engserv/tecsup/index

Suggested Implementation

Predesign-Site Selection
- Determine soil type, soil structure, and limitations of soil, by performing a detailed geotechnical analysis of the soil.

Schematic Design
- Determine what types of erosion and sedimentation control measures are appropriate for the specific types of soils on the site.

[1] Strategies to consider include: stockpiling topsoil for reuse, silt fencing, sediment traps, construction phasing, stabilization of slopes, and maintaining and enhancing vegetation and groundcover. The minimum wind speed to start soil movement on an erodible soil is 13 to 15 miles per hour.

[2] Strategies to consider include: hydro seeding, erosion control blankets, and/or sedimentation ponds to collect runoff.

Design Development

- Develop specific erosion and sedimentation control measures that are appropriate for specific types of soil.

Construction Documents

- Develop erosion and sedimentation control measures that are appropriate for the specific soils and are long-lasting.
- Document using appropriate drawings, specifications, and worksheets.

Construction Administration

- Make bidders aware of specific requirements for sustainable development.

Construction

- Construct, maintain and disassemble erosion and sedimentation control features according to drawings and specifications.

Ongoing Occupancy

- Monitor soil to ensure its carrying capacity is not diminished.

S.5 Stormwater Management

Intent

Minimize negative impacts on the natural site hydrologic cycle as much as possible by reducing downstream impacts, improving the overall water quality and clarity, and recharging groundwater through infiltration.

Required Performance Criteria

- Achieve no net decrease in the rate and quantity of on-site water recharge from existing to developed conditions; OR, if existing imperviousness is greater than 25%, implement an infiltration or storage plan that results in a 25% increase in the rate and quantity of on-site water recharge.
- Provide treatment systems designed to remove solids and pollutants for on-site water recharge to comply with water quality standards of Local Governing Unit (LGU) or "Urban Small Sites Best Management Practices" (Metropolitan Council), whichever is more stringent. It is the intent of these Guidelines to update tools and criteria such as Best Management Practices on an ongoing basis, to include the most comprehensive, stringent and consistent approach as possible for compliance.
- Achieve no net increase in the rate and quantity of stormwater runoff from existing to developed conditions; OR, if existing imperviousness is greater than 25%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff.
- Provide treatment systems designed to remove 80% of the average annual post development total suspended solids (TSS), and 40% of the average annual post development total phosphorous (TP), by implementing Best Management Practices (BMPs) outlined by EPA's Best Management Practices (BMP), "Urban Small Sites Best Management Practices" (Metropolitan Council), or Local Governing Unit (LGU), whichever is more stringent.

Tools

Best management practices for stormwater management authored by the EPA (See Table S-1), MPCA, MetCouncil, or LGU, whichever is most stringent.

EPA BMP's www.epa.gov/OST/stormwater/

www.bmpdatabase.org/

MetCouncil Small Sites BMP Manual

www.metrocouncil.org/environment/Watershed/BMP/manual.htm

Calculate runoff using Calculator and runoff coefficients listed in tables in Appendix S-2 at the end of this section.

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources

Websites

- www.pca.state.mn.us/water/pubs/sw-bmpmanual
- www.mnwatershed.org/infiltration
- www.pca.state.mn.us/publications/mnenvironment/impaired-waters-edition/stormwaterplants.html
- http://soils.usda.gov/sqi/files/UrbanSQ.pdf
- www.bmpdatabase.org (International Stormwater BMP Database)
- www.mnerosion.org/meca_eandstools.htm
- www.stormwatercenter.net

Publications

Plants for Stormwater Design: Species Selection for the Upper Midwest (MPCA.) Contact Kelly Turner 651-297-8679 for copies. (See web site above.)

Protecting Urban Soil Quality (USDA) (See web site above.)

Table S-1 EPA Best Management Practices

Practice	**Advantages**	**Disadvantages**	**Removal Efficiency[%]**	
			TSS (req. 80%)	TP (req. 40%)
Infiltration Basins & Infiltration Trenches	Provides groundwater recharge, high removal efficiency, provides habitat	Requires permeable soils, high potential for failure, requires maintenance	50 to 100	0 to 100
Porous Pavement	Provides groundwater recharge, no space requirement, high removal efficiency	Requires permeable soils, not suitable for high-traffic areas, high potential for failure, requires maintenance	60 to 90	60 to 90
Vegetated Filter Strips	Low maintenance, good for lowvelocity flows, provides habitat, economical	Not appropriate for high-velocity flows, requires periodic repair and reconstruction	40 to 90	30 to 80

Practice	Advantages	Disadvantages	Removal Efficiency[%]	
Grassy Swales	Small land requirements, can replace curb and gutter infrastructure, economical	Low removal efficiency	20 to 40	20 to 40
Filtration Basins	Provides groundwater recharge, peak volume control	Requires pretreatment to avoid clogging	60 to 90	0 to 80
Constructed Wetlands	Good for large developments, peak volume control, high removal efficiency, aesthetic value	Not economical for small developments, requires maintenance, significant space requirements	50 to 90	0 to 80
Dry Ponds	Peak flow control, less space and cost vs. wet pond	Space, maintenance, limited soil groups	70 to 90	10 to 60
Wet Ponds	Peak flow control, prevents scour and re-suspension	Space, cost, maintenance, limited soil groups	50 to 90	20 to 90

Source: EPA840B92002 Tables 4-5 and 4-7

Suggested Implementation

Predesign-Site Selection

- Select a site where the soil conditions will tolerate the increased stormwater flow caused by the impervious surfaces of the building(s) and its infrastructure.
- Perform a geotechnical analysis and slope analysis of the site to determine water runoff conditions and potential problems.

Schematic Design

- Determine what types of stormwater management techniques are appropriate for the specific building type and supporting infrastructure, including pervious paving.

Design Development

- Develop specific erosion and sedimentation control measures that are appropriate for specific types of soil, movement of water, and predicted wind speed and direction over the course of construction operations.

Construction Documents

- Develop sustainable details based on the specific site condition and surrounding environment.

Construction Administration

- Make bidders aware of specific requirements for sustainable construction.

Construction

- Construct stormwater management features in a sustainable manner, according to drawings and specifications.

Ongoing Occupancy

- Maintain stormwater management features at prescribed time intervals, determined by watershed protection standards, which allow natural stormwater processes to occur, benefiting both the project site and downstream environments.

Next Use

- Maintain historic records of performance of each stormwater feature to determine applicability of the feature for future uses.

S.6 Reduce Site Disturbance and Restore Site and Restore Site

Intent

Conserve existing site features during planning and construction to promote biodiversity on the site and to restore natural areas damaged by construction so the site can sustain its water, soil, and plant cover functions.

Required Performance Criteria

- On previously developed sites: Maintain or improve natural site functions and biodiversity for 50% of site area in accordance with existing conditions and surrounding site context. Determine spatially by area measurement, not including building footprint.
- On Greenfield sites: Limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways, and main utility branch trenches, 5 feet beyond tree driplines and the edges of site areas identified for protection and 25 feet beyond pervious paving areas and stormwater management features that require additional staging areas in order to limit compaction in the constructed areas.
- On all sites: Provide a minimum of 75% of all species planted on the site from stock identified as native to the local area and as identified in resources listed at the end of this guideline. In addition, a minimum of 75% of all trees and shrubs, by quantity, are to be native material.

Tools

Websites

- www.nh.nrcs.usda.gov/Technology/Engine

Seeding Manual - Latest Edition, Mn/DOT Office of Environmental Services, Turf Establishment & Erosion Control Unit

Resources

Municipal tree and natural resource inventory

Geotechnical soils analysis

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Suggested Implementation

Predesign-Site Selection

- Select a site where damage to existing soil, water, and flora/fauna can be minimized, thereby lowering construction costs.

Schematic Design

- Determine the areas of soil, water, and plant cover on the project site that are necessary to remain undisturbed because of their function of sustaining and protecting the site from soil compaction, soil erosion, and flora/fauna loss. Document that performance criteria are met by design.

Design Development

- Develop site disturbance techniques that minimize negative impacts on soil, water, and flora/fauna on the site and adjacent sites.

Construction Documents

- Develop detailing and specifications that support the use of native plantings, maintain existing biodiversity, and promote enhancement of site conditions for acceptable flora/fauna.

Construction Administration

- Make bidders aware of specific responsibilities for integrating the on-site techniques with adjacent site connection conditions.

Construction

- Protect existing plants and trees indicated to remain and maintain or improve soil and water conditions to promote and improve growth.

Ongoing Occupancy

- Maintain and enhance at least the minimum spatial areas necessary for soil stabilization, stormwater control, and flora/fauna establishment. This is determined by soil-type standards, local watershed guidelines, and minimum plant and green corridor widths.

Next Use

- Document the existing natural condition and its ability to function in its current capacity. Note what enhancements, and enlargements or reductions in spatial area would be needed to accommodate a different building type in the future.

S.7 Restorative Design

Intent

Go beyond guideline S.6 to further conserve existing site features during planning and construction, to promote biodiversity on the site and restore natural areas damaged by construction so the site can sustain its water, soil, and plant cover functions.

Recommended Performance Criteria

This criterion is recommended but not required by these guidelines:

- On previously developed sites: maintain or improve natural site functions and biodiversity for 75% of site area in accordance with existing conditions and surrounding site context. Determine spatially by area measurement, not including building footprint.

Resources

Websites

- www.epa.gov/owow/wetlands/restore

United States Dept. of Agriculture, Natural Resources Conservation Service, Engineering Field Handbook

Suggested Implementation

Each Phase

- Refer to Implementation for guideline S.6 (Reduce Site Disturbance and Restore Site and Restore Site) and ensure that higher performance criteria for this guideline (S.7) are also being met.

S.8 Reduce Site Water Use for Plant Materials

Intent
Limit, reduce, or eliminate potable water demand for maintaining plants and lawn areas.

Required Performance Criteria
- Use native plantings that do not require maintenance irrigation after 1 to 2 year establishment period.
- In areas where the use of native plant materials has not reduced or eliminated the need for additional maintenance irrigation, use high efficiency irrigation technology, AND/OR use captured rain or recycled site water and building gray water, to reduce potable water consumption for irrigation by 50% over conventional means.

Recommended Performance Criteria
- Recommendation for additional performance: Increase the percentage of native plantings on site, or use only captured rain or recycled building or site water for an additional 50% reduction (100% total reduction) of potable water for site irrigation needs, AND/OR, do not install permanent landscaped irrigation systems.

S.8 Reduce Site Water Use for Plant Materials

Tools

Table S-2 Irrigation Water Consumption

TYPICAL WATER CONSUMPTION FOR UNDERGROUND IRRIGATION SYSTEMS		
TYPE OF SPRINKLER		AREA 1 acre (43,560 sq. ft.)
1.	**Pop-up Spray Head - 15' spacing:** Used for small lawns, boulevards, narrow areas of grass, shrubs Average of 3.0 gallons per minute (gpm) per head	450 gpm
2.	**Pop-up mid-range Rotary Sprinkler - 40' spacing**: Used for large lawns, and similar open areas Average of 3.4 gallons per minute (gpm) per head	113 gpm
3.	**Pop-up long-range Rotary Sprinkler - 55" spacing**: Used for athletic fields, golf courses, and similar large open areas Average of 15 gallons per minute (gpm) per head	450 gpm

Suggested Implementation

Predesign-Site Selection
- Evaluate the site for existing natural features available for capturing water for re-use, and abundant stands of native plants adapted to harsh conditions and low water.

Schematic Design
- Determine spatial areas needed for plants to perform their functions of protecting the soil from erosion, aerating the soil, and reducing the heat island effect.

Design Development

- Select native plant communities, based on the site's elevation gradient.

Construction Documents

- Select individual plants within each plant community determined by their ability to perform a specific function in protecting and enhancing the site's soil and water resources.

Construction Administration

- Make bidders aware of specific requirements for planting in a sustainable manner using a plant community development model.

Construction

- Install native plants that occupy the low, medium, and high strata in each plant community to more effectively capture rainwater, overland stormwater runoff, and water from streams and water courses.
- Perform first and second year maintenance program to ensure establishment of plant communities which will enable them to continue with projected, minimal or no added water or chemical use.

Ongoing Occupancy

- Maintain the native stands of plants needed to protect the soil and water on the site. Naturalized or adapted species may be introduced in small numbers on non-critical portions of the site.
- Install native stands of plants in an informal manner to assure the most building flexibility and plant sustainability for the next site use.

Next Use

- New building and addition planning should take advantage of mature plant material on the site with its ability to structure the site, in terms of micro-climate enhancement, and screening and view-shed potential.

S.9 Reduce Light Pollution

Intent

Eliminate light trespass from the site, improve night sky access, and reduce development impact on nocturnal environments.
Reduce contribution of site lighting to overall electrical use through appropriate selection of type, sizing and operation of fixtures.

Required Performance Criteria

- Do not exceed Illuminating Engineering Society of North America (IESNA) footcandle level requirements as stated in the Recommended Practice Manual: Lighting for Exterior Environments.
- Reduce electrical use for site lighting to assist in achieving overall building energy use reduction of 30% beyond code requirements.

Recommended Performance Criteria

- Use lamps with broader color spectrum which appear closer to daylight color temperatures in areas of safety/security (i.e. main walking routes through large parking lots, isolated areas), at building entrances, and locations where identification of objects or individuals is essential

Tools
Illuminating Engineering Society of North America (IESNA) Recommended Practice Manual for lighting in exterior environments.

Table S-3 Light Trespass Limitations		
Environmental	**Description**	**Recommended Maximum Illuminance Levels [fc]**
E1: Intrinsically Dark	Parks and residential areas where controlling light pollution is a high priority	0.1
E2: Low Ambient Brightness	Outer urban and rural residential areas	0.1
E3: Medium Ambient Brightness	Urban residential areas	0.2
E4: High Ambient Brightness	Urban areas having both residential and commercial use and experiencing high levels of nighttime activity	.6

Note: This Table was adapted from IESNA RP-33-99, using "post curfew" recommendations for all values to ensure that light trespass is minimized for each environmental zone. In situations where the property line is very close to the area of development (commonly referred to as "zero property line"), and where lighting is required for emergency egress purposes, it may not be possible to meet these recommendations. Carefully explain and document these conditions.

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A).

Resources
Websites
- www.darksky.org

Suggested Implementation

Predesign-Site Selection
- Avoid sites where adjacent uses or occupancies create negative environmental, community, or human impacts which cannot be mitigated by project site or building design.

Schematic Design
- Determine landscape areas that need maximum, medium, and minimum levels of coverage based safety, security, and environmental concerns. Take into consideration existing nighttime ambient lighting levels.

Design Development
- Develop coverage patterns of lighting and height of light poles in scale with adjacent buildings, natural areas, and pedestrian zones to reduce glare, increase wayfinding, and minimize light trespass at site periphery.

Construction Documents

- Develop site lighting to address the following:
  - Add cut-off fixtures to put light only where needed.
  - Use lamps with appropriate color rendition for adjacent surroundings.
  - Use correct luminaire style to provide subdued or enhanced light patterns for safety in areas with transitioning light levels.

Construction Administration

- Monitor submittals for compliance with plans and details.
- Make bidders aware that plans are diagrammatic; adjustments will need to be made when installing lighting in wooded areas.

Construction

- Install site lighting upright and plumb, with correct fixtures and attachments.
- Test lighting for correct coverage pattern and color rendition.

Ongoing Occupancy

- Monitor and maintain vegetation around lighting to keep it from obscuring light coverage pattern.
- Clean/replace light lenses at regular intervals.

Next Use

- Study existing site lighting to see if the light poles could be re-used for future projects based on their height, style of pole, lamp rendition, and luminaire type.

S.10 Reduce Heat Island Effect

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Recommended Performance Criteria

This criterion is recommended but not required by these guidelines.

- Construct a minimum of 30% of non-roof impervious surface with high-albedo materials, OR
- Construct open-grid pavement system (less than 50% impervious) for a minimum of 50% of the parking lot area., OR
- Construct a minimum of 30% of non-roof impervious surface to be shaded within 5 years, OR
- Place a minimum of 50% of parking spaces underground or in a structured parking facility which reduces overall impervious surface coverage by 50%.
- Use ENERGY STAR Roof-compliant, high-reflectance AND high emissivity roofing (initial reflectance of at least 0.65 and three-year-aged reflectance of at least 0.5 when tested in accordance with ASTM #903 and emissivity of at least 0.9 when tested in accordance with ASTM 408) for a minimum of 75% of the roof surface; OR, install a "green" (vegetated) roof for at least 50% of the roof area.

Tools

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A).

Resources

Websites

- Public Technology, Inc., U.S. Green Building Council, U.S. DOE, U.S EPA. Sustainable Building Technical Manual, Part 3, Chapters 5, 6,7 and 8. Available from www.usgbc.org.

Suggested Implementation

Predesign-Site Selection

- Consider sites where existing vegetation or site features provide shading that can be integrated into future uses.
- Evaluate effects of maturing plantings or changing adjacent uses and construction on future heat island effects.
- Consider sharing parking facilities, constructing parking structures to minimize parking footprint, or placing parking underground.

Schematic Design

- Determine landscape features and orientation to provide shade for impervious surfaces.
- Consider replacing impervious surfaces (i.e. roofs, sidewalks, roads, driving lanes, etc.) with open grid paving or high albedo materials to reduce overall heat absorption.
- Consider replacing roofing surfaces with high albedo materials or vegetated surfaces. (This strategy may also contribute to storm water mananagement considerations.)

Design Development

- Develop site plan to minimize surface areas contributing to heat island effect.

Construction Documents

- Develop site lighting to address the following:
    - Reduce low-albedo areas (pavements, roof, sidewalks, etc.)
    - Use high-albedo surfaces (pavements, sidewalks, roof membranes or systems, etc.) to reduce heat accumulation.

Construction Administration

- Monitor submittals for compliance with plans and details.

Construction

- Install site or plant features to provide shade as designed.

Ongoing Occupancy

- Monitor and maintain vegetation around site to preserve its beneficial effects and mitigate negative developments.

Next Use

- Study existing site shading to see if its effects continue, where additional plantings may increase benefits, or where maintenance is required to preserve benefits.

S.11 Encourage Efficient Transportation Alternatives

Intent
Reduce negative land development and pollution impacts caused by transportation requirements. To reduce dependence on the automobile, reduce the amount of pavement impacting natural systems, and to allow for more ecologically responsive approaches to the site.

Recommended Performance Criteria
This criterion is recommended but not required by these guidelines.
- Locate the building within 1/4 mile of one or more bus lines or a light rail/bus station, and within 1/4 mile of retail and public services.
- Provide suitable means and mix for securing bicycles, with convenient changing/shower facilities for use by cyclists, for 5% or more of building occupants or according to local bicycle parking guidelines or zoning requirements, whichever is more stringent.
- Install alternative-fuel refueling station(s) for 3% of the total vehicle parking capacity of the site.
- Size parking capacity not to exceed minimum local zoning requirements; encourage shared parking with adjacent uses, add no new parking for rehabilitation projects; and provide preferred parking for hybrid vehicle owners, carpools or van pools capable of serving 5% of the building occupants.
- Locate preferred parking, bicycle parking, pick-up areas, and covered waiting spaces within close proximity of the main building entrances, with markings clearly designating these areas.

Tools
For more information on Light Rail Transit see Metropolitan Council. www.metrocouncil.org/planning/lrt-index.htm.

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources
Websites
- www.sprawlwatch.org
- www.metrocouncil.org/resources

Calthorpe, Peter. The Next American Metropolis. Princeton Architectural Press, 1993.

Suggested Implementation

Agency Planning
- Perform a transportation survey of future building occupants to identify transportation needs. Study feasibility of carpool/van pool programs.
- Determine number of vehicle trips per square foot of building and equate that to amount of CO_2 produced or 'reduced' over a one year life cycle by providing alternative transportation methods and monitoring their use.

Predesign-Programming
- Include transportation amenities such as bicycle racks and showering/changing facilities, alternative fuel refueling stations in the building and site program.

Predesign-Site Selection

- Seek location accessible to two or more bus lines or a light rail station, and within walking distance of retail and public services. Also consider sites that offer the possibility of sharing transportation facilities such as parking lots and refueling stations with neighboring developments.

Schematic Design

- Size parking capacity not to exceed minimum local zoning requirements. Add no new parking for rehabilitation projects.
- Provide preferred parking for carpools or van pools, or hybrid vehicles. Design to encourage use by occupants with clearly marked carpool parking, pick-up areas, and covered waiting spaces within close proximity of the building entrance.

Design Development

- Design means for securing bicycles, with convenient changing/shower facilities for use by cyclists.
- Liquid or gaseous fueling facilities must be separately ventilated or located outdoors.
- Enhance the design hybrid/carpool/vanpool parking to encourage its use by occupants.

Construction Documents

- Develop specifications and drawings to support decisions related to products and construction techniques for use by bicyclists, pedestrians, and mass transit/carpool members.

Next Use

- Evaluate if existing transportation alternatives support next use. Maintain and improve them where possible (including connections to new trailways or transportation opportunities.)

S.12 Building Water Efficiency

Intent

Minimize potable water use in buildings to conserve water resources and minimize water and wastewater treatment infrastructure cost.

Required Performance Criteria

- Reduce water use in building by 30% compared to code (1992 Energy Policy Act requirements.)

Tools

TABLE S-4 Fixture/Flow

FIXTURE	**ENERGY POLICY ACT OF 1992 FLOW REQUIREMENT**
Water Closets (GPF)	1.6
Urinals (GPF)	1.0
Showerheads (GPM)*	2.5
Faucets (GPF)*	2.5
Replacement Aerators (GPM)*	2.5
Metering Faucets (gal/CY)	0.25
*At flowing water pressure of 80 pounds per square inch (psi)	

Table S-5 Flush Fixtures

FLUSH FIXTURE TYPE	WATER USE (GPF)
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

Table S-6 Flow Fixtures

FLOW FIXTURE TYPE	WATER USE (GPM)
Conventional Lavatory	2.5
Low-Flow Lavatory	1.8
Kitchen Sink	2.5
Low-Flow Kitchen Sink	1.8
Shower	2.5
Low-Flow Shower	1.8
Janitor Sink	2.5
Hand Wash Fountain	0.5

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Use Water Calculator (Appendix S-1) to calculate building water use for base and design.

Suggested Implementation

Agency Planning

- Develop a water efficiency improvement goal of at least30% compared to code which is the required minimum.

Predesign-Programming

- Adapt the water efficiency goal and document it in the program

Schematic Design

- Communicate the water efficiency goal to all design team members. The goal shall also be documented in the schematic design submittals.

Design Development

- Document the water efficiency goal in the design development submittal.
- Provide annual water use calculations showing the reduction in water use compared to code. Use the total daily water requirements (Section 4715.3600) from the Minnesota Plumbing Code and the Energy Policy Act of 1992 for the basis of the calculations.*

Construction Documents

- Clearly indicate the water efficiency goal in the construction documents.
- Confirm or revise calculations from Design Development
- Specify appropriate fixtures.

Construction Administration

- Review shop drawings and verify compliance with specification
- Confirm installation on site

Ongoing Occupancy

- Repair or replace plumbing fixtures with same or better water use performance

Options to consider to achieve building water efficiency:

- Use infrared faucet sensors and delayed action shut-off or automatic mechanical shut-off valves.
- Use low-flow or ultra low-flow toilets.
- Use lavatory faucets with flow restrictors for a maximum rate of .5 GPM, or use metering faucets at 0.25 gallons per cycle.
- Use low-flow kitchen faucets at 1.8 GPM.
- Use low-flow showerheads.
- Use domestic dishwashers that use 10 gallons a cycle or less. Use commercial dishwashers (conveyor) which use 120 gallons per hour.
- Use waterless urinals.

S.13 Use Graywater to Reduce Wastewater Treatment Impacts

Intent

Reduce use of potable water for wastewater systems and decrease the amount of graywater exiting the site.

Recommended Performance Criteria

This criterion is recommended, but not required by these guidelines.

- Use graywater systems to reduce the use of potable water for wastewater on the site and/or within the building and decrease the amount of graywater exiting the site.[3] No specific limits or required reduced amounts are set, because each project's requirements will be site specific, based on soil quality, current runoff volumes, local ordinances, and projected use.

Tools

Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat, Environmental Protection Agency. www.epa.gov/owow/wetlands/construc/intro.html

[3] Use graywater for non-potable water uses such as irrigation, toilets, vehicle washing, sewage transport, HVAC/process make-up water, etc. Technologies include, but are not limited to constructed wetlands, basins, cisterns, and ponds; a mechanical re-circulating sand filter; and graywater reclamation and plumbing systems.

Suggested Implementation

Agency Planning

- Seek direction from Local Governing Unit (LGU) or authority having jurisdiction on which water utility districts in the local community are stressed and will be impacted by this development.
- Engage the water authority about alternative proposals of graywater treatment, in order to streamline the approval process.

Predesign-Programming

- Determine whether graywater systems are appropriate based on program and activities within the building and on the site. If so, develop goals and objectives for graywater reclamation and use.
- Develop specific programming criteria and standards for graywater systems.

Predesign-Site Selection

- Evaluate the site to determine if there are opportunities to collect rainwater for non-potable use on the site or within the building.
- In areas not served by a public waste treatment facility, select a site that can accommodate approved graywater collection.

Schematic Design

- Evaluate the site and building for opportunities for graywater reclamation (from exterior catchment areas, sinks, showers, etc.) and identify potential non-potable water uses (i.e. irrigation, toilets, etc.)
- Evaluate availability of potential storage areas on the site (basins, cisterns, ponds, etc..) Research and analyze systems early in the design process to ensure successful and effective design solutions.
- Evaluate requirements for permits and/or variances.
- Develop appropriate design strategies and select appropriate systems based on program, occupants, and site.
- Develop strategies that integrate ecologically appropriate toilets and related systems.

Design Development

- Select and design appropriate graywater system based on site and building determinants.

Construction Documents

- Specify type of system, or multiple systems, selected for the site and building. Specify the type of storage area that is most applicable for the project.

Correction Period

- Educate occupants and operations staff about graywater systems.
- Perform appropriate testing.

Next Use

- Determine whether existing systems are appropriate for next use.

S.14 Use Biological Wastewater Treatment System

Intent
Reduce wastewater and use of potable water for wastewater systems.

Recommended Performance Criteria
This criterion is recommended, but not required by these guidelines.

- Use a biological waste treatment system to reduce the volume of blackwater entering the municipal system and use of potable water.[4] No specific limits or required reduced amounts are set, because each project's requirements will be site specific, based on soil quality, current runoff volumes, local ordinances, and projected use.

Tools
Supply information required for evaluation of impacts (environmental, economic, human, and community) in Outcome Documentation Report Form (Form S-A)

Resources
Web sites

- www.waterrecycling.com/biblio
- www.attra.ncat.org

1988 United States Environmental Protection Agency Design Manual - Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment

Suggested Implementation

Agency Planning
- Seek direction from Local Governing Unit (LGU) or authority having jurisdiction on which water utility districts in the local community are stressed and will be impacted by this development.
- Engage the water authority about alternative proposals of graywater treatment, in order to streamline the approval process.

Predesign-Programming
- Determine whether gray water or biological wastewater treatment systems are appropriate based on program and activities within the building and on the site. If so, develop goals and objectives for gray water reclamation or biological treatment.
- Develop specific programming criteria and standards for biological waste treatment.

Predesign-Site Selection
- In areas not served by a public waste treatment facility, select a site that can accommodate approved exterior biological waste treatment systems such as peat moss, drain fields, treatment wetlands, etc.

Schematic Design
- Evaluate availability of potential storage areas on the site (ponds, etc..) Research and analyze systems early in the design process to ensure successful and effective design solutions.
- Evaluate requirements for permits and/or variances.

[4] Alternatives include peat moss drain fields, constructed wetlands, aerobic treatment systems, solar aquatic waste systems (or living machines), and composting or ecologically-based toilets, etc.

- Develop appropriate design strategies and select appropriate systems based on program, occupants, and site.
  - Consider alternative waste treatment system options such as peat moss drain field, constructed wetlands, consolidated systems, and composting (or ecologically appropriate) toilets instead of treating waste at municipal treatment plant.
  - Develop strategies that integrate ecologically appropriate toilets and related systems.
- If considering constructed wetland systems, (which use microbes and plants to break down waste,) identify design requirements based on users, capacity, pollutants to be removed from water, area and detention time necessary for thorough treatment, vegetation and aquatic life survival requirements, and aesthetics. Two constructed wetland options are: 1) Surface-flow wetlands, or waste water lagoons, which consist of a tiered system of ponds filled with wetland plants to remove the waste, and 2) Subsurface-flow wetlands, which use a gravel medium to anchor plants instead of soil.
- If considering composting toilets, (which use heat and fresh air to turn human waste into a light, dry, odorless humus,) determine whether self-contained units or central systems will be used.

Design Development

- Where biological wastewater treatment systems are under consideration, evaluate savings incurred from minimized amount of piping required because of reduced volume of wastewater.
- Select and design appropriate treatment system based on site and building determinants.

Construction Documents

- Specify type of system, or multiple systems, selected for the site and building. Specify the type of storage area that is most applicable for the project.

Correction Period

- Educate occupants and operations staff about biological wastewater treatment strategies and systems.
- Perform appropriate testing.

Next Use

- Determine whether existing systems are appropriate for next use.

S.15 Outcome Documentation for Site and Water

Intent

Document information that supports an understanding of the economic, human, community and environmental outcomes related to site and water issues for the project.

Recommended Performance Criteria

See Form S-A.

- Compile information as required on Form S-A Outcome Documentation Form. Provide calculations indicated. Attach additional documentation, including plant lists, drawings, and related items required to support claims for compliance with guidelines.

Tools

Complete Form S-A.
See Form S-B and Appendices S-1 and S-2.

Suggested Implementation

Agency Planning

- Select building and site baseline model parameters (e.g.: type, size, use) which provide the benchmark against which project choices will be compared and evaluated for performance.

Schematic Design

- Document local examples of site infrastructure approaches for the comparison between green infrastructure and constructed infrastructure.
- Collect data from respective Site and Water guidelines and input into the Project Data Model that is being constructed to document project decisions.

Design Development through Correction Period

- Update data from respective Site and Water guidelines and continue to document annually. This information may also be used in Facility Performance Evaluations/ Post Occupancy Evaluations (FPEs/POEs .)

FORM S-A: SITE AND WATER — OUTCOME DOCUMENTATION
For work through phase: ________________________ as of the date: __________________________

LAND

- Type of site (check all that apply):
  Greenfield ______ Brownfield ______ Urban infill ______ Other ______
- Size of site (acres) ______________
- Brownfield restored (acres) ______________
- Wetland (% of site):
  Mitigated ______ Preserved ______ Restored ______ Created ______
- Site density (building floor area/site area):
  Before development ______ After development ______
- Building footprint (square feet):
  Before development ______ After development ______ Area of green roof ______
- Flora/fauna (% of site):
  Before development ______ After development ______
  (Attach list of plants installed with representative coverage on site and establishment and maintenance plan)

WATER

- Did community build new sewer/utility infrastructure for this project? _____ Cost ______________
- Were erosion/sedimentation control plans developed for construction? _____ For occupancy? _____
- Potable water used (gallons per year):
  Baseline (meets code) __________ Project design __________
- Water discharged to sanitary sewer (gallons per year): __________
- Water (gray) discharged to storage or site (gallons per year):
  For reuse within the building __________ For irrigation __________
- On site water recharge: Rate before ________ Rate after ________
  Quantity before ________ Quantity after ________
- Stormwater runoff: Rate before ________ Rate after ________
  Quantity before ________ Quantity after ________
- Water quality: Total phosphorous before ________ Total phosphorous after ________
- Surface areas: Pervious surface before ________ Pervious surface after ________
  Impervious surface before ________ Impervious surface after ________

TRANSPORATION

- Did community build or change roads for this project? _____ Cost ______________
- What is the distance to the nearest bus line? ________
- What is the distance to the nearest mass transit line? ________
- Are showers and bike racks provided? ________ Location/number ______________
- Is preferred parking provided for car pools? ________ What types? _____________
- Are alternative fueling stations provided? ________ What types? _____________
- Parking provided on site: Before ________ After ________

SITE LIGHTING

- Amount of light leaving the site at night: Baseline ________ Design ________
- Amount of lumens and energy used for site lighting: Baseline ________ Design ________

SITE COSTS

- Total site costs ________ Total infrastructure costs ________

FORM S-B SITE WATER EFFICIENCY WATER CALCULATIONS

FORM S-B: BUILDING AND SITE WATER – S.8, S.13, S.14 -WATER EFFICIENCY FORM

For work through phase: ________________________________ As of date: ____________________

Public Agency					Project No.		
Guideline Manager					Date		
Project Engineer					Building		
Project Description							

WATER SAVINGS - SUMMARY

	GALLONS OF WATER						
	Base		Low Flow		Savings	%	
From Building Water System							
From Irrigation System							
From Graywater Storage							
Other							
OVERALL (Include Building water and Site water use)							

APPENDIX S-1 - BUILDING WATER CALCULATOR

FIXTURES: Water Use Calculator

BASE FIXTURES

	Flow Rate (GPM)	Uses per day	Minutes per use	No. occupants/ persons	Gallons per day	Person-days per year	Gallons per year
Flow Fixtures - Based on occupants							
Lavatory Faucet	2.2	4	0.25	44	96.8	240	23,232
Shower	2.5	0.65	5	1	8.125	240	1,950
Other					0		0
Other					0		0

	Flow Rate (GPM)	Uses per day	Minutes per use	No. Fixtures	Gallons per day	Days per year	Gallons per year
Flow Fixtures - Based on use per day							
Kitchen Faucet	2.2	35	0.25	1	19.25	240	4,620
Laboratory Faucet	2.2			0	0	240	0
Other					0		0
Other					0		0
Total - Flow Fixtures							29,802

	Flow Rate (GPF)	Times per day		No. occupants/ persons	Gallons per day	Person-days per year	Gallons per year
Flush Fixtures - By gender							
Water Closet - Female	1.6	4		11	70.4	240	16,896
Water Closet - Male	1.6	1		33	52.8	240	12,672
Urinal - Male	1.0	3		33	99	240	23,760
Other							
Other							
Total - Flush Fixtures							53,328

BUILDING WATER CALCULATOR – PAGE 2

	Water Use Gallons	Times per day	No. Days used per year	Gallons per year
Other equipment *				
Dishwasher	15	0.2	200	600
Clothes Washer	30	0.0	150	0
Other				0
Other				0
Total - Other equipment				600
Grand Total - BASE				**83,730**

* No current regulation identified for commercial equipment; Use local codes if applicable.

FIXTURES: Water Use Calculator

LOW-FLOW FIXTURES

	Flow Rate (GPM)	Uses per day	Minutes per use	No. occupants/ persons	Gallons per day	Person-days per year	Gallons per year
Flow Fixtures - Based on occupants							
Lavatory Faucet	0.5	4	0.25	44	22	240	5,280
Shower	2.0	0.65	5	1	6.5	240	1,560
Other					0		0
Other					0		0
Flow Fixtures - Based on use per day							
Kitchen Faucet	1.8	35	0.25	0	0	240	0
Laboratory Faucet	1.8			0	0	240	0
Other					0		0
Other					0		0
Total - Flow Fixtures							6,840

BUILDING WATER CALCULATOR – PAGE 3

	Flow Rate (GPF)	Times per day	No. occupants/ persons	Gallons per day	Person-days per year	Gallons per year
Flush Fixtures						
Water Closet - Female	1.6	4	11	70.4	240	16,896
Water Closet - Male	1.6	1	33	52.8	240	12,672
Urinal - Male	0.7	3	33	69.3	240	16,632
Other						
Other						
Total - Flush Fixtures						46,200

	Water Use Gallons	Times per day	No. Days used per year	Gallons per year
Other equipment *				
Dishwasher	9	0.2	200	360
Clothes Washer	15	0.0	150	0
Other				0
Other				0
Total - Other equipment				360
Grand Total - LOW FLOW				**53,400**

NOTES:

1. Water calculator only includes flow and flush fixtures covered by Energy Policy Act of 1992 and dishwashers and clothes washers.

2. Water coolers, water fountains, and other beverage service using water is not included in the water reduction calculation.

3. 240 work days in a year: 52 weeks minus 10 holidays and 2 weeks vacation used in the example calculation for an office. Use an appropriate number of days for your facility.

4. Areas in gray do not change for your calculations for both base and low-flow fixtures.

5. Areas in blue are calculated from input and fixed values.

INSTRUCTIONS

BASE FIXTURES - Baseline calculation

Flow Fixtures - Based on occupants

1. Flow rate (gpm) - The base values are listed and do not change for this baseline calculation
2. Since this calculation is based on the number of occupantes, uses per day is per occupant.
3. Minutes per use for hand washing can be assumed to be 15 seconds per hand washing and 5 minutes for showering.
4. No.of occupant/persons should reflect the number of full-time (8 hour day) equivalents.
5. Person-days per year for this example is for an office and is based on 50 work-weeks, 10 holidays and two weeks vacation. Schools and seasonal facilities should reflect the number of 8-hour days the facility is occupied per year.
5. Gallons per day - Is calculated by the program. Default value is zero.

6. Gallons per year - Is calculated as gallons per day x days per year. Values are added to other water uses for the calculation of overall water use reduction.

7. Other - Used for additional fixture types.

Flow Fixtures - Based on use per day

1. Flow rate (gpm) - The base values are listed and do not change for this baseline calculation
2. Since this calculation is based on use per day, estimate or survey building occupants for an accurate number of uses per day.
3. Minutes per use is estimated or from a survey of building occupants.
4. No. fixtures - The number recorded is the the total for all fixtures of the type listed.
5. Gallons per day - Is calculated by the program. Default value is zero.
6. Gallons per year - Is calculated as gallons per day x days per year. Values are added to other water uses for the calculation of overall water use reduction.
7. Other - Used for additional fixture types.

Flush Fixtures

1. Flow rate (gpm) - The base values are listed and do not change for this baseline calculation
2. Times per day - Baseline value is set for this calculation and does not change.
3. No.of occupant/persons should reflect the number of full-time (8 hour day) equivalents.
4. Gallons per day - Is calculated by the program. Default value is zero.
5. Person-days per year is the same number used for Flow Fixtures - based on occupants.
6. Gallons per year - Is calculated as gallons per day x days per year. Values are added to other water uses for the calculation of overall water use reduction.

7. Other - Used for additional fixture types.

Other Equipment

1. Water Use - Enter a value for a standard machine that you are already using.
2. Times per day - Estimate or survey building occupants.
3. No. Days used per year - Estimate or survey building occupants.
4. Other - Used for additional fixture types.

LOW-FLOW FIXTURES - Design calculation

All fixture types

1. All the values, except flow rate/water use, in the Base Fixture case must be used in the Design case.
2. For each type of fixture, select an alternate with a lower flow rate, flush rate, or water use per task.
3. The Base case can be reused for each set of fixtures chosen for the design. The water use reduction will be calculated for each change made to the Low-Flow, Design case.

APPENDIX S-2 - SITE WATER INFILTRATION CALCULATOR

Table of Runoff Coefficients for Site Conditions			
Surface Type	**Runoff Coefficient**	**Surface Type**	**Runoff Coefficient**
Pavement, Asphalt	0.95	Turf, Flat (0 - 1% slope)	0.25
Pavement, Concrete	0.95	Turf, Average (1 - 3% slope)	0.35
Pavement, Brick	0.85	Turf, Hilly (3 - 10% slope)	0.4
Pavement, Gravel	0.75	Turf, Steep (> 10% slope)	0.45
Roofs, Conventional	0.95	Vegetation, Flat (0 - 1% slope)	0.1
Roof, Garden Roof (< 4 in)	0.5	Vegetation, Average (1 - 3% slope)	0.2
Roof, Garden Roof (4 - 8 in)	0.3	Vegetation, Hilly (3 - 10% slope)	0.25
Roof, Garden Roof (9 - 20 in)	0.2	Vegetation, Steep (> 10% slope)	0.3
Roof, Garden Roof (> 20 in)	0.1		

Instructions:

1) **Calculate projected runoff for the baseline case design for your project using information from the table above (Runoff Coefficients), or, if not in the table, from manufacturer of specific material, product or system.**
2) **Then, using information from the table above, information from manufacturer of alternative materials, products or systems, calculate projected runoff for your design case using the equations noted (1 & 2). Indicate improvements in runoff to meet requirements of Guideline S-5.**

APPENDIX S-2 - SITE WATER INFILTRATION CALCULATOR

BASE CASE IMPERVIOUSNESS CALCULATIONS

Surface Type	Runoff Coefficient	Area	Impervious Area		
				Equation 1:	
Pavement, Impervious (1)				Impervious Area [SF] = Surface Area [SF] x Runoff Coefficient	
Pavement, Impervious (2)					
Pavement, Pervious				**Equation 2;**	
Roof				Imperviousness [%] = Total Pervious Area [SF] / Total Site Area [SF]	
Vegetation (1)					
Vegetation (2)					
	TOTAL AREA	____________			
	TOTAL IMPERVIOUS AREA		____________		
IMPERVIOUSNESS [%] ______________					

DESIGN CASE IMPERVIOUSNESS CALCULATIONS

Surface Type	Runoff Coefficient	Area	Impervious Area		
				Equation 1:	
Pavement, Impervious (1)				Impervious Area [SF] = Surface Area [SF] x Runoff Coefficient	
Pavement, Impervious (2)					
Pavement, Pervious				**Equation 2;**	
Roof				Imperviousness [%] = Total Pervious Area [SF] / Total Site Area [SF]	
Vegetation (1)					
Vegetation (2)					
	TOTAL AREA	____________			
	TOTAL IMPERVIOUS AREA		____________		
IMPERVIOUSNESS [%] ______________					

Guidelines: Energy & Atmosphere

Guidelines (Required except where noted with * which indicates recommended.)

Forms

Overview

Energy consumption for building operations represents approximately one third of the total energy use in the state. This section of the MSBG provides guidance on mitigating both the cost of energy and associated ecological impacts to our state's economy. Minnesota, through its Conservation Improvement Program, already has a decade's history of successfully promoting energy conservation at the levels required by this guide. For each building, there are multiple paths to conservation. Other sections of the MSBG having requirements for indoor air quality, lighting design, daylighting and other factors pertaining to human health and comfort complement this section and collectively enable individual resolution of the conservation objective while achieving superior interior environments.

To further reduce impacts on the environment and to promote community economic development, this guide recommends the investigation of renewable and distributed forms of power generation using wind, solar and biomass technologies as well as other cleaner forms of hydrogen or hydrocarbon-based power generators. Combined Heat and Power (CHP) systems may be an appropriate solution for individual buildings or groups of State facilities.

Goal

To provide energy efficient buildings that reduce the State's expenditures on imported fuel and power and have the lowest reasonable environmental impacts resulting from energy generation and the use of refrigerants harmful to the atmosphere. A parallel goal is to support and enhance the State's building benchmarking activities for ongoing operations performance.

[1] Legislation governing this guideline requires a 30% conservation of energy relative to the Minnesota State Energy Code. Savings of greater than 30% and up to 60% are achievable for many building types with payback periods well under the allowable 15-year time frame. Agencies are encouraged to seek these savings greater than 30%.

Objectives

- Design new buildings to use 30% less energy than code [2]
- Provide building performance data for benchmarking activities
- Reduce plug loads and process energy through energy-smart purchasing practices
- Encourage the consideration of power usage from renewable energy and cleaner generation systems whether generated on-site or purchased from off-site, "green power" generated in Minnesota.
- Encourage the balanced consideration of Global Warming Potential, Ozone Depletion Potential and Atmospheric Lifetime in selecting refrigerants
- Help assure that long-term operations meet or exceed original design operating parameters

Exclusions for Energy and Atmosphere

1. Buildings less than 5,000 gross square feet in floor area
2. Buildings that are not heated

E.1 Reduce Energy Use by at Least 30%

Intent

Ensure annual energy costs are reduced by at least 30% as required by the Minnesota Legislature. A whole building, comparative analysis methodology must be used before the Construction Document phase of the design process to determine the energy conservation solution with the lowest lifetime cost.

Required Performance Criteria

- Reduce design energy costs compared to the energy cost budget by at least 30% for regulated energy components as described in the Minnesota State Energy Code in effect as of 15 January 2003. Compliance with the Performance Criteria are only valid under the following conditions:
    - Only one building geometry may be used for a given project analysis.
    - Only one set of plug and process loads may be used for a given project analysis.
    - Only one mechanical system type may be used for a given project analysis.
    - Design teams must first use the Indoor Environmental Quality section I.1 of this guide to establish base operation parameters for outside air requirements.
- For each step in the process outlined below, the design team is to provide a concise record of the significant energy related issues discussed, decisions made and action items identified.

Tools

- Daylight Factor Calculator (See Appendix I-4)
- Small Building Methodology (See Appendix E-1)

Resources

The Minnesota Office of Environmental Assistance (MOEA) web page on Financing for Energy Improvements is a resource for information on utility programs, performance contracting, the MSBA lease purchase program for schools, and more. www.moea.state.mn.us/greenbuilding/financing.cfm

The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm

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[2] Legislation allows a significant payback period of up to 15 years. However, results should be much better than that for most buildings. Payback periods less than the following figures should be readily achievable; 3 years for a building over 120,000 square feet; 4 years for a building between 80,000 to 120,000 square feet; 5 years for a building between 50,000 to 80,000 square feet; 6 years for a building between 30,000 to 50,000 square feet and; 7 years for a building less than 30,000 square feet.

The MOEA web page on Design Guidelines, Specifications and Rating Systems provides links to the Energy Star online design tools, Portfolio Manager and Target Finder. Also links to ASHRAE standards, the U.S. Department of Energy's Buildings for the 21st Century program, and the MN Commerce Department Energy Office. www.moea.state.mn.us/greenbuilding/design.cfm

Suggested Implementation

Comparative analysis is required for all buildings over 5,000 square feet that are heated. The required process is similar for all buildings but there is a different path to compliance for buildings less than 30,000 gross square feet.

Agency Planning

- Budget for building performance at 30% better than code

Predesign-Programming

- Use Daylight Program Area Tool to identify programmed spaces and areas where Daylighting is desirable and/or allowable.
- Review guidelines for building geometry and daylighting design
- Identify and review potential energy conservation strategies for your building type

Predesign-Site Selection

- Use Daylight Geometry Tool to evaluate building geometry, daylighting depth and site development implications for primary north and south exposure

Schematic Design

Buildings Over 30,000 Square Feet:

- Provide base building characteristics for an hourly energy performance simulation model based on a specific building geometry.
- Perform baseline energy simulation modeling to establish a Code Base Case that meets the minimum prerequisite standard of the Minnesota State Energy Code and the IAQ standards identified within this guideline. [3]
- Establish energy strategies to investigate in each of the following categories [4]
    - Envelope
    - Lighting Control
    - Lighting Design
    - HVAC system efficiency levels
    - Load Responsive control
    - Outside Air control

Buildings Under 30,000 Square Feet: [5]

- Calculate building envelope metrics using the Small Buildings Methodology included in this guide (Appendix E-1.)
- Evaluate building envelope and system options in the Small Buildings Methodology included in this guide.

Design Development

Buildings Over 30,000 Square Feet:

- Use the baseline energy simulation model and simulate isolated Energy Conservation Measures (ECMs) (strategies) to compare with the Code Base Case

[3] Allowable software for buildings over 30,000 GSF includes calculation tools supported by a DOE 2 engine.
[4] Variables must be sufficient to allow meaningful comparative analysis. At least three options per category must be included.
[5] The model presented here is for small office buildings. For other building types or for variations to the prescriptive bundles presented, you may use the methodology for buildings over 30,000 gross square feet or contact the Department of Commerce for other options.

- Develop, document and distribute modeling parameters for use in comparative cost estimating
- Develop incremental costs for each ECM based on the difference of the cost of constructing the ECM versus the cost of constructing the code level requirement for the strategy.
- Bundle and compare ECMs to approximate lowest life time cost
- Select a bundled ECM option to implement
- Guideline Leader submits preliminary Tier 1, 2, and 3 data on building to State Benchmarking collection team via the guideline report. (See Section P.1 for details of reporting processes.)

Buildings Under 30,000 Square Feet

- Develop net incremental cost estimates to compare bundled options to the cost of constructing the code level requirement
- Select bundled option to implement
- Comply with building envelope and system options in the Small Buildings Methodology included in this guide.
- Guideline Leader develops preliminary Tier 1, 2, and 3 data. (See Section P.1 for details of reporting processes.)

Construction Documents

- Design team includes all ECMs from the selected bundle
- Guideline Leader and Commissioning Team review construction documents at 95% completion to verify design progress against modeling assumptions and reports findings back to design team. (See Section P.1 for details of review processes.)
- Design team makes additions, deletions or corrections, if any, and bids project.

Construction

- Guideline Leader submits Tier 1, 2, and 3 data on building to State Benchmarking collection team. (See Section P.1 for details of reporting processes.)
- Review shop drawings to assure compliance with ECMs

Correction Period

- Guideline Leader for ongoing occupancy is identified; they will provide benchmarking data
- Commissioning Leader reviews execution of Measurement and Verification protocol during commissioning phase. (See Section P.1 for details of review processes.)

Ongoing Occupancy

- Guideline Leader (or possibly Utility Provider in future) sends monthly energy consumption to benchmarking collection team each year. (See Section P.1 for details of reporting processes.)

E.2 Efficient Equipment and Appliances

Intent

Reduce energy use associated with plug loads and process loads in buildings. These energy savings are in addition to those attributed to the building itself which are accounted for in guideline E.1.

Required Performance Criteria

- Select new equipment and appliances that meet Energy Star criteria.

Resources

DOE Energy Star Program: www.eren.doe.gov/buildings/energystar.html

For Energy Star Products: www.energystar.gov

The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm

Suggested Implementation

Agency Planning

- Budget for energy efficient (Energy Star) equipment and appliances

Construction Documents

- Provide drawings, cut sheets, and specifications highlighting compliance of equipment and appliances with Energy Star requirements. Document efficiency ratings of motors and drives, water service equipment, and other electrical load components.
- Include plug and process load energy savings when accounting for operational savings due to E.2 during outcome documentation.

Construction

- Review shop drawings to assure compliance with Energy Efficient equipment specifications.

E.3 Evaluate Renewable and Distributed Energy Generation

Intent

Encourage the consideration and use of renewable energy sources and cleaner forms of hydrogen and hydrocarbon-based distributed generation systems to reduce atmospheric pollution. This can provide a stimulus to the State's economy through investments in local jobs and materials while reducing the State's expenditures on imported fuel and power.

Required Performance Criteria

- There is no required amount of renewable or distributed energy generation for State buildings at this time. However, an analysis is required that includes the environmental, economic, and community impacts from supplying a percentage[6] of the building's total energy use with on-site or off-site renewable or cleaner distributed generation systems. The evaluation should assess the benefits for solar, wind, or biomass energy systems as well as micro-turbines and fuel cells, as applicable.

Resources

The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm

The Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy. www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MN

[6] Renewable and cleaner distributed generation percentages may be as little as 1% or as great as 100% depending on the outcome of the evaluation and may be achieved through the construction budget by paying for the design and installation of a renewable or cleaner distributed generation system or through the operating budget through a contract to purchase renewable or cleaner distributed generation. Calculations for the cost of the percentage of renewable and distributed generation for the project should be calculated after the requirement for 30% or greater energy conservation has been met.

Suggested Implementation

Predesign-Programming

- Use Renewable and Distributed Energy Evaluation Tool to identify the potential investment value of on-site generation or the purchase of offsite renewable energy.

Predesign-Site Selection

- Use Daylight Geometry Tool and the Renewable and Distributed Energy Evaluation Tool to evaluate building geometry and orientation for solar-based energy solutions.
- Investigate the viability and potentiality of other on-site renewable and distributed energy options.
- Investigate the proximity to nearby renewable and distributed energy generation sources and the transmission potential to your site and/or the investment potential for your project.

Schematic Design

On-site:

- Locate renewable and distributed energy installation areas on plans, elevations and sections as appropriate.
- Investigate spatial and loading impact on site, architectural, mechanical and electrical systems.
- Develop preliminary performance specifications for the selected technology(s)
- Calculate available area and refine performance/cost assumptions based on installation intentions and anticipated system efficacy at this stage of design.

Off-site:

- Locate renewable and distributed energy installation areas on plans.
- Determine availability of resource relative to project demands
- Investigate spatial and loading impact on site, architectural, mechanical and electrical systems.
- Develop preliminary purchase contract language
- Refine performance/cost assumptions based on contractual intentions and anticipated system efficacy at this stage of design.

Design Development

On-site:

- Develop dimensioned installation profiles on plans, elevations and sections.
- Refine performance specifications for the selected technology(s), identify and contact potential vendors
- Refine performance/cost assumptions based on installation profiles and anticipated system efficacy at this stage of design.
- Prepare and submit preliminary Tier 2 and 3 data to Guideline Leader on renewable and distributed energy systems for the State Benchmarking collection team. (See P.1 for details of reporting process.)

Off-site:

- Confirm availability of resource relative to project demands
- Develop design to accommodate spatial and loading impact on site, architectural, mechanical and electrical systems if any
- Develop final purchase contract language
- Refine performance/cost assumptions based on contractual intentions and anticipated system efficacy at this stage of design.
- Refine and submit preliminary Tier 2 and 3 data to Guideline Leader on renewable and distributed energy systems for the State Benchmarking collection team. (See P.1 for details of reporting process.)

Construction Documents
On-site:

- Develop dimensioned installation details and specifications for the selected technology(s) and specify potential vendors
- Refine performance/cost assumptions based on installation profiles and anticipated system efficacy at this stage of design.
- Refine and submit preliminary Tier 2 and 3 data to Guideline Leader on renewable and distributed energy systems for the State Benchmarking collection team. (See P.1 for details of reporting process.)

Off-site:

- Re-confirm availability of resource relative to project demands
- Complete design to accommodate spatial and loading impact on site, architectural, mechanical and electrical systems if any
- Refine performance/cost assumptions based on contractual intentions and anticipated system efficacy at this stage of design.
- Refine and submit preliminary Tier 2 and 3 data to Guideline Leader on renewable and distributed energy systems for the State Benchmarking collection team. (See P.1 for details of reporting process.)

Construction Administration

- Review shop drawings to assure compliance with renewable and distributed energy equipment specifications.
- Submit revised Tier 1, 2, and 3 data to Guideline Leader on building to State Benchmarking collection team. (See P.1 for details of reporting process.)

E.4 Atmospheric Protection

Intent

Encourage the investigation and evaluation of refrigerants to reduce environmental impacts harmful to the atmosphere. Energy conservation should be achieved with the lowest reasonable environmental impacts.

Recommended Performance Criteria[7]

There are no required levels for atmospheric pollution from refrigerants at this time except for CFC reduction which is required in the MN State Building Code. It is recommended that the following three criteria be met.

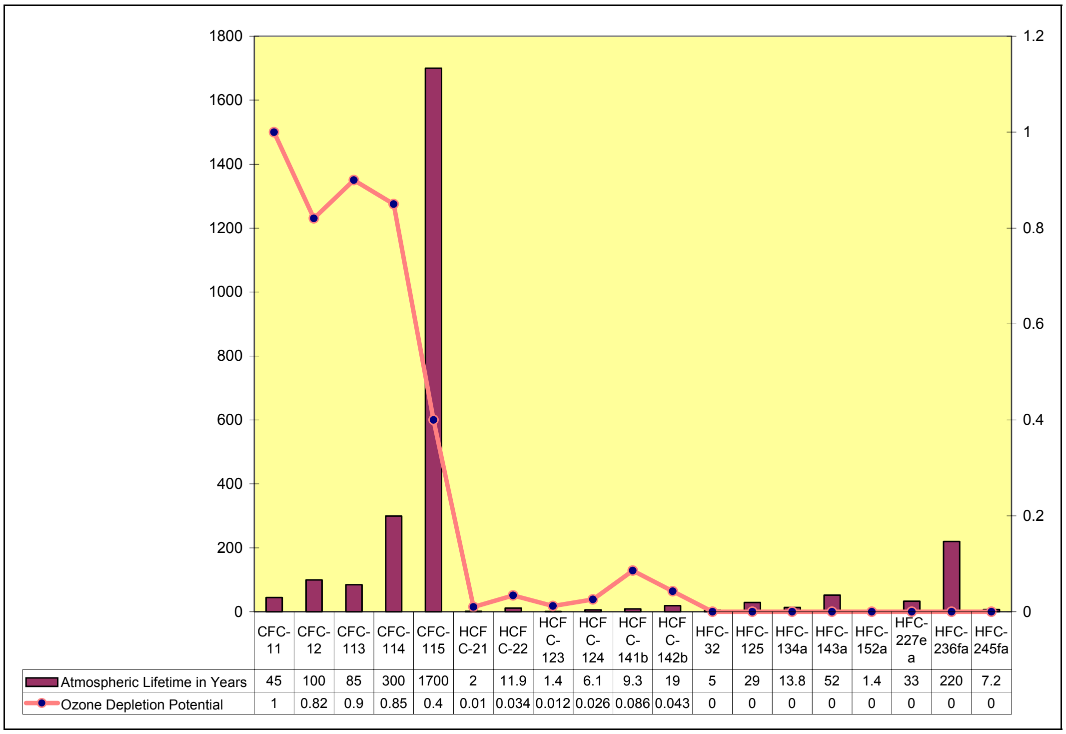
- Achieve an atmospheric Lifetime (AtL) < 33. Atmospheric Lifetime is a measure of the average persistence of the refrigerant if released. A longer lifetime has worse environmental effects.
- Achieve an Ozone Depletion Potential (ODP) < 0.034. Ozone Depletion Potential is a normalized indicator based on the ability of a refrigerant to destroy atmospheric ozone, where CFC-11 = 1.00. A higher ODP has worse environmental effects.
- Achieve a Global Warming Potential (GWP) < 3500. Global Warming Potential is an indicator of the potency of the refrigerant to warm the planet by action as a greenhouse gas. A higher GWP has worse environmental effects.

[7] CFCs generally have high Ozone Depletion Potential and Global Warming Potential with long Atmospheric Lifetimes. CFCs are therefore not allowed by these guidelines and prohibited by State law. Halons have a higher Ozone Depletion Potential though a lower Global Warming Potential but a much longer Atmospheric Lifetime. Halons should not be used if possible. HCFCs such as R-123, which other guides put in the same class as Halons, can have an Ozone Depletion Potential, a Global Warming Potential and an Atmospheric Lifetime two orders of magnitude less than CFCs and Halons. HFCs offer near zero Ozone Depletion Potential, but some have high Global Warming Potential. For example, R-134 has an Ozone Depletion Potential of 0.0 but a Global Warming Potential and an Atmospheric Lifetime approximately 10 times greater than R-123, an HCFC alternative. Substituting an HFC, which tends to be less energy efficient than an HCFC, may result in the use of more energy, resulting in a further increase in global warming.

Table E-1 Refrigerant Climate Data Meeting the Guidelines[8] [9]

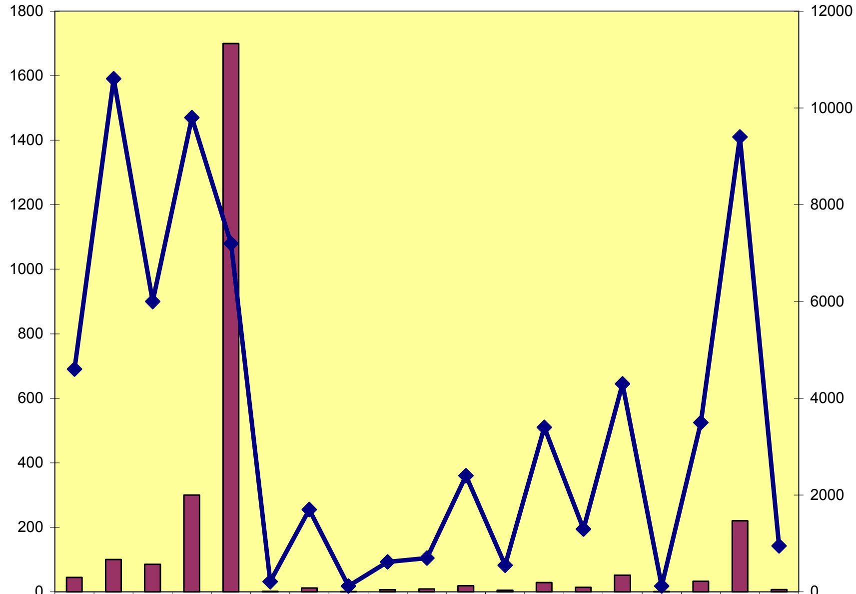
Refrigerant	Atmospheric Lifetime in Years	Ozone Depletion Potential	Global Warming Potential
HFC-152a	1.4	0	120
HCFC-123	1.4	0.012	120
HCFC-21	2	0.01	210
HFC-32	5	0	550
HCFC-124	6.1	0.026	620
HFC-245fa	7.2	0	950
HFC-134a	13.8	0	1300
HCFC-22	11.9	0.034	1700
HFC-125	29	0	3400
HFC-227ea	33	0	3500

Table E-2 Atmospheric Lifetime and Ozone Depletion Potential



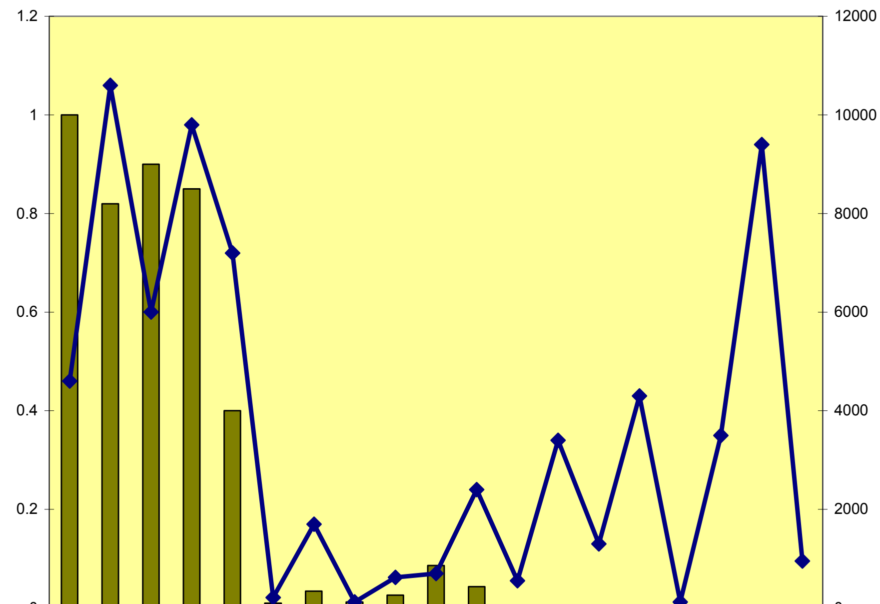
8 James M. Calm "Refrigerant Data Summary" Engineered Systems Magazine Nov 2001.
9 Additional criteria such as equipment efficiency and net environmental impact may be applied to the selection of the refrigerants to be used in a project.

Table E-3 Atmospheric Lifetime and Global Warming Potential



	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	HCFC-21	HCFC-22	HCFC-123	HCFC-124	HCFC-141b	HCFC-142b	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa
Atmospheric Lifetime in Years	45	100	85	300	1700	2	11.9	1.4	6.1	9.3	19	5	29	13.8	52	1.4	33	220	7.2
Global Warming Potential	4600	1060	6000	9800	7200	210	1700	120	620	700	2400	550	3400	1300	4300	120	3500	9400	950

Table E-4 Ozone Depletion Potential and Global Warming Potential



	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	HCFC-21	HCFC-22	HCFC-123	HCFC-124	HCFC-141b	HCFC-142b	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa
Ozone Depletion Potential	1	0.82	0.9	0.85	0.4	0.01	0.034	0.012	0.026	0.086	0.043	0	0	0	0	0	0	0	0
Global Warming Potential	4600	10600	6000	9800	7200	210	1700	120	620	700	2400	550	3400	1300	4300	120	3500	9400	950

Suggested Implementation

Predesign-Programming

- Determine on-site fire suppression requirements

Schematic Design

- Plan and organize building to minimize the need for the use of Halon fire suppression systems
- Using the tables below and other information as may be available at the time of design, identify candidate refrigerants that have a low Global Warming Potential, short Atmospheric Lifetime and a low Ozone Depletion Potential.
- Use one of the weighted evaluation metrics provided to evaluate the refrigerants.
- Prioritize the list in the order given.

Design Development

- Evaluate the economic impacts of the prioritized list
- Evaluate the community impacts of the prioritized list
- Adjust priorities pursuant to the analysis

Construction Documents

- Develop specifications based on adjusted priorities

Construction Administration

- Verify shop drawings to assure compliance

E.5 Outcome Documentation for Energy and Atmosphere

Intent

Calculate and record the community, environmental, and life-cycle economic, impacts related to energy use and generation for the building. These results are inputs for the total building outcome documentation and life cycle cost analysis.

Required Performance Criteria

- Complete E-A Outcome Documentation Form at the end of each phase to document design decisions for those portions of the guideline implemented at that time.

Table E-5 Sample Data

Economic Performance Indicators	Units	Code Baseline	Design Solution	Savings	% Savings
Annual Energy Cost	Dollars per sf				
Incremental Construction Costs	Dollars per sf				
Simple Payback					
Energy Performance Indicators	**Units**	**Code Baseline**	**Design Solution**	**Savings**	**% Savings**
Electric Consumption	kWh				
Electric Demand	kW				
Natural Gas consumption	Therms				
Purchased chiller water	Ton-hrs				
Purchased Steam	Mlbs				
Primary Energy	?				

Atmosphere Performance Indicators	Units	Code Baseline	Design Solution	Savings	% Savings
CO2 Emissions					
SOx Emissions					
NOx Emissions					
Particulate Emissions					
Others?					

FORM E-A: ENERGY AND ATMOSPHERE-OUTCOME DOCUMENTATION

For work through phase: _________________________as of the date:___________________

- Fill out tables below based on project design (atmosphere and life cycle factors will be provided):

Economic Performance Indicators	**Units**	**Code Baseline**	**Design Solution**	**Savings**	**% Savings**	**% Renewable**
Annual Energy Cost	Dollars per sf					
Incremental Construction Costs	Dollars per sf					
Simple Payback						

Energy Performance Indicators	**Units**	**Code Baseline**	**Design Solution**	**Savings**	**% Savings**	**% Renewable**
Electric Consumption	kWh					
Electric Demand	kW					
Natural Gas consumption	Therms					
Purchased chiller water	Ton-hrs					
Purchased Steam	Mlbs					
Primary Energy	?					

Atmosphere Performance Indicators	**Units**	**Code Baseline**	**Design Solution**	**Savings**	**% Savings**	
CO2 Emissions	Tons					
SOx Emissions	Tons					
NOx Emissions	Tons					
Particulate Emissions	Tons					
Others?						

Life Cycle Assessment Indicators (Athena)	**Units**	**Code Baseline**	**Design Solution**	**Savings**	**% Savings**	
Primary Energy	MJ					
Solid Waste	kg					
Air Pollution Index						
Water Pollution Index						
Global Warming Potential	kg					
Weighted Resource Use	kg					

- Describe and evaluate two scenarios using renewable and distributed energy systems. Fill out a table similar to the table in item #1 for each scenario.
- List all refrigerants used in the building mechanical equipment. For each refrigerant indicate:
  Atmospheric lifetime _____ Ozone depletion potential _____ Global warming potential _____

APPENDIX E-1 - SMALL BUILDING METHODOLOGY

Small Buildings Methodology
Prescriptive Bundle Option Method
Office Buildings less than 30,000 GSF

- This section describes energy strategy requirements for three different *Prescriptive Bundle Options* for use in meeting energy performance compliance for *office building* projects less than 30,000 gross square feet. Project designs using this approach are required to select and implement one of the three bundle options in its entirety.
- As an alternative to using the Prescriptive Bundle Option method, projects less than 30,000 gross square feet or non-office projects less than 30,000 GSF may use the comparative analysis method defined for larger buildings in Section C. Project teams may also contact the Department of Commerce for additional options.

- The Prescriptive Bundle Options represent three different objectives to meet the energy performance goals of this section. The options defined provide a range of energy strategy solutions based on building design parameters and preferences of the Design Team and Building owner. The three bundles are grouped by building system focus below:

Bundle 1 - Lighting dominates performance	**Bundle 3 – Balanced** Lighting and HVAC balance performance	**Bundle 2 – HVAC** dominates performance
Focuses implementation of Daylight, and lighting control and design high performance strategies	Focuses implementation of a balanced approach between lighting and HVAC design and control high performance strategies.	Focuses implementation of HVAC system and control high performance strategies.

- Each Prescriptive Bundle Option identifies which strategies are required and or a minimum level of strategy component performance for the following four building system sections:
  Envelope Requirements based on building envelope metrics
  Calibrated Daylight Control Requirements based on building metrics and the Prescriptive Bundle Option selected.
  Lighting Control and Design Requirements based on Prescriptive Bundle Option selected
  HVAC Control and Design based on Prescriptive Bundle Option selected.

Envelope Requirements

Intent: To reduce the thermal heating and cooling load of the building envelope.

- The Prescriptive Bundle Option Method requires the calculation of the following building envelope design metrics:

BUILDING ENVELOPE METRIC	RATIO	BUILDING COMPONENT	SQUARE FEET
Ratio of window + skylight area (ft^2) to building gross floor area (ft^2)		[1] Window and skylight area	
		[4] Gross floor area	
Ratio of above grade wall area (ft^2) to building gross floor area (ft^2)		[2] Above grade wall area	
		[4] Gross floor area	
Ratio of roof area (ft^2) to building gross floor area (ft^2)		[3] Roof area	
		[4] Gross floor area	

Note 1: Area calculated for glazed rough opening areas for all windows and skylights

Note 2: Area calculated for all gross wall surfaces above grade including window and door area, excluding parapets

Note 3: Area calculated for all gross roof surface area including rough opening skylight areas

Note 4: Area calculated from the outside of exterior perimeter walls for all conditioned spaces

- Design the building envelope to meet the thermal characteristics for all window, wall, and roof areas identified in the table below based on the envelope area metrics calculated:

Ratio of Window + Skylight area to Floor area	**0 to 0.10**	**0.10 to 0.20**	**Over 0.20**
Unit U-Factor[1] (btuh/sf*F°)	< 0.46	< 0.42	< 0.38
Solar Heat Gain Coefficient[2] (dimensionless)	< 0.56	< 0.38	< 0.30
Visible Light Transmittance[3] (dimensionless)	> 0.45	> 0.45	> 0.40
Ratio of above grade Wall area to floor area	**0 to 0.25**	**0.25 to 0.50**	**Over 0.50**
Wall Insulation R-Value[4] (btuh/sf*F°)	> R-11	> R-14	> R-18
Ratio of Gross Roof area to Roof area	**0 to 0.45**	**0.45 to 0.65**	**Over 0.65**
Roof Insulation R-Value (btuh/sf*F°)	> R-26	> R-30	> R-32

[1] **Unit U-factor** is the U-factor of the glass and frame assembly together. The unit U-factor of the glass and frame assembly is typically higher than the center-of-glass U-factor only. Lower U-factors reduce heat loss.

[2] **Solar Heat Gain Coefficien**t is the ratio of the amount of solar radiation transmitted through the glass compared to the amount of exterior radiation incident on the glazings exterior surface. Lower SHGC values reduce cooling loads.

[3] **Visible light transmittance** is the ratio of the amount of light radiation transmitted through the glass compared to the amount of light striking the glazing's exterior surface. Higher values provide more daylight.

[4] **Wall and Roof insulation R-values** include the entire opaque wall and roof envelope construction assembly including air films.

Daylight Control Requirements

Intent: To reduce the electric lighting energy consumption within areas of the building design where daylight can provide a substantial amount of the required illumination during the day.

- For the building design calculate the Total Ratio of Daylight floor area to building gross floor area.

Space type Daylight floor area	**Square feet**
Open Office Daylight floor area (ft^2)	
Private Office Daylight floor area (ft^2)	
Lobby/Circulation Daylight floor area (ft^2)	
Sum of Total Daylight floor area (ft^2) above	
Gross Building Floor Area (ft^2)	
Ratio of Total Daylight floor area (ft^2) to building gross floor area (ft^2)	

- Calculation method to determine Daylight floor area by space type

ace Type Area	pth of zone	ngth of zone
en Office Daylight floor area (ft^2):	indow head height from floor in ft.) x (**2.0**)	ace length (ft) where the window area equals more than **20%** of the zone depth per linear foot of wall
vate Office Daylight floor area (ft^2)	indow head height from floor in ft.) x (**1.8**)	ace length (ft) where the window area equals more than **15%** of the zone depth per linear foot of wall
bby/Circulation Daylight floor area (ft^2)	indow head height from floor in ft.) x (**1.5**)	ace length (ft) where the window area equals more than **15%** of the zone depth per linear foot of wall

- Design the building lighting system to meet the bundle option selected for the building design.

Calibrated Daylight Controls	**Bundle 1 Lighting**	**Bundle 2 Balanced**	**Bundle 3 HVAC**
Total Ratio of Daylight floor area (ft^2) to building gross floor area (ft^2)	**> 0.50**	**> 0.35**	**> 0.20**
Calibrated Stepped Daylight controls in all Daylight floor areas for, Lobby / Vestibule / Circulation areas. Requirements: Use interior or exterior photo sensors or astronomical time-clock to control electric light relay for ½ of all lamps in each daylight zone.	Yes	Yes	Yes
Continuous Dimming Daylight Control in all Daylight floor areas for Perimeter Open office areas. Requirements: Use dimming ballasts with interior photo sensor for each Open office space.	Yes	Yes	Yes
Strategic Switching controls in all Daylight areas for Perimeter Private office areas. Requirements: Use two manual wall switches per private office space. o. One switch located by the door to control ½ the lamps in each fixture of the room, The second switch is located away from the door and controls the other lamps within the fixture.	Yes	Yes	Yes

Electric Lighting and Control Strategies

Intent: To reduce the electric lighting load within the building utilizing lighting design and lighting control strategies that reduce consumption.

- Design the building lighting system to meet the bundle option selected for the building design.

LIGHTING CONTROL REQUIREMENTS BY SPACE TYPE	BUNDLE 1 LIGHTING	BUNDLE 2 BALANCED	BUNDLE 3 HVAC
Open Office	OS	N/R	N/R
Private Office	OS	OS	OS
Conference Rooms	OS	OS	OS
Circulation	OS	N/R	N/R
Toilets	OS	OS	OS
Storage Rooms	OS	OS	N/R

Notes:
OS: Occupancy sensor control
N/R: No occupancy sensor controls required

LIGHTING DESIGN MINIMUM POWER DENSITY BY SPACE TYPE	BUNDLE 1 LIGHTING	BUNDLE 2 BALANCED	BUNDLE 3 HVAC
Open Office connected (W/ft^2)	< 0.90	< 1.10	< 1.25
Private Office connected (W/ft^2)	< 1.10	< 1.30	< 1.50
Conference Rooms connected (W/ft^2)	< 1.35	< 1.55	< 1.75
Circulation connected (W/ft^2).	< 0.65	< 0.75	< 0.80
Toilets connected (W/ft^2)	< 0.65	< 0.75	< 0.80
Storage rooms connected (W/ft^2)	< 0.65	< 0.75	< 0.80
Mechanical Rooms connected (W/ft^2)	< 0.65	< 0.75	< 0.80

Notes:
Lighting design power densities to be increased by area factor calculation in Minnesota Energy Code.

HVAC Requirements

Intent: To reduce heating, cooling, fan, and pump energy consumption and peak electric demand within the building utilizing equipment efficiency and operation control strategies that reduce consumption.

Cooling System Efficiency Requirements	BUNDLE 1 LIGHTING	BUNDLE 2 BALANCED	BUNDLE 3 HVAC
Air Cooled Equipment			
Single Package <65,000 Btu/h, SEER	> 10.2	> 10.7	> 11.2
Split System <65,000 Btu/h, SEER	> 10.5	> 11.0	> 11.5
Split System & Single Package >65,000 and < 135,000 Btu/h, EER	> 9.3	> 9.8	> 10.3
Condensing Units > 135,000 Btu/h, EER	> 10.4	> 10.9	> 11.4
Chiller greater than or equal to 150 tons KW/ton	< 1.34	< 1.27	< 1.20
Chiller less than 150 tons KW/ton	< 1.23	< 1.17	< 1.11
Water Source Equipment			
Water Source Heat Pumps < 65,000 Btu/h, Standard Rating Indoor Air (80°F db/65° wb) and Entering Water (85°F) EER	> 9.8	> 10.2	> 10.7
Water Source Heat Pumps < 65,000 Btu/h Standard Rating Indoor Air (80°F db/67° wb) and Entering Water (75°F) EER	> 10.7	> 11.2	> 11.7
Water Source Heat Pumps > 65,000 Btu/h and < 135,000 Btu/h, Standard Rating Indoor Air (80°F db/67° wb) and Entering Water (85°F) EER	> 11.0	> 11.6	> 12.1
Water Source Heat Pumps > 65,000 Btu/h and < 135,000 Btu/h, Standard Rating Indoor Air (80°F db/67° wb) and Entering Water (75°F) EER	> 11.6	> 12.1	> 12.7
Groundwater – Cooled Heat Pumps < 135,000 Btu/h, Standard Rating Entering Water (70°F) EER	> 11.6	> 12.1	> 12.7
Groundwater – Cooled Heat Pumps < 135,000 Btu/h, Low Rating Entering Water (50°F) EER	> 12.1	> 12.7	> 13.2
Water Cooled Equipment			
Centrifugal KW/ ton (non-CFC)	< 0.69	< 0.66	< 0.62
Helical-rotary (screw) KW/ton (non-CFC)	< 0.76	< 0.72	< 0.68
Reciprocating or scroll KW/ton	< 0.88	< 0.84	< 0.79

Heating System Efficiency Requirements	**BUNDLE 1 LIGHTING**	**BUNDLE 2 BALANCED**	**BUNDLE 3 HVAC**
Gas Furnace efficiency	> 0.83	> 0.85	> 0.90
Gas Boiler efficiency	> 0.83	> 0.85	> 0.90
Water Source Heat Pumps < 135,000 Btu/h Entering Water (70°F) COP	> 4.0	> 4.2	> 4.4
Water Source Heat Pumps < 135,000 Btu/h Entering Water (75°F) COP	> 4.1	> 4.3	> 4.5
Ground Source Heat Pumps < 135,000 Btu/h High Temperature Rating Entering Water (41°F)	> 2.8	> 3.0	> 3.1
Ground Source Heat Pumps < 135,000 Btu/h Low Temperature Rating Entering Water (32°F)	> 2.6	> 2.8	> 2.9
Load Responsive Control Requirements	**BUNDLE 1 LIGHTING**	**BUNDLE 2 BALANCED**	**BUNDLE 3 HVAC**
VFD's on VAV supply and return fan motors	YES	YES	YES
VFD's on chilled water pump	NO	NO	YES
VFD's on hotwater water pump	NO	NO	YES
Outside Air Control Requirements	**BUNDLE 1 LIGHTING**	**BUNDLE 2 BALANCED**	**BUNDLE 3 HVAC**
Total energy recovery of exhaust air for VAV systems	NO	NO	YES
Total energy recovery of exhaust air for Constant Volume systems	NO	YES	YES
CO2 control of outside ventilation air	YES	YES	YES
Fan/pump motor Efficiency Requirements	**BUNDLE 1 LIGHTING**	**BUNDLE 2 BALANCED**	**BUNDLE 3 HVAC**
Supply and return fan motors	Premium	Premium	Premium
Chilled water pump motor	Code Level	Code Level	Premium
Hot water pump motor	Code Level	Code Level	Premium

Note: Premium efficiency requirements are listed in Table below

Code vs. Premium Motor Efficiencies

All efficiency values are nominal efficiencies.

Horse power	Open drip-proof motors*						Totally-enclosed fan-cooled motors*					
	Code			Premium			Code			Premium		
	3600 rpm	1800 rpm	1200 rpm	3600 rpm	1800 rpm	1200 rpm	3600 rpm	1800 rpm	1200 rpm	3600 rpm	1800 rpm	1200 rpm
1		82.5%	80.0%		85.5%	82.5%	75.5%	82.5%	80.0%	77.0%	85.5%	82.5%
1.5	82.5%	84.0%	84.0%	84.0%	86.5%	86.5%	82.5%	84.0%	85.5%	84.0%	86.5%	87.5%
2	84.0%	84.0%	85.5%	85.5%	86.5%	87.5%	84.0%	84.0%	86.5%	85.5%	86.5%	88.5%
3	84.0%	86.5%	86.5%	85.5%	89.5%	89.5%	85.5%	87.5%	87.5%	86.0%	89.5%	89.5%
5	85.5%	87.5%	87.5%	86.5%	89.5%	89.5%	87.5%	87.5%	87.5%	88.5%	89.5%	89.5%
7.5	87.5%	88.5%	88.5%	88.5%	91.0%	90.2%	88.5%	89.5%	89.5%	89.5%	91.7%	91.0%
10	88.5%	89.5%	90.2%	89.5%	91.7%	91.7%	89.5%	89.5%	89.5%	90.2%	91.7%	91.0%
15	89.5%	91.0%	90.2%	90.2%	93.0%	91.7%	90.2%	91.0%	90.2%	91.0%	92.4%	91.7%
20	90.2%	91.0%	91.0%	91.0%	93.0%	92.4%	90.2%	91.0%	90.2%	91.0%	93.0%	91.7%
25	91.0%	91.7%	91.7%	91.7%	93.6%	93.0%	91.0%	92.4%	91.7%	91.7%	93.6%	93.0%
30	91.0%	92.4%	92.4%	91.7%	94.1%	93.6%	91.0%	92.4%	91.7%	91.7%	93.6%	93.0%
40	91.7%	93.0%	93.0%	92.4%	94.1%	94.1%	91.7%	93.0%	93.0%	92.4%	94.1%	94.1%
50	92.4%	93.0%	93.0%	93.0%	94.5%	94.1%	92.4%	93.0%	93.0%	93.0%	94.5%	94.1%
60	93.0%	93.6%	93.6%	93.6%	95.0%	94.5%	93.0%	93.6%	93.6%	93.6%	95.0%	94.5%
75	93.0%	94.1%	93.6%	93.6%	95.0%	94.5%	93.0%	94.1%	93.6%	93.6%	95.4%	94.5%
100	93.0%	94.1%	94.1%	93.6%	95.4%	95.0%	93.6%	94.5%	94.1%	94.1%	95.4%	95.0%
125	93.6%	94.5%	94.1%	94.1%	95.4%	95.4%	94.5%	94.5%	94.1%	95.0%	95.4%	95.0%
150	93.6%	95.0%	94.5%	94.1%	95.8%	95.4%	94.5%	95.0%	95.0%	95.0%	95.8%	95.8%
200	94.5%	95.0%	94.5%	95.0%	95.8%	95.4%	95.0%	95.0%	95.0%	95.4%	96.2%	95.8%

**Code values are from Energy Policy Act of 1992, also reference NEMA Standard MG1-1998, Revision 2, Section 12.59 and Table 12-11, as tested in accordance with IEEE Standard 112 Method B.*

***Premium values are from NEMA Standard MG1-1998, Revision 2, Section 12.60 and Table 12-12, as tested in accordance with IEEE Standard 112 Method B.*

Guidelines: Indoor Environmental Quality

Guidelines (Required except where noted with * which indicates recommended)

Forms

Overview

The provision of Indoor Environmental Quality at levels that support productive human habitation is equal and complementary to the environmental and economic goals for sustainable building. Appropriate indoor environmental qualities of air, temperature, sound, light, visible and physical space and occupants' ability to personally control these are the building's contributions to the biological bases of occupant comfort, health and well-being. Harmful effects on occupants of poor indoor environmental quality are well documented in laboratory and field studies. Similarly, enhanced indoor environmental quality helps occupants feel and perform at their best, with subsequent health, well-being and productivity benefits for themselves and their work organizations. These indoor environmental quality guidelines are constructed to first and foremost ensure that no harm comes to occupants, then to optimize environmental quality conditions to correspond with human physiological processes, and finally to fine tune environmental conditions to work activities in a way that further enhances personal and organizational productivity.

Goal

To provide exemplary indoor air quality and other interior environmental conditions to promote occupant health, well-being and productivity. Here, "health" is more than the absence of disease and "well-being" includes provision of physical comfort and psychological satisfaction with the physical work environment.

Objectives

- Provide a clean building that will minimize pollutant sources in the structure and its occupants.
- Provide a dry building to minimize structural and health problems associated with water intrusion and accumulation.
- Provide a well-ventilated building to dilute pollutants and bioeffluents emitted by the building materials, the occupants and their activities.
- Provide for occupant thermal comfort.
- Provide daylight for general ambient illumination.
- Provide interior view space or views to the exterior.
- Provide lighting solutions of high quality for visual tasks and preferred interior rendering.
- Provide interior conditions that avoid harmful vibration and noise effects and produce a positive soundscape acceptable to occupants and appropriate to their tasks.
- Provide for local occupant control of localized indoor environmental conditions in order to quickly correct harmful conditions and to better support work performance.
- Provide an interior spatial arrangement that encourages healthy human interaction and movement

I.1 Restrict Environmental Tobacco Smoke

Intent

Reduce indoor pollutants by eliminating environmental tobacco smoke (ETS) from occupied areas of the building.

Required Performance Criteria

- Establish a no smoking policy for the building.
- Smoking policy will state where smoking outside of building can occur, such that design considerations will not introduce ETS into the building from outdoor sources.
- Design documentation must state explicitly that the building was designed assuming that smoking would not occur in the building.

Suggested Implementation

Agency Planning

- The Agency (the State of Minnesota) certifies that the building will be operated as a smoke-free building and establishes a no-smoking policy for the building. Therefore, special barriers and controls will not be designed inside these buildings.

Construction Documents

- Design documentation must state explicitly that the building was designed assuming that smoking would not occur in the building.
- Plan drawings and other documentation must indicate outdoor designated smoking areas to ensure that smoke will not be introduced into the building through doorways, windows, outdoor air intakes or other openings.

Ongoing Occupancy

- Maintain the location of designated outdoor smoking areas or relocate areas with building changes or additions to ensure that smoke will not be introduced into the building through doorways, windows, outdoor air intakes or other openings.

Next Use

- The decision that this building was designed to be operated as a smoke-free building must be clarified for any new owner.
- The proper location of designated outdoor smoking areas must be communicated to any new owner, property manager, and occupants.

I.2 Indoor Air Quality and Ventilation Baseline

Intent

Ensure good indoor air quality by requiring most of the general procedures and information contained in Minnesota Code and referenced industry ventilation standard.

Required Performance Criteria

- Meet current Minnesota Code for ventilation rates and other indoor air quality requirements, except when superseded by other sections of these guidelines. (See guidelines I.3 and I.5.)

Tools

Reference Standards:

- Minnesota Code and referenced ASHRAE Standard 62

Suggested Implementation

Predesign-Programming

- Obtain the latest version of the Minnesota Code, and all applicable referenced standards and amendments.

Each Phase after Predesign-Programming

- Incorporate the requirements of Minnesota Code in to the work as appropriate for the phase.

I.3 Specify Low-emitting Materials

Intent

Reduce indoor chemical pollution in a building by choosing low-emitting materials and furnishings through construction, operations and maintenance. Since material emissions are a factor in the ventilation rate required by the guidelines, lower emitting materials may also reduce the ventilation rate.

Required Performance Criteria

Comply with requirements of indoor air quality (IAQ) limits for indoor air pollutants, meet or outperform volatile organic compounds(VOC) limits for adhesives, sealants, paints, composite wood products, finishes, furnishings, and carpet systems as follows:

- Meet or exceed the VOC and chemical component limits of California Section 01350 or the following, whichever is stricter, for materials or products. Materials or products will be evaluated as an assembly when typically installed as such.

- Adhesives must meet or outperform the VOC limits of South Coast Air Quality Management District rule #1168 by, AND all sealants used as a filler must meet or exceed Bay Area Air Quality Management District Reg. 8, Rule 51.
- Paints and coatings must meet or outperform the VOC and chemical component limits of Green Seal requirements. Paints containing a minimum of 20% recycled content, which may not meet Green Seal low emission requirements, may be used as a primer in spaces unoccupied for 72 hours after application and covered with final topcoat(s) that meet the requirements of Green Seal for finish paints. Refer to Guideline M.3 for recycled content recommendations.
- Carpet systems must meet or outperform the Carpet and Rug Institute Green Label Indoor Air Quality Test Program and comply with the low VOC-emitting requirements of California Section 01350.
- Composite wood and agrifiber products must contain no added urea-formaldehyde resins.
- Furnishings must meet or outperform the VOC and chemical component limits of the State of California Model Office Furniture System Final Environmental Specifications (Rev. 12/18/00), Sections A and B: Indoor Air Quality. Products must comply, at a minimum, with the 14 day 'flushing' period, comprised of 14 days conditioning with clean air, supplied by appropriate levels of air exchanges.

Tools

Information about material emission rates supplied by the manufacturer as cut sheets and Material Safety Data Sheets can be used to document compliance with performance criteria of guideline I.3 and will allow the engineers designing the ventilation system to calculate emissions of particular pollutant classes under I.4 Ventilation Based on Pollutant Concentrations.

Resources

South Coast (Los Angeles) Air Quality Management District. www.aqmd.gov

Carpet and Rug Institute. www.carpet-rug.com

California High Performance Building Standards Section 01350 found at www.ciwmb.ca.gov/greenbuilding/Specs/Section01350/default.htm. Section 01350 deals only with emissions related to installed and occupancy uses of products, not with emissions caused during manufacturing and processing.

GreenGuard www.greenguard.org
GreenGuard evaluates product emissions only after production and does not provide full LCA data, thereby limiting its reports on emissions caused during manufacturing and processing.

Green Seal www.greenseal.org

GreenSpec, Environmental Building News, www.buildinggreen.com

For information on low-emitting products, search database for attribute "release minimal pollutants" (subscriber service)

The Minnesota Office of Environmental Assistance (MOEA) web page on Building Products and Materials is a resource for information on low-emitting materials. Provides links to the Environmentally Preferable Purchasing Guide, GreenGuard, Green Seal, Scientific Certification Systems, ATHENA BEES 3.0, BuildingGreen (EBN), and more. www.moea.state.mn.us/greenbuilding/products.cfm

The MOEA web page on Design Guidelines, Specifications and Rating Systems provides links to the California Modular Office Furniture Specifications, EPA's Triangle Park specifications on Testing for IAQ and Sequence of Finishes Installation, and the GSA's Sustainable Building Technical Manual. www.moea.state.mn.us/greenbuilding/design.cfm

The MOEA web page on Environmentally Preferable Cleaners provides information about the Minnesota State Contract for low-emitting cleaning products, success stories, and other resources. www.moea.state.mn.us/lc/purchasing/cleaners.cfm

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Suggested Implementation

Schematic Design

- For those building materials and furnishings covered by the performance criteria and any additional materials or products included in the calculation for I.4, specifications must include the requirement that pollutant emission rates of the materials are certified by the manufacturer.
- Determine if more stringent goals will be set for material emission limits than those required for I.3 performance criteria. More stringent goals may be desired after evaluating ventilation/pollutant scenarios under Guideline I.4. Ventilation Based on Anticipated Pollutants.

Design Development

- Verify continued selection of materials and products to reflect guideline requirements or more stringent project team goals for material emission limits.
- Develop drawings and specifications which support material properties selected.

Construction Documents

- Specify low-emitting materials in construction documents. Ensure that emission limits are clearly stated in each section where materials covered by this guideline are addressed.

Construction

- Adopt an appropriate management plan during construction to prevent problems that will adversely affect IAQ when the building is occupied. See P.1 Performance Management.

Construction Administration-Programming

- Monitor submittals and construction site to ensure that materials, products, and systems are being correctly installed to preserve project goals and objectives. Review substitutions based on performance criteria to ensure consistency and compliance with goals as represented in the drawings and specifications.
- Document changes to requirements for construction that occur that may seriously impact the provision or installation of materials, products, or components or materials ensuring indoor air quality standards are achieved.

Ongoing Occupancy

- Based on the facility management plan (developed prior to occupancy, see P.1), use low or no-VOC emitting materials for products including cleaning supplies, pest management applications, minor remodeling and maintenance associated with "churn" or standard product replacement of furnishings and finishes.

I.4 Ventilation Based on Anticipated Pollutants

Intent
Ensure good indoor air quality by identifying pollutant concentration target values for use by the design team to calculate ventilation rates for a space.

Required Performance Criteria
Calculation of ventilation requirements based on pollutant concentrations is required using the Calculation Method in Required Tools/Calculations in the following situations:

- Section I.3 - Specify Low-emitting Materials is not followed
- Concentrations of pollutants will be present in higher concentrations than listed in the table below due to particular activities in the building or on site
- Special pollutants not listed in Table I-1 below are part of the building use or site. Establish target pollutant concentrations for the special pollutants in order to calculate ventilation requirements

Radon is not listed in the guideline table since it is a pollutant that is best controlled using source prevention techniques rather than ventilation. If construction is to occur in one of the 68 Minnesota counties considered "Zone 1" by the US EPA, guidance contained in the EPA document, "Radon Prevention in the Design and Construction of Schools and other Large Buildings", must be followed.

Table I-1: Guideline Range for Pollutants

Pollutant	**Sources**	**Guideline Range**
Formaldehyde (HCHO)	Pressed-wood products, furniture and furnishings	0.01 to 0.05 ppm
Ozone (O3)	Electrostatic appliances, office machines, ozone generators, outdoor air	0.01 to 0.02 ppm
Total Volatile Organic Compounds (TVOC)	New building materials and furnishings, consumable products, maintenance materials, outdoor air	100 to 300 µg/m3
Particles (PM2.5)	Combustion products, cooking, candles, incense, outdoor air	1 to 10 µg/m3

Recommended Performance Criteria

- Calculate ventilation requirements based on the pollutant concentration ranges shown in Table I-1. These are concentration ranges that are typically seen in buildings with acceptable indoor air quality in the U.S. - they are not intended to be action levels. If sources that are listed in the Table will be present in the building or at the building site then the pollutant target should be part of the ventilation calculation for this building.

Tools
ASHRAE (2001.) Addendum 62ad, Summary of Selected Air Quality Guidelines, Atlanta, USA

US EPA, Radon zone map: www.epa.gov/iaq/radon/zonemap.html

US EPA, "Radon Prevention in the Design and Construction of Schools and other Large Buildings", EPA document 625-R-92-016, June 1994. www.epa.gov/iaq/radon.pubs/index.html

Walton, GN. Persily, AK (2004.) Prototype Software for Contaminant-Based Design. NISTIR 6723, National Institute of Standards and Technology

Resources

ASHRAE (2001.) Ventilation for acceptable indoor air quality: ASHRAE 62-2001. Atlanta, USA: 34 pp.

Seifert, B. (2000.) Ways to specify, reach, and check guideline values for Indoor Air Quality. Healthy Buildings 2000, Helsinki.

Seifert, B., N. Englert, et al. (1999.) Guideline values for indoor air pollutants. the 8th International Conference on Indoor Air Quality and Climate, Edinburgh, Scotland, Indoor Air '99

Suggested Implementation

Predesign-Programming

- Determine with the help of the owner/agency the special pollutant sources that are associated with activities that will be present in the building. (This is in addition to typical pollutant sources specifically called out in I.3 and I.4.)

Predesign-Site Selection

- Evaluate candidate sites for outdoor pollutants and determine if there are any particular outdoor pollutant sources that are present on the selected site.
- Evaluate candidate sites for radon and determine if construction is to occur in one of the 68 Minnesota counties considered "zone 1" by the US EPA. See the EPA document, "Radon Prevention in the Design and Construction of Schools and other Large Buildings" to determine requirements for design.

Schematic Design

- The design team shall work with the owner to choose concentration guidelines that are appropriate for the building's program and local site.
  - Choose concentration targets within the required target ranges for those pollutants listed in the performance criteria.
  - Choose additional concentration targets based on other indoor or outdoor pollutants identified in Predesign Programming or Site Selection phases.
- Gather emission information for all pollutant sources listed in I.3, and those listed in I.4 performance criteria under the "Sources" column. Also obtain emission information for any other pollutant sources the team has identified for the particular site and project conditions.
- Based on concentration targets and emission information above, calculate corresponding ventilation rates using the mass balance equations given in Appendix I-3 or mass balance calculation procedures such as IAQDT developed by the National Institute of Standards and Technology (NIST.) One estimate will result from each pollutant.
- Compare these ventilation rates with those calculated in Guideline I.5 based on C02 concentrations. The guideline design ventilation rate for each space is the largest of the values required to control pollutant concentrations (I.4) or CO_2 concentrations (I.5.)
- The ventilation rate determined by this method will most likely, but not necessarily, be greater than that determined by Minnesota Code for minimum outdoor supply air.
- Coordinate with the energy analysts for the project, so that actual design ventilation rates are the same in both ventilation and energy design processes. The design team should consider using strategies that will provide the opportunity to reduce energy use associated with ventilation. The list recommended to consider includes, but is not limited to:
  - CO_2 or other occupancy control to reduce ventilation in the building when it is unoccupied.
  - Use of ventilation strategies that increase ventilation efficiency such as displacement ventilation.
  - Using economizer cycles when possible.
  - Using heat recovery strategies in the ventilation design chosen.

Design Development through Construction Documents

- Update the design ventilation rate as any changes are made to the material and product emission rates to be used in the building. Communicate these changes to the parties evaluating energy performance, so that significant changes in ventilation rate can be taken into account in energy calculations and strategies that address minimizing energy use of ventilation.

Construction

- Utilize a construction IAQ management plan during construction to prevent problems that will adversely affect IAQ when the building is occupied. See P.1.

Ongoing Occupancy

- Perform recommended contaminant testing per P.1.

Next Use

- Concentration guidelines used in the design and operation of the building shall be transferred to a new owner of the building. See P.1 for record keeping and transfer procedures.

I.5 Ventilation Based on Carbon Dioxide Limits

Intent

Provide adequate ventilation to control bioeffluents from building occupants, using CO2 concentrations as the indicator of bioeffluents levels.

Required Performance Criteria

- The CO2 concentration in occupied zones*[1] shall not exceed 450 ppm above outdoor concentrations.

Tools

ASHRAE 62-2001, Addendum 62n.Revision of the Ventilation Rate Procedure for calculating design ventilation rates. www.ashrae.org

Resources

The choices about CO2 concentrations come from many sources. Primary are the studies that relate CO2 concentrations to ventilation rates and to occupant complaints. A representative collection of references are:

- Apte, M. G., W. Fisk, et al. (2000.) "Associations between indoor CO2 concentrations and sick building syndrome symptoms in US office buildings: An analysis of the 1994-96 BASE study." Indoor Air 10: 246-257.
- Fisk, W., P. Price, et al. (2002.) Worker performance and ventilation: analyses of time-series data for a group of call-center workers. Indoor Air 2002, Monterey, CA., vol. 1, pp. 791-796.
- Mumma, S (2004.) Transient occupancy ventilation by monitoring CO2, IAQ Applications, 5(1): pgs. 21-23.
- Persily, A. (1997.) "Evaluating building IAQ and ventilation with indoor carbon dioxide." ASHRAE Transactions 103(2.)
- Schell, M. B., S. C. Turner, et al. (1998.) "Application of CO2-based demand-controlled ventilation using ASHRAE Standard 62: Optimizing energy use and ventilation." ASHRAE Transactions 104(2): Paper TO-98-21-1.

[1] Occupied zone: the region within an occupied space between 3 and 72 in. (75 and 1800 mm) above the floor and more than 2 ft (600 mm) from the walls or fixed air-conditioning equipment. (ASHRAE Standard 62-2001)

- Seppänen, O. A., W. J. Fisk, et al. (1999.) "Association of ventilation rates and CO2 concentrations with health and other responses in commercial and institutional buildings." Indoor Air-International Journal of Indoor Air Quality and Climate 9(4): 226-52.
- Sundell, J., T. Lindvall, et al. (1994.) "Associations between type of ventilation and airflow rates in office buildings and the risk of SBS-symptoms among occupants." Environment International 20: 239-251.
- Tshudy, J (1998.) In: Proceedings of ASHRAE Conference IAQ and Energy 98, New Orleans, pp.63-80. Calculation of ventilation rates for acceptable IAQ based on emission rates from building materials.
- Wargocki, P., D. P. Wyon, et al. (2000.) "The effects of outdoor air supply rate in an office on perceived air quality, sick building syndrome (SBS) symptoms and productivity." Indoor Air-International Journal of Indoor Air Quality and Climate 10(4): 222-36.
- Wargocki, P., J. Sundell, et al. (2002.) "Ventilation and health in non-industrial indoor environments: Report from a European Multidisciplinary Scientific Consensus Meeting (EUROVEN.)" Indoor Air-International Journal of Indoor Air Quality and Climate 12(2): 113-28

Suggested Implementation

Predesign-Programming

- Determine design occupancy levels to calculate design CO2 emissions in occupied zones.1 Use estimated design occupancy levels or ASHRAE design occupancy levels by space type.

Schematic Design

- Determine design occupancy levels to calculate design CO2 emissions in occupied zones.* Use estimated actual design occupancy levels or ASHRAE design occupancy levels by space type.
- Determine ventilation rate per person needed to limit CO2 concentrations to 450 ppm above the outdoor concentrations in all occupied zones. Use CO2 generation rates based on activity level of occupants. See Appendix I-3 and Form I-A.
- Compare these ventilation rates with those calculated in Guideline I.4 (if used) based on pollutant concentrations. The guideline design ventilation rate for each space is the largest of the values required to control pollutant concentrations (I.4) or CO2 concentrations (I.5.)
- The ventilation rate determined by this method will most likely, but not necessarily, be greater than that determined by Section I.2 - Indoor Air Quality and Ventilation Baseline.
- Coordinate with the energy analysis process, so that actual design ventilation rates are the same in both ventilation and energy design processes. The design team should consider using strategies that will provide the opportunity to reduce energy use associated with ventilation. The list recommended to consider includes, but is not limited to:
    - CO2 or other occupancy control to reduce ventilation in the building when it is unoccupied.
      NOTE: If occupancy control is used, ventilation rates should not go to zero during unoccupied times. Minimum values during these periods shall be either:
      a) largest value calculated for indoor pollutant sources using 1.4 or
      b) value for building ventilation specified in ASHRAE 62-2001, Addendum 62n.
    - Use of ventilation strategies that increase ventilation efficiency such as displacement ventilation.
    - Using economizer cycles when possible.
    - Using heat recovery strategies in the ventilation design chosen

Design Development through Construction Documents

- Update the design ventilation rate as any changes are made to the design occupancy levels planned for the building. Communicate these changes to the parties evaluating energy performance, so that significant changes in ventilation rate can be taken into account in energy calculations and strategies that address minimizing energy use of ventilation.

Construction

- Utilize a Construction IAQ Management Plan during construction to prevent problems that will adversely affect IAQ when the building is occupied. See P.1.

Ongoing Occupancy

- Perform recommended contaminant testing per P.1.

Next Use

- Concentration guidelines used in the design and operation of the building shall be transferred to a new owner of the building. See P.1 for record keeping and transfer procedures.

I.6 Moisture Control

Intent

Prevent exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water.

Required Performance Criteria

- Design the building envelope to resist moisture penetration. Since all buildings have potential for moisture penetration, provide drainage planes to the exterior during the heating season and drainage planes to the interior during the cooling season (Lstiburek, 02.)
- Design HVAC systems (and exterior wall/window construction) to hold interior relative humidity (RH) between 20 and 50%. (Wyon, 02)
- Design building envelope elements so that surface temperatures remain warm enough to resist indoor condensation.
- Specify maximum moisture content of materials used in construction to assure that subsurface layers are dry enough to prevent moisture trapping by surface finish materials (Harriman et al., 2001)
- When exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water occurs, the intrusion, leakage or accumulation shall be corrected because of the potential for these conditions to cause the growth of mold. (Title 8, Chapter 4, Section 3362(g) of California Occupational Safety and Health Standards, Sept. 2002.) Establish maintenance procedures that will identify unintended water intrusion, leakage or accumulation quickly and provide drying or removal of building structure elements within 48 hours of the unintended event (Horner, 2001.) Review past water damaged materials to ensure mold growth has not occurred. Also See Performance Management.

Resources

ASHRAE 62-2001 Addenda

- 62s - Filtration requirements for HVAC ductwork upstream of all cooling coils and other devices with wetted surfaces; {approved 1999}
- 62t - condensate management and maintenance of moisture conditions in ductwork; {approved 2002}
- 62w - requirements that ductwork be resistant to mold growth; {approved 1999}

- 62x - humidity control and pressure control in spaces that are mechanically cooled; {currently in 5th public review}

California Occupational Safety and Health Standards Board, Title 8, Chapter 4, Article 9, Section 3362(g) "uncontrolled accumulation of water" (2002.)

Harriman, L. I., G. Brundrett, et al. (2001.) Humidity Control Design Guide for Commercial & Institutional Buildings. Atlanta, ASHRAE.

Horner, W. E., P. R. Morey, et al. (2001.) "How quickly must gypsum board and ceiling tile be dried to preclude mold growth after a water accident". Moisture, Microbes, and Health Effects: Indoor Air Quality and Moisture in Buildings, San Francisco, CA, IAQ 2001.

Lstiburek, J. (2002.) "Moisture Control for Buildings." ASHRAE Journal 44(2): 36-41.

Lstiburek, J, and J Carmody (1993) Moisture Control Handbook, New York, Van Nostrand.

Wyon, D., L. Fang, et al. (2002.) "Limiting Criteria for Human Exposure to Low Humidity Indoors". Indoor Air 2002, Monterey, CA, Vol. 4, pp. 400-405.

Suggested Implementation

Predesign-Programming

- Programming shall note any unusual water uses in the building for this occupancy class.

Predesign-Site Selection

- Site selection shall note any potential water intrusion potential associated with the site.

Schematic Design

- Design building envelope and mechanical systems to meet the performance criteria for I.6. Calculate dew points for interior surfaces of all exterior wall elements at winter design day conditions.

Construction Documents

- Bid documents must describe how materials at construction site are to be stored to protect them from moisture damage during construction and procedures that will be followed to remove moisture-damaged materials from the construction site.

Construction

- Store materials appropriately to prevent water damage. Materials with evidence of moisture damage, including stains, are not acceptable. They must be removed from the site and disposed of properly. Replace any moldy materials with new, undamaged materials.
- Sequence drying of construction materials appropriately during the construction process to prevent future problems. Follow guidance found in Appendix P-G, section B.1. Also See Performance Management.

Ongoing Occupancy

- Conduct regular inspections that ensure there are no visible signs of moisture intrusion or accumulation.
- Conduct regular testing of exterior wall construction to detect moisture in the exterior wall system.
- When exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water occurs, the intrusion, leakage or accumulation shall be corrected because of the potential for these conditions to cause the growth of mold. (Title 8, Chapter 4, Section 3362(g) of California Occupational Safety and Health Standards, Sept. 2002.) Establish maintenance procedures that will identify unintended water intrusion, leakage or accumulation quickly and provide drying or removal of building structure elements within 48

hours of the unintended event (Horner, 2001.) Review past water damaged materials to ensure mold growth has not occurred. Also See Performance Management.

Next Use

- Site information and ways the design team prevented potential problems should be passed to new owners. See Performance Management.

I.7 Thermal Comfort

Intent

Provide for occupant thermal comfort through control of ambient temperature, and operative temperature which includes wet bulb, dry bulb and globe temperatures, relative humidity (RH), mean radiant temperature (MRT), and air velocity.

Required Performance Criteria

- Maintain continuous indoor exposure to Ambient Temperature in occupied spaces less than 80°F and greater than 64°F.
- For transition spaces (entries, hallways, exterior walls) consider letting temperatures fall outside the limits for continuously occupied spaces to save energy.
- Maintain the wall, floor, and ceiling surface temperatures within 20o F when taken from all continuously occupied positions OR Maintain no continuous indoor exposure to greater than 0.30 asymmetry in MRT across three body plane hemispheres (front-back, side-side, top-bottom)
- Maintain air velocity greater than or equal to 10 fpm for continuously occupied spaces.
- Maintain interior relative humidity (RH) greater than 20% and less than 50% in continuously occupied workspace.

Recommended Performance Criteria

- Higher Thermal Comfort performance is achievable with the following criteria:
    - Full compliance in keeping thermal variables within ASHRAE 55-1992 winter and summer comfort zones.
    - Vary dry bulb temperature (DBT) via building control system so as to avoid thermal boredom. Produce ramped drifts of up to + 2.0°F/hr in peak-to-peak variation around neutral temperature. Note: Operative Temperature (OT) is also known as Wet Bulb Globe Temperature, (OT or WBGT = 0.7 Natural Wet Bulb Temperature + 0.3 Globe Temperature)

Tools

ASHRAE 52-1992, with Addendum 55a-1995.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Calculate or simulate thermal comfort using guideline performance criteria and other appropriate thermal comfort indices. Operative Temperature is determined by dry bulb temperature, relative humidity and mean radiant temperature (DBT, RH, MRT), and air velocity. Calculation can also include Clo value (the insulation value of clothing), physical activity, and time. See especially ASHRAE Standard 55-1992, Addendum 1995, and the Human Factors Design Handbook for explanation of conditions and measures to provide for thermal comfort. See other references, particularly Engineering Data Compendium and NASA MSIS for handling special condition problems. See Handbook of Environmental Psychology for discussion of thermal issues for particular settings (e.g. offices, industrial environments) and for perceived control of thermal variables.

Resources

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.

Stokols, Daniel, & Alt man, Irwin (Eds.) (1991) Handbook of Environmental Psychology. Krieger Publishing Co. NY.

Suggested Implementation

Predesign-Programming

- Determine special thermal comfort requirements or problems that may be encountered in the building due to work activities or siting/design considerations.
- Review conditions that affect thermal comfort using ASHRAE Standard 55-1992, Addendum 1995 or Human Factors Design Handbook. Perform any baseline studies on thermal problems or issues that may exist in current facilities if the project involves a move or remodel.

Schematic Design

- Estimate thermal comfort performance measures using ASHRAE Standard 62 occupancy limits for spaces and comfort zone and other thermal conditions in ASHRAE Standard 55. Ensure that no major design characteristic of the building required by these guidelines will push these variables outside general comfort ranges as defined by the guidelines.

Design Development

- Consider additional calculations of thermal comfort indices as appropriate to specific project conditions. Additional measures may include operative temperature, new effective temperature (which combines air temperature and relative humidity,) or wet-bulb globe temperature (which combines dry bulb, wet bulb and globe temperature measures.) The latter is the effective index under potential heat stress conditions.

Correction Period

- Measure performance variables on site. (See P.1 for commissioning procedures.)

Ongoing Occupancy

- Document thermal comfort-related complaints. (See P.1 for documentation procedures.) and resolve as appropriate to satisfy these guidelines and general Human Factors Engineering practices.

I.8 Daylight

Intent
Provide daylight for ambient illumination at levels and conditions known to produce physiological and psychological benefits. Daylight contributes to a perception of a 'bright and cheery' workplace through provision of volumetric brightness (also called "room-surface brightness".) The important qualities of daylight are its inherent variation, power spectrum (color), and the predominantly horizontal component of its illumination vector (direction of illumination.)

Required Performance Criteria
At least 75% of the floor area of continuously occupied spaces in the building shall have a minimum daylight factor of 1% when measured without furniture and at 2'6" above the floor.

Recommended Performance Criteria
Better visual comfort and optimized energy performance may be achieved with the following criteria:

- In every continuously occupied space with daylight, not more than 15% of the floor area shall exceed a uniformity ratio of 10:1when measured without furniture and at 2'6" above the floor.
- For spaces with daylight the Window to Floor Area Ratio (WFAR) shall not exceed 20%.

Tools
Daylighting Factor Calculator See Appendix I-4.

Daylighting simulation modeling and other documented information.

Using physical models is one very effective way to analyze daylighting performance of a building. Even the simplest foam core models will inform the design team about how the behavior of daylight changes as building parameters are varied. Daylight apertures and reflectance values of material surfaces must be accurately modeled for valid results. Such daylighting models can then be tested on site or under artificial sky conditions in a daylighting laboratory. Sundials attached to the model base allow such models to be tested so as to simulate annual variation of direct sunlight.

In addition, computer analysis and simulation may be used to generate a daylighting solution. Some widely available programs are noted below. Usually, three-dimensional digital models are constructed using (CAD) computer-aided design software that is then imported into the lighting software. Such programs usually require the user to define location, sky conditions, and date and time and interior surface characteristics. Some programs produce lifelike renderings of the design but do not provide accurate quantitative results.

The US Department of Energy and its associated national laboratories and their outreach programs are rich sources of information and simulation and analysis programs for daylighting. Among these are

- ADELINE (Advanced Daylighting and Electric Lighting Integrated New Environment) at www.ibp.fhg.de/wt/adeline/, which "provides architects and engineers with accurate information about the behavior and the performance of indoor lighting systems. Both natural and electrical lighting problems can be solved, in simple rooms or the most complex spaces."
- Radiance. radsite.lbl.gov/radiance/, The primary advantage of Radiance over simpler lighting calculation and rendering tools is that there are no limitations on the geometry or the materials that may be simulated. Radiance is used by architects and engineers to predict illumination, visual quality and appearance of innovative design spaces, and by researchers to evaluate new lighting and daylighting technologies..
- EREC Reference Brief "Daylighting for Commercial, Institutional an d Industrial Buildings" www.eere.energy.gov/consumerinfo/factsheets/cb4.html an excellent introduction to daylighting fundamentals.
- DOE Buildings Program: Daylighting www.eere.energy.gov/buildings/info/design/integratedbuilding/passivedaylighting.html for everything you ever wanted to know about daylighting, and more.

- Efficient Windows Collaborative www.efficientwindows.org contains references, resources and simulation tools for window design and selection for daylighting.
- An entire course in daylighting is provided by the online available Vital Signs Curriculum Materials Project by Marc Schiller and Schweta A. Japee (both at the University of Southern California School of Architecture): "Interior Illuminance, Daylight Controls, and Occupant Response." It is " a complete range of exercises covering everything from an understanding of how your eye works to how to do image processing on a digitized video scan."

Resources

Baker, Nick, & Steemers, Koen (2002) Daylight Design of Buildings: A Handbook for Architects and Engineers. James & James, Publishers.

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Rea, Mark S. (Ed.) (1999) The IESNA Lighting Handbook: Reference & Application. Illuminating Engineering Society of North America, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- While programming identify and list continuously occupied spaces without security, hazard or other restrictions to windows and daylighting as appropriate for daylighting.
- Using the Daylighting Factor Calculator or similar tool establish room proportions, window area and surface properties that satisfy the required performance criteria for each of the main prototype spaces.

Schematic Design

- Using the Daylighting Factor Calculator or similar tool establish room proportions, window area and surface properties that satisfy the required performance criteria, if this has not already been completed. Begin organizing the building volume and fenestration so as to maintain the required performance criteria. Use the output from the Daylighting Factor Calculator to check the performance periodically as the design evolves.
- For each of the main prototype spaces, test and determine the implications for orientation, room proportion, window area, and finishes that achieve the performance criteria. Coordinate this effort with related lighting quality and view space guidelines (I.9, I.10) and with energy conservation approaches (E.1.)
- The Daylighting Factor Calculator is designed to identify the physical attributes for room dimensions, surfaces and fenestration in order to just meet the performance criteria for standard CIE overcast sky conditions. It does not currently take into account light shelves, partitions, non-orthogonal planes, significant exterior obstructions or exterior reflecting surfaces. For such parameters that go beyond the current capability to the Daylighting Factor Calculator, physical models or computer simulations are recommended to refine the volumetric and surface attributes of the final design in order to assure compliance with the required and recommended performance criteria.

Design Development

- Demonstrate compliance using the Daylighting Factor Calculator, computer simulation or physical modeling whichever tool is appropriate. For each of the main prototype spaces, show a summary of calculations, and quantitative results indicating conformance with performance criteria. Coordinate this effort with related lighting quality and view space guidelines (I.9, I.10) and with energy conservation approaches (E.1.)

Construction Administration

- Observe and verify that the room, window, finishes (upon which estimated compliance was based) are proceeding according to goals and are reflected in drawings and specifications.

Acceptance Testing

- Measure performance criteria on site. Develop sampling plan to confirm daylighting performance over first three years of occupancy. Compare performance at specific test times to what would be expected under same conditions in model.[2]

Acceptance Testing

- Demonstrate that performance criteria are maintained via a sampling plan of daylighting performance over varying conditions during the first three years of occupancy.

I.9 Quality Lighting

Intent

Provide lighting (natural and artificial) of high quality for visual tasks and preferred interior rendering. The important lighting quality characteristics and effects include: glare-free, good (natural) color rendering, enhanced sense of spaciousness, and attractive rendering of people for social exchanges. Quality lighting enhances effectiveness of social communication and contributes to creating the perception of a 'bright and cheery' workplace through volumetric brightness.

Required Performance Criteria

A glare index based on Visual Comfort Probability (VCP) or Discomfort Glare Rating (DGR) or Unified Glare Rating (UGR) of no less than 70% in all continuously or intermittently occupied spaces except storage areas and mechanical rooms.

Recommended Performance Criteria

Higher Lighting Quality performance is achievable with the following criteria:

- Increase CRI at least 90 for all continuously or intermittently occupied spaces.
- From a distance equal to the ceiling height on a line parallel with all permanent interior partitions, the horizontal illumination value of light reflected from a solid wall should be at least 50% of the vertical illumination value measured or simulated without interior furnishings at a level equal to average standing eye height.

Tools

Lighting design tables, lighting design software, luminaire specification sheets. See the latest edition of the IESNA Lighting Handbook (as referenced below) for detailed instructions and examples. For am example of Lighting Modeling Software, see the Daylight I.8 or

- Lightscape SW, available from AUTODESK usa.autodesk.com/

[2] * For example, if the onsite lighting measurements are taken at noon, on September 21, compare to a model condition at noon on September 21. Measure under overcast sky conditions if verifying against the Daylighting Factor Calculator

Resources

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Rea, Mark S. (Ed.) (1999) The IESNA Lighting Handbook: Reference & Application. Illuminating Engineering Society of North America, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Incorporate performance criteria into lighting design criteria in program document. Develop additional quality lighting criteria as needed for special facility issues. Example: security or anti-vandalism lighting may need to be incorporated into lighting considerations.

Schematic Design

- Conduct a first order check for design constraints on lighting design. Ensure that general daylighting schemes and lighting plans are not in conflict with achieving lighting quality and any additional lighting criteria.

Design Development

- Complete a lighting analysis and develop the lighting design in conformance with performance criteria. Perform any lighting modeling studies as needed to confirm or substitute for calculations.

Construction Administration

- Observe and verify that the room, window, finish, and lighting variables (upon which estimated compliance was based) are proceeding according to goals as reflected in drawings and specifications.

Correcton Period

- Conduct onsite measurements once all lighting is operational. (See P.4 for commissioning requirements.)

Ongoing Occupancy

- Log complaints related to lighting conditions. (See P.1 for record keeping requirements.)

I.10 View Space and Window Access

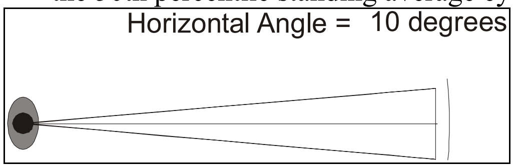
Intent

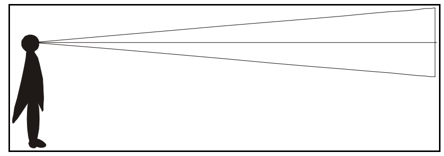
Provide interior view space or views to the exterior, that possesses preferred and demonstrably beneficial characteristics. The benefits are the ability for focal rest to avoid eyestrain, and access to visual information about changing outside conditions. A view amenity also aids varying attention cycles and relieves the stress of mental work.

Recommended Performance Criteria

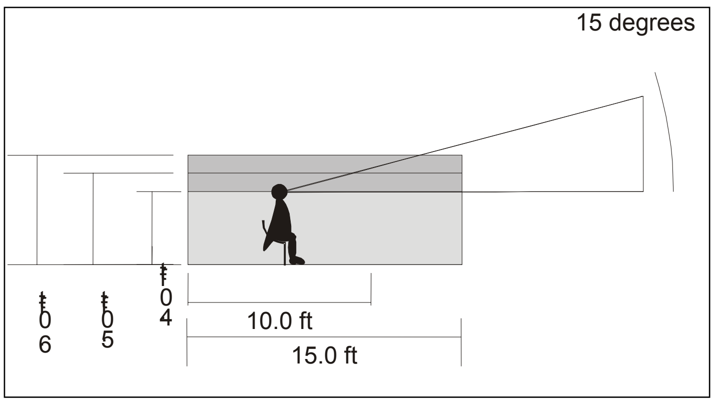
These criteria are recommended but not required by these guidelines:

- From every continuously occupied position in spaces there shall be visual access to an external window view that is at least 10 degrees in horizontal visual angle at no greater than the 50th percentile standing average eye height of 64 inches.





- From every assigned and continuously occupied workstation position at seated eye of 48 inches there shall be available at least a continuous 20 degrees horizontal and 15 degrees vertical view space beginning at not more than 10 degrees from the horizontal that is at least 20 feet in sight vector length.



Distance in feet from the viewer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Minimum Horizontal dimension of the view aperture for a 10 degree angle.	0.2	0.3	0.5	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.6	2.8	3	3.1	3.3	3.5
Maximum height of vertical obstruction from seated eye height	0.2	0.4	0.5	0.7	0.9	1.1	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5	2.6	2.8	3	3.2	3.4	3.5

- Higher performance is achievable with the following view space criteria:
  - Views to horizon lines, clouds, tree lines and clusters and natural waterscapes.

Tools

Calculation from drawings or simulation via analytic software. Software broadly incorporating view space calculations is embedded in the "Spatialist" program from the School of Architecture, Georgia Institute of Technology, Atlanta, GA.

Resources

Baker, Nick, & Steemers, Koen (2002) Daylight Design of Buildings: A Handbook for Architects and Engineers. James & James, Publishers.

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Rea, Mark S. (Ed.) (1999) The Iesna Lighting Handbook: Reference & Application. Illuminating Engineering Society of North America, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Include performance criteria in the program document. Develop any special view and window requirements during functional programming of activities for the building. Examples: presence of an amenity view space, special security concerns for windows in certain locations of the building.

Schematic Design

- Determine implications of performance criteria for space planning and incorporate into schematic design. Perform first order estimates of view access given projected uses within building and initial sizing and placement of windows. Identify any problems with window configuration and placement.

Design Development

- Confirm compliance with a check of design development drawings.

Construction Administration

- Observe and verify that the room, window, and furnishing variables (upon which estimated compliance was based) are proceeding according to goals as reflected in drawings and specifications.

Correction Period

- Verify that performance criteria are met by checking performance on site.

Ongoing Occupancy

- Log comments relating to view space and window access. (See P.1 for record keeping procedures.)

I.11 Eliminate Whole Body Vibration in Buildings

Intent

Provide interior conditions that avoid harmful vibration effects produced by wind sway, transmitted outdoor sources, indoor machinery (especially HVAC) and foot traffic. This will avoid prolonged exposure to unhealthy vibration levels, and enable prolonged comfortable work at a workstation. It will also diminish anxiety and stress due to wind sway on upper floors as well as maintain the value of the building.

Required Performance Criteria

- Return period of greater than 0.5% g horizontal acceleration in top third of building is not less than 6 years.
- Floor vibration shall be kept above Splittgerber Minimum Complaint Level (approximately 0.001 A rms,g across 4-8 hz resonant with human body components) or 8 hr reduced comfort level (approximately 0.15m/sec2 across 4-8 hz resonant with human body components) for all continuously occupied spaces, restrooms and meeting rooms.

Recommended Performance Criteria

- Higher performance is achievable with the following vibration criteria:
  - Extend floor vibration criterion to all intermittently occupied spaces except storage areas.

Tools

Vibration control practices. Lookup tables. Calculation. See NASA MSIS, Chapter 10 of the Engineering Data Compendium, the Human Factors Design Handbook, and the ISO 2631 (Guide for the Evaluation of Human Exposure to Whole-Body Vibration), all referenced below.

Resources

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

International Organization for Standardization (ISO) (1982.) Guide for the Evaluation of Human Exposure to Whole-Body Vibration. (ISO 2361-1978/AI 1982) Geneva: ISO.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Include performance criteria in programming document. Identify any potential sources of unusual vibration conditions within building (e.g. heavy equipment or machinery operations, inclusion of windpower generators, etc.)

Schematic Design

- Consider performance criteria in placement of machinery and in general building form and layout. Confirm isolation of vibration sources in schematic design, or tag for special treatment in design development.

Design Development

- Demonstrate compliance via structural calculations or table citation.

Correction Period

- Verify achievement of performance criteria onsite with full systems running and with stops and starts of systems at varying degrees of load.

Ongoing Occupancy

- Log vibration related complaints. (See P.1 for record keeping procedures.)

I.12 Effective Acoustics and Positive Soundscapes

Intent

Provide interior conditions that avoid harmful noise effects and produces a basis for a positive soundscape acceptable to occupants and appropriate to their tasks. The benefits are avoiding exposure to: unhealthy noise levels, the elevated stress which accompanies higher background noise levels and noise distraction impacts on mental work. Effective acoustics enable effective speech communications at normal speaking voice while providing for local speech privacy.

Required Performance Criteria

- Recurrent background noise from external and internal sources shall not exceed 70 dBA.
- All continuously occupied office space shall meet a NC (Noise Curve) of no greater than NC-50, recommended level is NC-45.
- All classroom space shall meet an NC of no greater than NC-45.
- Reverberation time for all continuously occupied space shall be no less than 0.2 sec and no greater than 0.8 sec. The Hz level deemed most appropriate for the activities of the setting shall be met.
- Speech Interference Level (SIL) for continuously occupied office spaces shall be no greater than 55 dBa.
  OR: Articulation Index shall be no less than 0.50 and no greater than 0.70.

Recommended Performance Criteria

- Higher acoustic performance is achievable with the following criteria:
  - Reduce NC criterion to NC 45 for continuously occupied spaces and no greater than NC 40 for intermittently occupied meeting spaces like conference rooms and classrooms.
  - Create a background 'positive soundscape' through introduction of sounds that provide variations similar to benign natural environments. (White noise is generally not a preferred solution for acoustic soundscapes.)

Tools

There are several US University programs focused on architectural acoustics and many sources of room acoustics modeling software that are commercially available. There are also free acoustics modeling and analysis software programs available from some universities and companies. These programs provide calculated estimates of quantities like reverberation time and sound pressure levels given certain parameters that account for room size, shape, surface absorption and activity types.

Very informative introductions to room acoustics modeling are given by Lokki & Jarvelainen, (2001) and Rindel, (2000.) A very helpful, illustrated, online PowerPoint presentation that includes room acoustics modeling is given by Lokki & Savioja (2002.) The University of California at Berkeley, The Rensselaer Technical Institute, and McGill University all have extensive online resources available on architectural acoustics.

Helpful Internet resources include:

- The Engineering Toolbox www.engineeringtoolbox.com/27_521qframed.html or Room Acoustics www.roomacoustics.info/calculator/arch/room-acoustics-arch.htm. Both websites reference a calculator for architectural acoustics calculations.
- IRCAM (a French research project with many useful publications and free software) www.ircam.fr/departements/recherche/page-e.html
- ODEON (distributes room acoustics modeling software) www.dat.dtu.dk/~odeon
- SARA (a Spatial Audio & Room Acoustics Project from the Academy of Finland) www.acoustics.hut.fi/~vpv/projects/sara.htm

Resources

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

Harris, C. M. (1979) Handbook of Noise Control. McGraw-Hill, New York.

Hass, Ellen, & Edworthy, Judy (Eds.) (2002) The Ergonomics of Sound. Human Factors & Ergonomics Society, Santa Monica, CA.

Lokki, T. & Jarvelainen Hanna, (2001) Proceedings of the 2001 International Conference on Auditory Display, July 29-August 1, 2001. Pgs. 26-31 Espoo, Finland. (Available online.)

Lokki, T. & Savioja, L. (2002) VR Research at HUT and Real-Time Auralization. Future Workplaces, Stuttgart, 10-11 October 2002. (Available online.)

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Rindel, J.H. (2000) The use of computer modeling in room acoustics. Journal of Vibroengineering. No. 3(4) Index 41-72. (Available online)

Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Wise, James. The Human Nature of Noise and Vibration. Eco-Integrations, Inc. (Available in Appendix)

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Include performance criteria in programming document. Develop any additional special acoustical performance requirements to support functional programming of building. (E.g. sources of recurrent noise that needs to be controlled, special user populations which may have distinct auditory performance limitations, multiple uses of building spaces which may have different acoustic criteria. Investigate and choose appropriate acoustics modeling software for the project. (See Tools.)

Schematic Design

- Consider performance in building layout and form. Ensure that there are no inherent acoustic conflicts or limits to meeting performance criteria at schematic design level. Perform initial software simulations to ensure that general acoustics parameters are met.

Design Development

- Demonstrate complete compliance with acoustical performance criteria via calculations or more detailed simulation modeling.

Construction Documents

- Address explicit performance criteria in design and materials selection and specification. Check to ensure materials selection meets necessary criteria for acoustical controls.

Correct1on Period

- Measure acoustic performance onsite with full systems running. Check against predictions from software models.

Ongoing Occupancy

- Log noise and other sonic environment complaints. Check for needed sonic modifications if programmed activities of spaces change to require different supports. (See Performance Management for recordkeeping procedures.)

I.13 Personal Control of IEQ Conditions and Impacts

Intent

Provide for local occupant control of interior conditions to better support work performance. Personal control will enable immediate improvement of intermittent discomfort and will help indicate personal availability or current work status. It will also allow workers to increase personal comfort in changing organizational contexts. However, occupants shall not be put in recurrent uncomfortable conditions, so that continuous adaptation is necessary to maintain comfort.

Recommended Performance Criteria

- Provide adjustable task lighting to include 'on', 'off', and intermediate levels.
- Demonstrate means of ameliorating direct solar gain at all continuously occupied and assigned positions.
- Demonstrate means of mitigating intermittent noise, drafts or low air circulation at all continuously occupied and assigned positions.
- Demonstrate means of alleviating building control system malfunctions at all continuously occupied and assigned positions.
- Demonstrate access to operable windows at all continuously occupied and assigned positions.

- Neck extension for continuously viewing monitors at workstation shall not be greater than 0 degrees vertical. Head rotation for continuous viewing shall not be greater than 10 degrees horizontal.
- At keyboard rest, there shall be no continuous deviation from an approximate 0 degree angle in elevation from elbows at sides at rest through wrists to fingertips on keyboard.
- Higher performance is achievable with the following personal control criteria:
    - Increase flexibility of workspace through adoption of standards for ergonomically adjustable and movable furniture elements. (BIFMA Office Furniture Standard, European CEN Workplace Standard, NASA Man-System Integration Standards.)
    - Use tools to perform Spatial Syntax and other (e.g. Isovist) analyses that can be used to improve flexibility and habitability of workspace.

Resources

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

BIFMA (Business and Institutional Furniture Manufacturers Association) (2001) Ergonomics Guideline for VDT Furniture Used in Office Workspaces. BIFMA G1-2001, Grand Rapids, MI.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

Human Factors Society (1988) American national standard for human factors engineering of visual display terminal workstations. (ANSI/HFS 100-1988.) Santa Monica, CA. Human Factors and Ergnomics Society.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Include performance criteria in programming documents. Perform an ecological matrix analysis to demonstrate the planned means of occupant control over environmental quality variables under their routine and foreseeable extreme variations.

Schematic Design

- Consider personal control criteria impact on the schematic design. Check that there are no obvious limits on personal control strategies in the schematic design and that personal control strategies are incorporated in the general design of building.

Design Development

- In the design documentation and documentation of compliance for this phase, call out the personal control strategies enabled by and included in the design.

Construction Documents

- Include testing of occupant control options over indoor environmental qualities in the commissioning plan.

Correction Period

- Verify achievement of performance criteria by exercising the range of occupant control strategies available on site per the commissioning plan. (See P.1 for commissioning plan.)

Ongoing Occupancy

- Log complaints or shortcomings noticed in lack of personal control overindoor environment. (See P.1 for record keeping procedures.)

I.14 Encourage Healthful Physical Activity

Intent

Provide spatial conditions conducive to incidental physical activity. Movement (like walking) between workplace destinations helps maintain cardiovascular fitness, mental alertness, and encourages synergistic staff interactions that improve morale and well-being.

Recommended Performance Criteria

These criteria are recommended but not required by these guidelines:

- All new buildings shall have an 'open' or 'enhanced' stair design connecting the main (entry level) floor with at least the next two floors above it and the first floor beneath it. This encourages and enables building occupants to safely and conveniently use the stairs to travel between floors in their daily building circulation.
- Encourage staff to walk to routinely used building service centers and interior destinations through design of circulation path and its amenities. Features that encourage physical activity include:
  - Separation of restrooms and service centers (like mailrooms and refreshment dispensers and break rooms) from work areas
  - Enhanced daylight and views along a circulation path
  - Different routes to popular interior destinations
  - Interior circulation paths that allow round trips without reversal of direction.
- Interior circulation paths with adjoining meeting niches and nooks that encourage spontaneous staff interaction along the path lengths.
- Higher performance toward healthful activity is achievable with the following criteria:
  - Amenities that encourage such casual and continuous use of stairs include: position of stairs in floor plan, openness of stairway to surrounding interior views, provision of rest and incidental meeting nooks along stairway length, reversal or curving of stairway to facilitate expanded user view of stair traffic, proper stairway riser/tread ratios, surfacing, and grab handle meeting HFES (not minimum building code) design recommendations.

Resources

Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.

Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

Pauls, J. L. (1982) "Recommendations for Improving the safety of Stairs", Building Practice Note No. 35, June, Division of Building Research, National Research Council Canada, Ottawa.

Pauls, J. "What Can We Do to Improve Stair Safety?" (1984) Building Standards, May-June, pp 9-12, 42-43; July-August, pp 13-16, p. 42.

(1984) Southern Building, April-May, pp. 14-20; June-July 1984, pp. 22-28; (1984) The Building Official and Code Administrator. May-June, pp.30-36; July-August, pp. 10-15.

Pauls, J. (1991) "Cost of Injuries in the United States and the Role of Building Safety." The Building Official and Code Administrator, Jan/Feb, pp. 19, 31-35;

______ (1991) Building Standards, July/Aug, pp. 18-22, 24;

______(1991) Southern Building, July/Aug, pp. 6, 8-10, 12, 51; etc

Pauls, Jake. (1992) "What Should Inspectors Look for Regarding Safe Stair Construction?." Building Official and Code Administrator, July/August, pp. 32-39.

NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.

Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

Suggested Implementation

Predesign-Programming

- Look for opportunities in programming of building to encourage healthful physical activity by occupants. Include suggestions for activities and explicit performance criteria in programming documents.

Schematic Design

- Incorporate physical movement strategies in design of building. Include general layout and programming considerations for increasing occupant circulation as well as amenities that accommodate exercise activities during daily operations (e.g. inclusion of shower and locker to accommodate lunchtime joggers.)

Design Development

- In the design documentation and documentation of compliance for this phase, call out explicit physical movement strategies. Include necessary signage in design to encourage and direct circulation.

Correction Period

- Test stair use for potential variety of users. Check that signage and circulation amenities are present and installed correctly. (See Performance Management for commissioning plan.)

Ongoing Occupancy

- Include a physical-movement-related question on scheduled staff surveys. Track improvements in staff health and organizational productivity related to better physical circulation and social communication and analyze and document results in the annual Guideline Report. (See Performance Management for record keeping procedures.)

I.15 Outcome Documentation for Indoor Environmental Quality

Intent
Establish benchmarks and link IEQ requirements (and chosen recommendations) with measurable occupant benefits. These results are inputs for the total building outcome documentation and life cycle cost analysis.

Required Performance Criteria
Complete I-A Outcome Documentation Form at the end of each phase to document design decisions for those portions of the guideline implemented at that time.

FORM I-A: INDOOR ENVIRONMENTAL QUALITY— OUTCOME DOCUMENTATION

For work through phase: ________________________as of the date:__________________

INDOOR AIR QUALITY

- For each major type of occupied space, provide the following ventilation indicators:
  Area ______ Ventilation rate (cfm/sf) ______ % outside air ______ CO2 concentration ______
- For each major type of occupied space, provide the following emissions indicators:
  Area ______ Emission rates of interior finish materials (VOCs) ______
  (Attach a list of interior finish materials)
- For each major type of occupied space, provide the following thermal comfort design assumptions:
  Temperature range ______ Relative humidity range ______
- Provide documentation showing the location of designated outdoor smoking area and relationship to doors, windows, outdoor air intake and other openings

DAYLIGHT, LIGHTING AND VIEW

- For each major type of continuously occupied space, provide the following daylight indicators:
  Area ______% with minimum daylight factor of 1%
  Area ______% that exceeds uniformity ratio of 10:1
  Window to wall Ratio _______ %
  Overall area in the building ______ % of continuously occupied spaces with minimum daylight factor of 1%
- For each major type of continuously occupied space, provide the following quality lighting indicators:
  Area ______ Lighting type ______ Lighting quantity (footcandles at desktop) ______
  Glare index ______ Color rendering index ______ Lighting power density (W/sf) _____ _
- For each major type of continuously occupied space, provide the following view indicators:
  Area ______ % area with direct line of sight to a window ____ __
  Visual access angle to external windows (see Guideline I.10) ____ _
  Visual access angle and distance for internal view (see Guideline I.10) ______

ACOUSTICS AND VIBRATION

- For each major type of occupied space, provide the following acoustic indicators:
  Area (sf) ______
  Indicate the Noise Curve (NC) used for design ______
- Provide the following whole body vibration indicators (see Guideline I.11):
  Return period of >0.5% g horizontal acceleration in top third of building (years) ______
  Floor vibration criteria for HVAC equipment ______

PERSONAL CONTROL AND HEALTH

- For each major type of occupied space, provide the following personal control indicators:
  Distanceto operating windows ______
  Access + Distance to Temperature control ______
  Access + Distance to Air movement control ______
  Access + Distance to Lighting control ______
  Type of Glare control ______
  Type of Furniture adjustment (ergonomic standards) _____
- Indicate building design strategies used to encourage healthful activity _________

Appendix I-1 Action Values for Pollutants in Pollutant Guidelines

Guideline values for various pollutant classes are chosen as described in Guideline Element IA.4. The table below gives action levels for these same pollutant classes. Action levels are larger than the guideline levels and indicate concentrations where strong sources and/or low ventilation rates may be present. As such these represent conditions for which some type of preventive maintenance is recommended.

Guideline values are desirable target concentrations for the pollutant classes considered. The range is chosen to minimize exposure as much as practical. However, meeting the guideline concentration is not a guarantee that no adverse health effects will occur within the space. Action levels, on the other hand, have been identified by various groups as concentrations where occupant complaints begin to be noted. If concentrations exceed action levels remedial steps should be taken to reduce the concentrations such as reducing source strengths or increasing ventilation rates.

(Carbon dioxide in an office setting would not be considered a pollutant with health concerns at these levels.)

Pollutant	**Action Level**
Carbon Monoxide (CO)	10 ppm (8 hr avg.)
Formaldehyde (HCHO)	0.08 ppm (30 min avg.)
Nitrogen Dioxide (NO_2)	0.1 ppm (1 hr avg.)
Ozone (O_3)	0.06 ppm (8 hr avg.)
Total Volatile Organic Compounds (TVOC)	1000 $\mu g/m^3$
Particles ($PM_{2.5}$)	15 $\mu g/m^3$

Appendix I-2 Calculating Pollutant Concentrations in a Zone

Calculating pollutant concentrations in a zone when information about the emission factors of the materials, the loading in the space, and the ventilation rate is known.

This calculation uses a steady state mass-balance model. The model assumes zero outdoor concentrations, perfect mixing and no sink effects.

The concentration of a compound in the building shall be calculated using the following Equation:

$$\textbf{Pollutant Concentration} = \frac{\text{Emission factor X Loading}}{\text{Ventilation Rate}}$$

OR

$$\textbf{Pollutant Concentration} = \frac{\text{Emission Rate}}{\text{Ventilation Rate}}$$

The required ventilation rate for the zone can also be found from the formula by rearranging to:

$$\textbf{Ventilation Rate} = \frac{\text{Emission Rate}}{\text{Concentration}}$$

Typical units for these terms are:

[concentration] = $\mu g/m^3$

[emission factor] = $\mu g/m^2$ hr

[loading] = m^2

[ventilation rate] = m^3/hr

The product of the emission factor and the loading is sometimes called the emission rate. In general determine the emission rate by multiplying the emission factor by the amount of the material to be used in the building or air handler zone being evaluated, that is multiply the emission factor by the area of the material in the building zone being assessed. Note that in some cases a length or mass may be the appropriate unit for emission factor that must then be multiplied by the length or mass of the emission source.

Once the concentration guideline for a pollutant is established and the emission rate of all sources of that pollutant in the building or air-handling zone is known, the ventilation rate required to limit the pollutant concentration to the guideline value can be calculated per the formula above.

APPENDIX I-3 Calculating CO_2 Concentrations in a Zone

For work through phase: ______________________ As of date: ________

Public Agency ______________________ Project No. ______________________
Guideline Manager ______________________ Date ______________________
Project Engineer ______________________ Building ______________________
Project Description ______________________

NOTE: Calculation of ventilation rate per person required based on CO_2 generation with an estimate of occupant activity level and maximum zone CO_2 concentration of 450 ppm over outdoor.

A mass balance equation for the outdoor air flow rate needed to maintain the steady-state concentration below a given limit is:

$$V_o = N / (C_s - C_o)$$

Where:
V_o = outdoor air flow rate per person
N = generation rate per person
C_s = CO_2 concentration in the space
C_o = CO_2 concentration in the outdoor air

The formula can be further simplified, given that the guideline limit is 450 ppm over outdoor:

$$C_s - C_o = 450 \text{ ppm}$$

Reference: ASHRAE 62-2001, Appendix C and Figure C-2

TABLE 1

CO_2 generation rates, per person based on activity level
ASHRAE 62-2001, Figure C-2

	N (cfm)	L/min	mets
Seated, office	0.0109	0.31	1
Light machine	0.0177	0.5	2
Heavy work	0.0353	1	4

N (cfm) = L/min * 0.0353 (conversion from metric to english units)
mets = metabolic rate

APPENDIX I-3 Calculating CO_2 Concentrations in a Zone

TABLE 2

Ventilation Rate Required - CFM per person

	Vo	N	Cs - Co
	cfm	cfm	ppm
Seated, office	**24.3**	0.0109	0.00045
Light machine	**39.2**	0.0177	0.00045
Heavy work	**78.4**	0.0353	0.00045

450 ppm = 450 / 1,000,000 = .000450

INSTRUCTIONS
Grayed cells are either calculated from input or fixed.
1. Determine Co2 generation rate based on activity level of occupants in the space. Use the graph of mets vs. CO_2 generation in ASHRAE 62-2001. Figure C-2.
In the above example, the "mets" level (metabolic rate) is chosen for three activity levels and corresponding L.min of CO_2 generation is read off the Carbon Dioxide Production Line.

2. Enter the level in the L/min column of **Table 1** and the corresponding cfm per person will be calculated in the N (cfm) column.

3. Enter the N (cfm per person) in **Table 2** (Ventilation Rate Required, CFM per person)
The required ventilation rate, per person (**Vo**) will be calculated.

NOTE:
For large areas such as gymnasiums, use an average activity level for required CFM per person.

Control of measured CO_2 levels with occupancy sensors can reduce overall ventilation.

Appendix I-4 Daylighting Factor Calculator - Instructions

This section describes proper use of the tool provided for conceptual level and Schematic design level calculations for traditional overcast sky daylighting. The spreadsheet tool uses fundamental algorithms and has been bench tested against RADIANCE, the most accurate computer simulation tool for lighting and daylighting available[2]. The current tool allows windows only on one wall of a room.

The tool uses a standard CIE overcast sky to calculate the Daylight Factors[3] (DF) and can therefore be used for any regular orthogonal space in any location. However, the Report makes specific use of sky data pertaining to Minnesota.

Defaults

1. Overcast Sky
2. Minnesota weather file
3. DF required is 1% in 75% of the Grid
4. The grid automatically adjusts to provide a granularity of 20 X 20 points in any room.
5. The limiting uniformity ratio at the work plane 10:1

Inputs

1. Room Width[4]
2. Room Depth[5]
1. Ceiling Height
2. Number of Windows (distributed horizontally in the wall, max of 3)
3. Width of each window
4. Sill height of the vision windows
5. Head height of the vision windows
6. Sill height of the Clerestory windows if any[1]
7. Head height of the Clerestory windows if any[2]
8. Ceiling Reflectance (typically between 75 -95 % for white ceilings)
9. Wall Reflectance[3]
10. Floor Reflectance (typically between 20 -40 % for carpets)
11. Glass Visible Transmittance (VT)

Footnotes

[1] Use only the tables labeled Tool and Report to complete Summary Form I-D.1. Use of other tabs will render the results inaccurate.

[2] The accuracy of the spreadsheet when used within the limits allowed is 90% to 100%. It is most accurate when the measured points are in front of the window and about 1 head height away from it.

[3] The Daylight Factor is a ratio of the light delivered (inside at the work surface) to the diffuse light available outside.

[4] For open office plans a structural bay can be considered as a room width.

[5] Room depths in excess of 40 feet are likely to require ceilings in excess of 10 feet and/or very high visible transmittance of the glass or highly reflective surfaces in order to meet the performance criteria.

[6] The clerestory sill height should be equal to or greater than the head height of the vision window.

[7] The clerestory head height cannot be greater than the ceiling height.

[8] Light colored walls are very important to the appearance of room brightness and visual comfort.

[9] Ambient light levels range from 30 to 50 foot candles for most common task area functions. Consult the IESNA Handbook

Appendix I-4 Daylighting Factor Calculator - Instructions Page 2

How to use

Begin on the tool sheet tab. You can compare 2 alternatives side by side. Enter information only in the yellow cells at the top. Press the **"calculate"** button each time you wish to see the results of a scenario. The calculate button calculates both alternatives at once. Summary results are shown in red text at the top. To see grid points with

You may enter the results for each room or space type in the table on sheet tab 'Summary' to calculate the overall

Outputs

1. DF on a grid illustrating the extent of B3 compliance
2. Minimum DLF Achieved
3. Maximum DLF - Achieved
4. Percent variation in DLF – reported as max uniformity ratio
5. Average Task Illuminance – at the work plane
6. Percent of Ambient Task Lighting

Factors not included in this version that will affect final results

1. Partition heights
2. Partition reflectance

Daylighting Factor Calculator - Summary Form Appendix I-4

Project					
Overall continuously occupied spaces that achieve the minimum daylight factor				#DIV/0!	
List all the continuously occupied spaces below and enter results from the Tool Sheet					
Room Name	Room Number	Room Area	% Area above min Daylight Factor	% Area exceeding Uniformity Ratio	% Window to Wall Ratio

ALTERNATIVE 1

All dimensions are in feet

Geometry	Alternative 1	Alternative 2
Room Width	30	30
Room Depth	30	30
Ceiling Height	10	10
Number of Windows	2	3
Width of each window	8	6
Sill - Vision	2.5	3
Head - Vision	6	9
Sill - Clerestorey	8	
Head - Clerestorey	10	

Summary Results

67% area above 1.0% Daylight Factor
7% area exceeds max uniformity ratio
10% window/ floor area ratio

Surface Properties	
Ceiling Reflectance	90%
Wall Reflectance	60%
Floor Reflectance	30%
Glass Visible Transmittance	60%

Do Isocontours | CALCULATE | Color for B3 Conditions

	0.75'	2.25'	3.75'	5.25'	6.75'	8.25'	9.75'	11.25'	12.75'	14.25'	15.75'	17.25'	18.75'	20.25'	21.75'	23.25'	24.75'	26.25'	27.75'	29.25'
	W I N D O W W A L L																			
0.75'	1.1%	1.7%	4.4%	17.0%	21.2%	21.8%	21.7%	20.3%	10.9%	3.1%	3.1%	10.9%	20.3%	21.7%	21.8%	21.2%	17.0%	4.4%	1.7%	1.1%
2.25'	1.8%	2.8%	5.3%	9.2%	12.0%	12.9%	12.8%	11.3%	8.1%	5.3%	5.3%	8.1%	11.3%	12.8%	12.9%	12.0%	9.2%	5.3%	2.8%	1.8%
3.75'	2.1%	2.9%	4.3%	6.0%	7.4%	8.0%	8.0%	7.3%	6.1%	5.2%	5.2%	6.1%	7.3%	8.0%	8.0%	7.4%	6.0%	4.3%	2.9%	2.1%
5.25'	2.1%	2.7%	3.5%	4.4%	5.1%	5.5%	5.6%	5.3%	4.8%	4.5%	4.5%	4.8%	5.3%	5.6%	5.5%	5.1%	4.4%	3.5%	2.7%	2.1%
6.75'	1.9%	2.3%	2.8%	3.3%	3.7%	4.0%	4.1%	4.0%	3.8%	3.7%	3.7%	3.8%	4.0%	4.1%	4.0%	3.7%	3.3%	2.8%	2.3%	1.9%
8.25'	1.7%	2.0%	2.3%	2.6%	2.9%	3.0%	3.1%	3.1%	3.1%	3.0%	3.0%	3.1%	3.1%	3.1%	3.0%	2.9%	2.6%	2.3%	2.0%	1.7%
9.75'	1.5%	1.7%	1.9%	2.1%	2.3%	2.4%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.4%	2.3%	2.1%	1.9%	1.7%	1.5%
11.25'	1.4%	1.5%	1.6%	1.8%	1.9%	2.0%	2.0%	2.0%	2.1%	2.1%	2.1%	2.1%	2.0%	2.0%	2.0%	1.9%	1.8%	1.6%	1.5%	1.4%
12.75'	1.3%	1.3%	1.4%	1.5%	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.5%	1.4%	1.3%	1.3%
14.25'	1.2%	1.2%	1.3%	1.3%	1.4%	1.4%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.3%	1.3%	1.2%	1.2%
15.75'	1.1%	1.1%	1.2%	1.2%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.1%
17.25'	1.0%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.1%	1.0%
18.75'	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%
20.25'	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%
21.75'	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.9%	0.9%
23.25'	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
24.75'	0.8%	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%
26.25'	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
27.75'	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
29.25'	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%

Greater than B3 max Contrast | Daylight factor and contrast ok | Less than B3 min daylight factor

ALTERNATIVE 2

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All dimensions are in feet

Surface Properties	
90%	Ceiling Reflectance
60%	Wall Reflectance
30%	Floor Reflectance
60%	Glass Visible Transmittance

Summary Results

100% area above 1.0% Daylight Factor
6% area exceeds max uniformity ratio
12% window/ floor area ratio

	0.75'	2.25'	3.75'	5.25'	6.75'	8.25'	9.75'	11.25'	12.75'	14.25'	15.75'	17.25'	18.75'	20.25'	21.75'	23.25'	24.75'	26.25'	27.75'	29.25'
	W I N D O W W A L L																			
0.75'	2.5%	5.7%	15.3%	18.3%	18.5%	15.8%	7.1%	7.1%	15.8%	18.6%	18.6%	15.8%	7.1%	7.1%	15.8%	18.5%	18.3%	15.3%	5.7%	2.5%
2.25'	4.1%	7.3%	11.8%	14.6%	14.9%	13.0%	10.1%	10.2%	13.2%	15.3%	15.3%	13.2%	10.2%	10.1%	13.0%	14.9%	14.6%	11.8%	7.3%	4.1%
3.75'	4.0%	5.9%	8.0%	9.5%	9.9%	9.3%	8.5%	8.6%	9.5%	10.4%	10.4%	9.5%	8.6%	8.5%	9.3%	9.9%	9.5%	8.0%	5.9%	4.0%
5.25'	3.4%	4.5%	5.6%	6.4%	6.7%	6.7%	6.5%	6.6%	6.9%	7.2%	7.2%	6.9%	6.6%	6.5%	6.7%	6.7%	6.4%	5.6%	4.5%	3.4%
6.75'	2.9%	3.5%	4.1%	4.5%	4.8%	4.9%	4.9%	5.0%	5.1%	5.3%	5.3%	5.1%	5.0%	4.9%	4.9%	4.8%	4.5%	4.1%	3.5%	2.9%
8.25'	2.4%	2.8%	3.1%	3.4%	3.6%	3.7%	3.8%	3.9%	3.9%	4.0%	4.0%	3.9%	3.9%	3.8%	3.7%	3.6%	3.4%	3.1%	2.8%	2.4%
9.75'	2.1%	2.3%	2.5%	2.7%	2.9%	3.0%	3.0%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.0%	3.0%	2.9%	2.7%	2.5%	2.3%	2.1%
11.25'	1.8%	2.0%	2.1%	2.2%	2.4%	2.4%	2.5%	2.5%	2.6%	2.6%	2.6%	2.6%	2.5%	2.5%	2.4%	2.4%	2.2%	2.1%	2.0%	1.8%
12.75'	1.7%	1.8%	1.8%	1.9%	2.0%	2.1%	2.1%	2.1%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.0%	1.9%	1.8%	1.8%	1.7%
14.25'	1.5%	1.6%	1.7%	1.7%	1.8%	1.8%	1.8%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.8%	1.7%	1.7%	1.6%	1.5%
15.75'	1.4%	1.5%	1.5%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.6%	1.5%	1.5%	1.4%
17.25'	1.3%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.3%
18.75'	1.3%	1.3%	1.3%	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
20.25'	1.2%	1.2%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%
21.75'	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
23.25'	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%
24.75'	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
26.25'	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
27.75'	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
29.25'	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%

Greater than B3 max Contrast | Daylight factor and contrast ok | Less than B3 min daylight factor

PROJECT NAME

Room (Name/ Number/ Other details)

Alternative 1

Minimum Daylight Factor Required	1.0%		
Max Uniformity Ratio Allowed	10.0		
	67%	area achieves 1.0% Daylight Factor	
	7%	area exceeds Max Uniformity Ratio	
Minimum daylight factor Achieved	0.8%	Maximum daylight factor achieved	21.8%
Design Ambient Illuminance	50	fc	

On an overcast day in each month the average daylighting is predicted to be:

Month	Average Daylight FC*	% of Amb. Illum.	Overcast days in month**
Jan	16.0	32%	48%
Feb	19.1	38%	50%
Mar	27.0	54%	55%
Apr	31.3	63%	50%
May	32.8	66%	48%
Jun	35.2	70%	40%
Jul	33.0	66%	29%
Aug	31.5	63%	32%
Sep	23.2	46%	40%
Oct	18.8	38%	45%
Nov	15.8	32%	60%
Dec	13.4	27%	58%

Summary of Inputs

Geometry		**Surface Properties**	
Room Width	30.0 '	Ceiling Reflectance	90%
Room Depth	30.0 '	Wall Reflectance	60%
Ceiling Height	10.0 '	Floor Reflectance	30%
Number of Windows	2.0	Glass Visible Transmittance	60%
Width of each window	8.0 '		
Sill - Vision	2.5 '		
Head - Vision	6.0 '		
Sill - Clerestorey	8.0 '		
Head - Clerestorey	10.0 '		

Summary Geometry Information

Exterior Wall Area	300 sf
Window Area	88 sf
Floor Area	900 sf
Window/ Floor Area	9.8%

Alternative 2

Minimum Daylight Factor Required	1.0%		
Max Uniformity Ratio Allowed	10.0		
	100%	area achieves 1.0% Daylight Factor	
	6%	area exceeds Max Uniformity Ratio	
Minimum daylight factor Achieved	1.0%	Maximum daylight factor achieved	18.6%
Design Ambient Illuminance	50	fc	

On an overcast day in each month the average daylighting is predicted to be:

Month	Average Daylight FC*	% of Amb. Illum.	Overcast days in month**
Jan	20.3	41%	48%
Feb	24.2	48%	50%
Mar	34.4	69%	55%
Apr	39.8	80%	50%
May	41.6	83%	48%
Jun	44.7	89%	40%
Jul	42.0	84%	29%
Aug	40.1	80%	32%
Sep	29.5	59%	40%
Oct	23.9	48%	45%
Nov	20.1	40%	60%
Dec	17.0	34%	58%

Summary of Inputs

Geometry		**Surface Properties**	
Room Width	30.0 '	Ceiling Reflectance	90%
Room Depth	30.0 '	Wall Reflectance	60%
Ceiling Height	10.0 '	Floor Reflectance	30%
Number of Windows	3.0	Glass Visible Transmittance	60%
Width of each window	6.0 '		
Sill - Vision	3.0 '		
Head - Vision	9.0 '		
Sill - Clerestorey	0.0 '		
Head - Clerestorey	0.0 '		

Summary Geometry Information

Exterior Wall Area	300 sf
Window Area	108 sf
Floor Area	900 sf
Window/ Floor Area	12.0%

*Based on overcast day sky data by Claude Robbins 1986

**Source - NOAA

The Human Nature of Noise and Vibration

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Noise and vibration continue to be dominant problems in modern buildings because we think of and treat them 'unnaturally'. While we have exemplary equipment and computational techniques to assess and analyze our acoustic and vibratory environments, these 'mechanic exercises' are often performed with relative insensitivity to the natural pattern of people and purposes those environments intersect. Noise and vibration considerations become disconnected from half of the person-environment equation, as it were, and are consequently misinterpreted or inconsequently rendered.

I propose that incorporating the 'human nature' of noise and vibration into our building assessments and analyses reveals new ways of addressing otherwise intractable issues, and promotes efficient and effective problem solving, which is what design is supposed to do. In addition, designing with awareness of the more subtle psychological and physiological impacts of the 'soundscapes' around us allows us to actually treat environmental sounds in more positive and productive ways, which produces added value for designed settings.

Consider the following real example of an urban restaurant owner who was concerned about the level of noise in his establishment due to complaints from his patrons. He engages an engineering firm for an assessment, which takes sound measures, and informs him that yes, the lunchtime noise levels are high at ~78+ DBA. Part of the problem appears to be the antique tin ceiling he has in his building, which he considers an indispensable part of the décor. They recommend covering it with acoustic tiles, at a cost of a few tens of thousands of dollars.

Does this sound familiar?

Dismayed and seeking an alternative solution, the restaurateur engages a new analysis by a Human Factors Psychologist. This maps the rise in sound levels as the restaurant fills for lunch, and correlates it against the number of patrons and where they sit in the establishment. A new pattern emerges: rises in sound levels lag the actual introduction of new patrons, and the successive increases seem to originate from two locations within the interior. One is at the serving line of the open kitchen along one side. The other is at the busing station on the opposite far wall. Coupled with knowledge of a fundamental habit of human speech, this suggests an entirely different design solution.

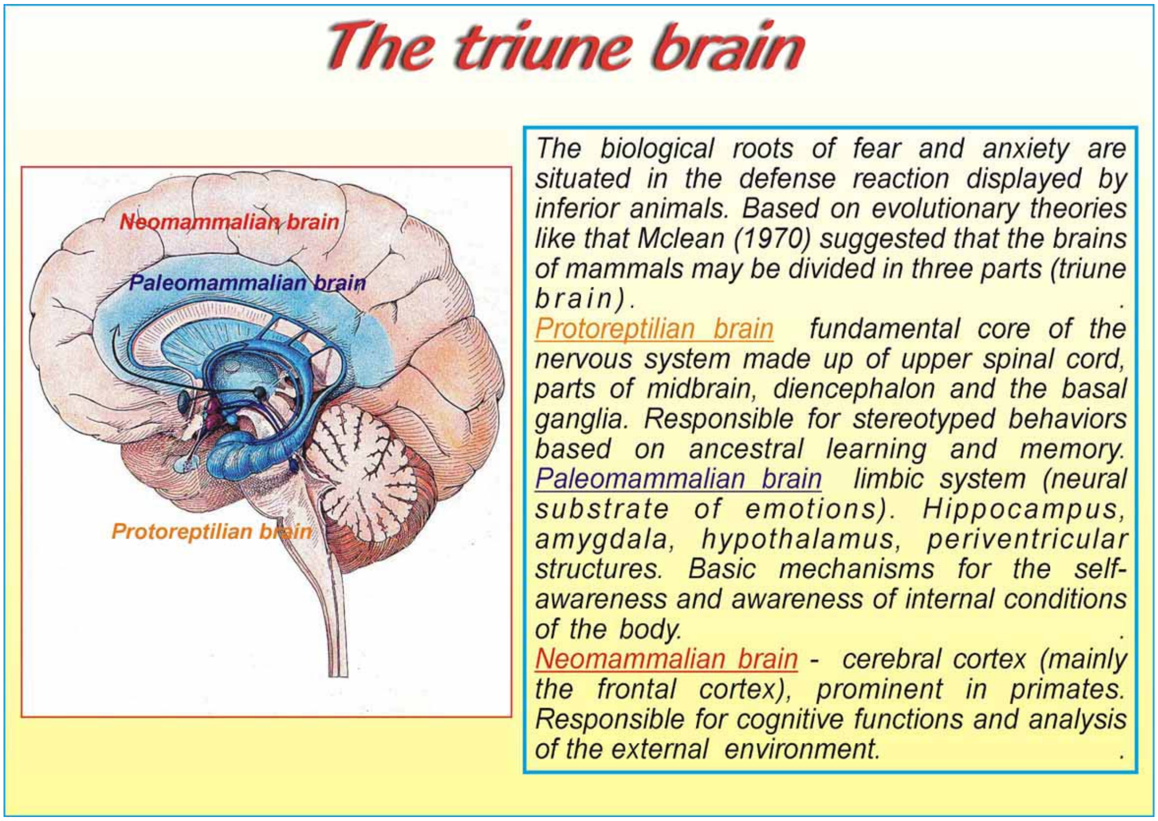
What is actually happening is that as patrons order and are served, the clatter and clinking of serving dishes increases as cooks and waitpersons become more active. The increased 'noise' produced by handling dishes, silverware and glassware naturally originates where the dishes are prepared and where they are transferred to collect and return for washing.

Patrons seated next to these locales speak louder so as to be heard over the increased clatter, which competes with speech frequencies (~1- 4MHz). People tend to speak at ~10DB higher than background noise, so as the most impacted patrons raise their voices, those next to them do likewise, only 10 DB greater. This sets in motion a rapid positive feedback loop wherein patrons now try to successively talk over higher and higher background levels, up to their sustained maximum capability.

The solution? Stop the generators of the entire noise-production system by resurfacing the serving line and floor area with noise absorptive materials, enclosing the busing station and treating its interior similarly, then altering some serving and busing activities to be less noise producing—all at a cost of less than a fifth that of a new ceiling, with no loss of interior atmosphere to the establishment.

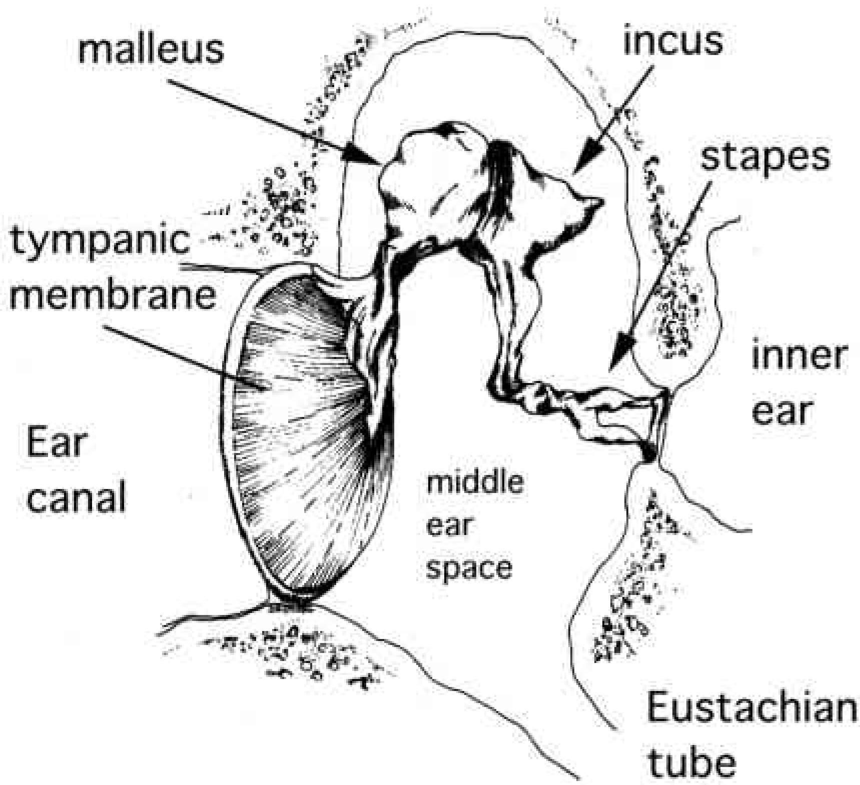
This example shows how a 'noise' problem can be reconceived and successfully addressed if it is construed within the broader person-environment context. There is more than just the physics of sound at work in any of these; there is the inherent psychophysics and the active perceptual control loops of the performers in the setting. These in turn are neither arbitrary nor idiosyncratic, but the result of social convention, our neural/sensory processes and our species' own biological heritage on planet Earth.

As I described in an earlier article for HPAC (1), every person alive today encounters the environment in three qualitatively different ways according to the hierarchy of our neural construction: *Reflexivel*y at the level of our neural chassis, *Emotionally* at the level of our midbrain and limbic system, and *Cognitively* at the level of our own most recent addition, the cerebral cortex.



(Figure 1. Hierarchical Brain Construction < www.psicobio.com.br/eng/ the_triune_brain.html>)

All of these need to be considered in addressing the human nature of noise and vibration, because sounds and vibrations have long been essential characteristics of the natural world. And in its structure and function, our auditory system retains the history of how life has encountered and utilized sound in settings. For example, we have an *acoustic reflex* similar to the well-known pupillary reflex, where the pupil constricts in response to light. In the acoustic reflex, the tensor tympani, a small muscle attached to the eardrum, and the stapedius, a small muscle attached to the stapes bone of the middle ear, contract in the presence of a loud sound, stiffening the eardrum and ossicles to prevent transfer of impacting sound energy to the inner ear. This is a curious reflex, since it is primarily low-frequency sounds that are damped. This reflex also occurs when talking or chewing something, and illustrates how our auditory system at a base level differentially treats low vs. higher frequency sounds.



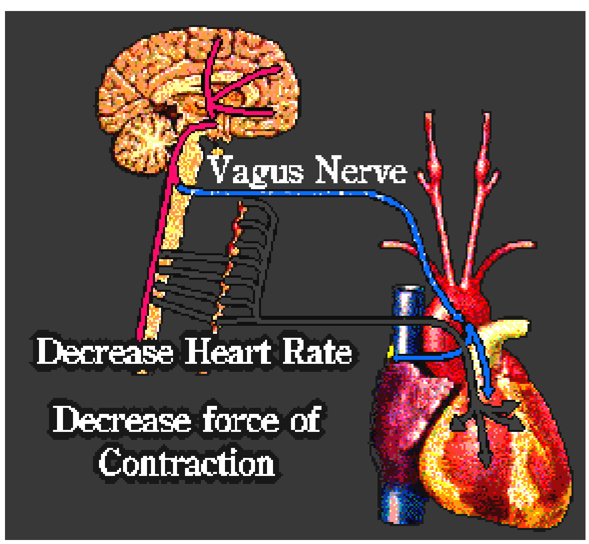
(Figure 2. Structure of the Middle Ear, < depts.washington.edu/.../ images/middleear.jpg>)

This distinction between low and higher frequencies is reinforced in those neural structures that handle our emotional responsiveness to environmental sounds. Lower sound (and even frequencies below the lower limit of our hearing instill a sense of arousal, awe, or unease in us (2) depending on contextual cues, and have long been used to set mood in movies' background scores. This emotional subtext appears to have an ancient origin in the early days of mammals, when reptiles were dominant on Earth. Reptiles both hear and communicate at lower frequencies, because they rely solely on bone conduction to transmit sound. Mammals shifted their communication exchanges to higher frequencies above that accessible to dinosaurs by transforming the earlier jaw structure of reptiles, which eventually became the bones of the mammalian inner ear. But this was accompanied by a fork in mammals' neural processing of sounds: one predominant pathway became devoted to their own vocal communications, and the other (through the vagus nerve) remaining highly emotionally responsive to low frequencies--the prime range occupied by then prevalent predatory reptiles. As a result, sounds to us are intimately bound up with the neurology of our emotional controls (and soft jazz or martial music each has their desired emotional effects on us).

In modern industrial society, noise composed of low frequency sounds produced by machinery and transportation are ubiquitous, and may have a special emotional impacts on children, who rely more on inherited neural processing programs than maturational (via developing cerebral structures) and socially acquired ones. In animal studies, proper postnatal maturation of the visual system requires the kind of visual inputs that would be encountered in a ‘normal’ environment, and there is increasing evidence in animals of the same for the auditory neural system (3). Indeed, evidence is also growing regarding the adverse impacts of general chronic background noise on reading development and other cognitive processes in young children (4).

Consider this in the context of the new ANSI/ASA standard S12.60, *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools,* which mandates no more than an NC 35DBA background noise criterion for classrooms (5). All of the research done to support this new standard appears built around the assumption that all effects of background noise in classrooms directly interfere with the higher speech frequencies. Yet naturalistic observations in actual classrooms that generated concerns would have included the more likely low frequency sounds which predominate there, and which likely induce their own emotional impacts on children. Here’s why:

> When neural activation (via the facial and the trigeminal nerves) to the ossicles (the bones of the middle ear) is decreased, the middle ear does not successfully filter out the low frequency sounds so evident in classrooms. That neural damping is lowered when the ability to acquire and maintain a calm behavioral state through the myelinated vagus nerve lessens. Neural damping is subverted in an environment *with a standing pattern of low frequency sounds*, *which is ancestrally similar to the one where dominant reptiles preyed upon early mammals*; and so is one where low frequencies must be attended to for survival reasons. The normal (sympathetic) state of the nervous system that handles activated responses then becomes dominant. Such an environment is 'arousing' (6).



(Figure 3. Vagus Nerve Connections < user.gru.net/clawrence/ vccl/chpt6/a05.gif>)

So consider children, whose voices are pitched correspondingly higher than adults, and who rely on ossicular stiffening even more for social verbal communication. Put them into a setting with low frequency noise; say from nearby traffic or HVAC units. What happens then is that under such consistent noise they lose the standing neural activation along their ossicular chain, along with their ability to discriminate the human voice. Then all of this is accompanied by loss of a parasympathetically administered calm behavioral state, with concomitant rise in arousal and the 'flight or fight' syndrome it creates. Does this start to sound like a ‘normal elementary school classroom’?

The point here is that the new ANSI/ASA standard may be misguided in mandating a relatively low NC curve based on speech interference concerns alone when low frequency sounds in classrooms may be the root source of difficulties. And if one looks at NC curves, they all rise significantly in the low frequencies, since these are not ’interfering’ in normal speech communication studies. The solution to young students' inability to hear and to their disruptive states may not be to institute a drop to an overall NC 35 or lower curve as the Acoustical Society of America has decided. The solution may rather be to reduce the low frequency noise, and let our biological nature and neural systems work as evolution has equipped them to do. At the very least, this alternative hypothesis around an emotionally driven source of hearing and learning difficulties in schools deserves a longer look and some real tests before embarking on expensive school buildings modifications programs to an NC 35 standard.

The modern open and cubicled office workplace is another setting inordinately impacted by noise from machines and conversations. Noise complaints commonly end up in the first or second rank of those surveyed (behind temperature problems). Noise problems here are of two types: One is annoyance with background noises, and the other is concern for speech privacy. Annoyance appears to mandate low background NC curves, while speech privacy appears to call for higher ones, in order to produce masking effects. A recent pair of studies on simulated office noise levels and adjusted spectral composition by J. Veitch and her colleagues (7) lay the groundwork for yet a third way of regarding noise in offices. She found again that a measure of the *difference* between A-weighted levels of *low frequencies relative to high* was the best predictor of the different dependent measures. Her results also showed that louder levels of noise at low frequencies than high ones were preferred, that noise levels much greater than 45dBA are judged as too loud, and that acoustic satisfaction increases as speech intelligibility decreases. So, the task for treating background noises in an open-plan office becomes a complex one: Provide speech privacy without overly increasing the higher frequencies that normally would effectively mask speech. This again suggests the differential treatment of low and higher frequencies in the construction of an appropriate background ‘soundscape’ that enlists both the emotive and the speech masking effects of background sounds. Such constructions can no longer be thought of as simply, “masking noise”.

Indeed, the ‘human nature’ of noise requires that it never be treated solely as the acoustic abstraction that term seems to imply, because in natural settings there never was a meaningless, random panorama of background sounds in the history of life on earth. Every ‘soundscape’ was associated with living or environmental events, and carried potentially critical cues for survival to all who could engage it. In modern work and living environments, it is not enough to simply reduce 'noise'. The real question, and effort, lies in creating supportive and informational built environment soundscapes that fulfill the same roles as those of our ancestral landscapes, still resounding in our neural makeup.

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Guidelines: Materials & Waste

Guidelines

Forms

Overview

Selection and use of materials and resources for more sustainable building has been an evolving process since the first recycled content products hit the market in the early 1970s. Costs related to increased waste from construction, depletion of non-renewable resources, and air and water pollution from production and distribution are becoming increasing drains on our economy. Because the building industry consumes over 3 billion tons of raw materials annually - around 40 percent of the total material flow in the global economy - the need to reduce the effects of building material extraction, processing, delivery, use, and disposal has become imperative to improving the health of our economy and our communities. To this end, guidelines and rating systems have sought to guide practitioners toward choices that reduce waste and the negative environmental impacts associated with materials through prescriptive requirements for such characteristics as amount of recycled content, locally produced or assembled products, and sustainably harvested wood. The State of Minnesota Sustainable Building Guidelines (MSBG) are moving away from prescriptive requirements toward material selection based on Life Cycle Assessment (LCA) and Life Cycle Cost (LCC), which will provide a better connection to real effects and costs based on outcome-based performance criteria. However, until there is more complete data available, MSBG will still use prescriptive requirements to effect change. To gather the necessary performance data, MSBG requires "Outcome Documentation" (M.4,) which provides measurements of the environmental, economic, community and health impacts related to materials selection.

Current tools associated with LCA include ATHENA (www.athenasmi.org) and BEES (Building for Environmental and Economic Sustainability -www.bfrl.nist.gov/oae/software/bees.html.) These programs offer basic information on the environmental impacts associated with full life cycle review of materials and products - from extraction/harvesting through production/ manufacturing, transportation, use/reuse, and disposal. Where information from LCA and LCC data is available, it has been provided in easily accessible charts to assist in making informed decisions to use or not use a variety of individual materials as well as assemblies. The aim of MSBG is to gather additional data from projects, both technical and anecdotal, and to augment current information in order to improve the selection process and provide real choices, based on quantifiable data specific to our region.

Goal
To produce projects with the lowest reasonable life cycle cost and environmental impact, while providing the highest level of community and human benefits, based on material resource use and waste management.

Objectives
- Evaluate design alternatives to optimize the life cycle of the building and to minimize a projects material resource use over its lifecycle considering alternatives such as: designing for reduced construction through shared use of spaces, building or material reuse, design for disassembly/future reuse of building components, and design for flexibility and adaptability, appropriate to intended building and material life and selecting building systems taking into account their economic, human, community, and environmental outcomes over the lifecycle of the facility.
- Evaluate material alternatives to optimize their total life cycle performance considering material property alternatives such as: high recycled content, locally/regionally produced, made from rapidly renewable agricultural byproducts, ability to be reused, recycled, or that are biodegradable, and maximum durability based on anticipated life of interior construction, equipment, finishes, and furnishings.
- Reduce and manage wastes generated during the construction process and operation of buildings (building occupancy.)
- Determine the projects net environmental, economic, and community impacts over its lifecycle related to quantity and type of material used and the way that waste is reduced and managed.

M.1 Evaluation of Design for Resource Use

Intent
First, evaluate the benefits of planning for conservation approaches such as designing buildings appropriate to their projected life cycle and minimizing a project's material resource use over that lifecycle. Secondly, evaluate and select building systems taking into account their economic, human, community, and environmental outcomes over the lifecycle of the facility.

Required Performance Criteria
Planning for Conservation Analysis:
- In this guideline, there are no requirements for how to respond to planning for conservation strategies; however, documentation of design decisions is required to evaluate these strategies for their economic, human, community and environmental outcomes.
- Base the evaluation on a selected life projected for the building for the following basic systems: Substructure, Exterior Shell, Roofing, Interior Walls, Interior Finishes, Furnishings. If the agency responsible does not set a specific life of the building, use a 50 year minimum life for major structural, shell and cladding components. For interior construction, finishes, and furnishings assume an industry standard model of life cycle for project type and scale. Indicate appropriate information relative to life cycle term on Form M-A and Form M-1.
- Evaluate the following recommendations for their benefits towards economic, human, community, and environmental outcomes and document the information on Form M-A as appropriate to the level of detail required at this point:
- Design for Less Space: Maximize use of space by sharing space/services, expanding hours of use, or other means to reduce overall square footage requirements from traditional building model for specific project type. Refer to P.2 Planning for Conservation for Implementation.
- Design for Building Reuse: Reuse an existing building versus building a new building, to save or minimize material resources.

  - Design for Less Resource Use: Reuse existing building materials, equipment, finishes, or furnishings versus constructing using new materials, to save or minimize material resources.
- Design for Flexibility, Adaptability, and Disassembly: Reduce material resource use through design that: allows for adaptability of space and building components to accommodate new or alternative uses, provides flexibility to accommodate projections of churn, minimizes ongoing material requirements associated with renovation or remodeling, and provides capability for disassembling for reuse for a minimum of 25% of the mass of the building structure and 25% of the interior construction (partitions, finishes,` furnishings.)
- Design for Appropriate Life of Substructure and Structural Systems, Exterior Cladding and Shell, and Building Systems (Durability): Provide evaluation of building system components that meet agency requirements for life of building. Recommendation, if not specifically determined by client, is for a 50 year life for major building structural components, exclusive of interior construction, finishes, and furnishings.
- After analyzing alternatives, select desired planning for conservation approaches above and incorporate them, updating variables for items such as lifecycle planned for the building, reused building area versus new, or other reduced area of construction. If construction types have changed due to this analysis, for example to better accommodate disassembly, then also incorporate these.

Building System Life Cycle Analysis:

- Compare at least two alternatives for each of the following building systems: Substructure, Exterior Shell, Roofing, Interior Walls, Interior Finishes, Furnishings. These may be various traditional options or other proposed alternative building systems. The comparison shall consider impacts on economic, human, community and environmental outcomes where data is available. Use examples of typical building systems provided in resources for these Guidelines, or use proposed alternative examples created with Life Cycle Analysis software (recommended programs such as ATHENA or BEES.)
- Based on project sustainable goals, evaluate the comparisons and select those systems that offer the most beneficial outcomes for all of the project concerns.
- Complete requirements for Outcome Documentation of final building systems selection and evaluation for total material resources used.

Tools

See Appendix M-2.B Material/Assembly Selections Life Cycle Assessment Informational Chart for applicable material and system selections for basic calculations.

For more complete building system evaluations, use the ATHENA Tool/Calculator, BEES, or other LCA tools and programs. Where available, use manufacturers' Life Cycle Assessments, if public.

Resources

The Minnesota Office of Environmental Assistance (MOEA) web page on Construction and Demolition Waste (C&D) is an excellent resource for information on salvaged materials, designing for less waste (advanced framing), and deconstruction, and provides links to EPA's C&D Debris web site, INFORM and Institute for Local Self Reliance (ILSR) deconstruction fact sheets, ASTM sustainability standards, and more. www.moea.state.mn.us/greenbuilding/waste.cfm

The Minnesota Building Materials Database www.buildingmaterials.umn.edu

Building Construction and Reuse, article, Center for Construction & Environment, University of Florida; www.cce.ufl.edu/past/deconstruction/reuse.html.

National Association of Home Builders, Advanced Framing Techniques; www.nahb.org.

The Resourceful Waste Management Guide (RWM Guide) is produced by the Solid Waste Management Coordinating Board (SWMCB.) The SWMCB is a joint powers board of six metropolitan counties whose for the purpose of is planning and coordinating solid waste management activities. The RWM Guide provides a list of Twin Cities material outlets which building owners, contractors, or design professionals can contact to recycle demolition waste and donate equipment, materials, and other items generated from a building demolition. The following sections of the RWM Guide relate to building demolition: Donation Opportunities; Appliances; Building Materials Reuse, Computers, Electronics, and Office Machines; Concrete and Bituminous Asphalt; Fluorescent Lamps, Landscaping and Tree Waste; Office Furniture and Equipment; Railroad Ties; Scrap Metal; Textiles; and Wood Waste. If you would like a copy of the Resourceful Waste Management Guide, please email your name and address to: paul.kroening@co.hennepin.mn.us or call (612) 348-6358.

Suggested Implementation

Agency Planning

- Refer to Performance Management Guideline P.2 Planning for Conservation for phase recommendations in addition to those indicated below. Coordinate efforts of P.2 with M.1 so that all aspects of life cycle materials use are considered together.
- Establish recommendations for life of building and major building systems based on typical program, expectations for future expansion and reuse, and considerations for flexibility and adaptability.
- Complete Form M-A and Appendix M-1 by inserting information from appropriate Guideline Tables to determine relative impacts for typical building model.

Predesign-Programming

- Following recommendations on building less in P.3 Planning for Conservation, evaluate options of reuse of whole or partial buildings and materials, furnishings, and equipment.
- Set goal for amount of building to be designed for disassembly based on project type and use, and building systems affected.
- Estimate the percentage of building materials that are likely to be affected by the average 'churn' rate for the agency or project type. and set goal for integrating flexibility and adaptability into the design of primary material resource areas most impacted by churn.

Schematic Design

- If the material lifecycle plan includes disassembly goals, establish materials, products, or components that support disassembly goals and develop design strategies to achieve these goals. At this design phase, employ design strategies to reflect the following considerations as needed to meet disassembly goals:
    - Use structural systems, cladding systems, and non-load bearing wall systems that facilitate disassembly.
    - Use structure/shell systems that maintain integrity when demounted or disassembled (i.e. steel, glass, or concrete and panel claddings)
    - Use materials, systems, and components that can be assembled or fastened in a manner that facilitates reassembly into new construction or remodeling.
    - Provide cost and environmental data for comparison and evaluation.
- Where disassembly is not an option, or proves less efficient because of the expectations for the full life-cycle of the building, establish materials, products, and components that promote durable construction that supports life-cycle goals.
- Complete this process of evaluation using either the Tables provided in this Guideline, or a Life Cycle Assessment program such as ATHENA or BEES. Enter values obtained from the Tables or programs in the appropriate Forms included in the Appendix for these Guidelines.

Design Development

- Refine selection of materials and products to reflect project plan team recommendations for overall environmental performance for maximum flexibility, adaptability, and disassembly. At this design phase, employ design strategies to reflect the following considerations:
    - Use materials, systems, and components that can be recycled or reused in whole or in part.
    - Use materials that are durable, weather well, and last for the intended lifetime of the structure (including masonry, steel, glass, and some timber products such as beams, columns, floorboards, etc..)
    - Use materials, systems, and components that can be assembled or fastened in a manner that facilitates reassembly into new construction or remodeling.
    - For greatest flexibility, use homogeneous materials, products, or assemblies that facilitate separation and reuse, additional lateral recycling, or are readily biodegradable. However, if using composite, glued, adhered, or laminated components , select those which can be reused, deconstructed, recycled again, or composted, if possible. Ensure if composite, glued, laminated, or adhered materials are selected which have the potential to off-gas, they are properly sealed during or after fabrication and before occupancy.
- Provide updated cost and environmental data for comparison and evaluation.
- Complete appropriate sections of Form M-A and Appendix M-1 with selections of typical or alternative building systems which support project goals.

Construction Documents

- Develop final drawings and specifications detailing specific system requirements for disassembly, including description of fastening systems, connectors, and recommendations for reuse of materials to be reused within existing construction or which could be reused for other construction in the future.

Construction Administration

- Document any changes to recommendations for construction that occur that may seriously impact the future disassembly of components or materials.
- Observe construction site to verify that materials, products, and systems are being correctly installed to preserve project goals and objectives as represented in the drawings and specifications.

Next Use

- During considerations for the "next use" of the facility, consult the project data history to identify and inventory systems and building components that can be disassembled for reuse, salvage, or recycling and document their inclusion in project renovation, remodeling, or deconstruction for use in the future or at another location.

M.2 Evaluation of Material Properties for Improved Performance

Intent

To determine the value and encourage the use of materials and products that meet specific prescriptive requirements understood to provide improved life cycle performance. Proof of improved life cycle performance will encourage increased demand for these building materials and products and, therefore, increased availability for use.

Required Performance Criteria

This guideline does not require implementation of any minimum level of materials or products meeting these criteria. However, in most cases a recommended minimum level is suggested and an analysis is recommended that considers the economic, human, community and environmental outcomes from supplying a percentage of the building's total mass with materials and products meeting these criteria.

Material properties to be evaluated and documented in Appendix M-2.A:

- High recycled content
- Locally/regionally produced and manufactured.
- Made from rapidly renewable agricultural byproducts
- Able to be reused, recycled, or that are biodegradable
- Maximum durability based on anticipated life of exterior and interior construction, equipment, finishes, and furnishings

Evaluate material or product selections based on the following criteria and indicate benefits based on Life Cycle Assessment (LCA) information where available, or anecdotal information in the form of descriptive paragraphs where LCA is not available at this time. For consistency in collecting data for comparison, the following levels are recommended for evaluation:

- Materials that contain, in aggregate, a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 50% post-industrial recycled content material.
- Materials manufactured[2] regionally within a radius of 250 miles of project site to specified qualifications, or are manufactured within the State of Minnesota and contain products from state-sponsored, approved, or acknowledged recycling programs.
- Materials locally/regionally produced[1] (from within 500 miles of the project site, or within the State of Minnesota, or which contain materials from State of Minnesota recycling programs.)
- Wood products (for wood building components, including but not limited to structural framing and general dimensional framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete formwork, and pedestrian barriers) certified in accordance with approved third party authorities, which meet the following criteria at a minimum:
    - Provide 'chain of custody" for all wood products;
    - Use 'on-the-ground' performance-oriented evaluation techniques that do not rely only on procedural review;
    - Do not use a different standard for products obtained from suppliers not owned by the company seeking certification; and
    - Do not allow 'conversion' of natural forests to plantations.
- Materials made from rapidly renewable agricultural byproducts.
- Materials made from reusable, recyclable, or biodegradable resources. Refer to M-1 for materials specifically selected to promote minimum resource use.

Materials and products which have more than one recommended characteristic will, in most cases, provide higher cumulative benefits than those with only one characteristic.

Tools

Refer to Appendices M-2.A and M-2.B.

[1] Refer to Definitions in Glossary.

Resources

The Minnesota Office of Environmental Assistance (MOEA) web page on Building Products and Materials is an excellent resource for information on recycled-content products, including the OEA Recycled Products Directory, other directories, and informative fact sheets (including the Environmentally Preferable Purchasing Guide.) The page also provides links to standards and product lists from ASTM, EPA (Comprehensive Procurement Guidelines), Forest Stewardship Council for certified wood, Green Seal, and Scientific Certification Systems. Links to ATHENA, BEES 3.0, BuildingGreen (EBN), the OIKOS directory and more.
www.moea.state.mn.us/greenbuilding/products.cfm

Minnesota Building Materials Database www.buildingmaterials.umn.edu

Example: Use of major structural components and interior finishes that will withstand use and aesthetic requirements for length of service.

- Dakota County Northern Service Center: Designed and constructed for a 50-100 year lifecycle.

Suggested Implementation

Predesign-Programming

- Refer to recommendations established for M.1 for use in subsequent evaluations to meet this Guideline's requirements.

Schematic Design

- Identify the building systems assemblies where the most impact on improving environmental performance, as defined by LCA criteria, can occur for the project.
- Develop alternative strategies for building system components and compare environmental outcomes of durable products versus those which will be replaced more often, using life cycle tools or representative models and the Appendix M-2.B, or providing anecdotal evidence of improved environmental, economic, community, or human benefits.
- Complete the evaluations of building system components and specific materials and products selected using the format of Appendix M-2.A.
- Provide initial, building system assembly cost data for comparison and evaluation.

Design Development

- The next step in the documentation of life cycle impacts requires the selections be evaluated using criteria specifically designated by the State as important to the general population and economy. These criteria, such as recycled content and locally manufactured products, may not have specific attributes in standard life cycle programs; however, wherever possible, provide evaluation using life cycle assessment methods, including ATHENA or BEES. Refer to The Minnesota Building Materials Database (www.buildingmaterials.umn.edu.)
- Refine selection of materials and products to reflect project team recommendations for overall environmental performance.
- Research suppliers, costs, scheduling and availability of materials, and other criteria which may impact use of selected materials and systems.
- Complete Appendix M-2.A, using LCA or anecdotal data to build the database of product and system information available for review.
- Provide updated cost data for comparison and evaluation.

Construction Documents

- Develop detailing and specifications that support the selection and provision of materials, products, and systems selected for environmental performance.
- Develop detailing and construction recommendations that minimize material use and maximize performance of materials to support 'material resource efficiency' requirements.

- Compile material and product documentation from the manufacturer, declaring life cycle and warranty recommendations indicating durable life cycle projections for building components.
- Provide specifications which require contractor submittals highlighting durable materials installed.
- Provide a spreadsheet of all materials used on the project, highlighting categories of performance levels,, including durability, recycled content, locally manufactured, and those with high rapidly renewable resource content. Include calculations demonstrating that 50% of materials (by volume) are considered durable, and verify percentages of content where required to meet performance criteria.

- Provide updated cost data for comparison and evaluation.

Construction Administration

- Monitor submittals to ensure project includes selected materials; review substitutions based on selected criteria to ensure consistency and compliance with goals and objectives.
- Monitor construction site to verify that materials, products, and systems are being correctly installed to preserve project goals and objectives.

Next Use

- During considerations for "next use" of the facility, incorporate material selections which reflect selections that support use of durable materials, which can be disassembled, reused, or recycled.

M.3 Waste Reduction and Management

Intent

Minimize use of resources and negative environmental impacts through careful reduction and management of wastes generated during the construction process and operation of buildings (building occupancy.)

Required Performance Criteria

- Construction waste: Minimize waste generated from construction, renovation and demolition of buildings through detailing and specifications. Divert construction, demolition, and land clearing debris from landfill disposal. Redirect recyclable material back to the manufacturing process and reuse, recycle, and/or salvage at least 75% (by weight) of construction, demolition, and land clearing waste (per State of Minnesota requirements.)
- Packaging waste: Reduce and recycle packaging waste associated with the construction process, and encourage manufacturers to ship their product using reusable, recyclable, returnable, or recycled content packaging. Reuse or return 50% of all packaging material, by weight, to suppliers or manufacturers.
- Hazardous waste: Establish a goal of at least a 50% reduction in the use of hazardous materials through project construction and building operation. Appropriately store, handle, and dispose of hazardous waste generated during building construction, operation, and decommissioning.

Recommended Performance Criteria

- Recommendation for higher achievement on construction waste management: Recycle and/or salvage an additional 15% (90% total by weight) of the construction, demolition, and land clearing waste.
- Recommendation for higher achievement on packaging waste management: Return an additional 25% (75% total by weight) of all packaging material to suppliers or manufacturers

Tools

Worksheets: Appendices M-3.A, M-3.B and M-3.C.

- Construction Waste Management Worksheet M-3.A. (See Example for inclusion in Specifications.)
- Packaging Specification Worksheet M-3.B
- Hazardous Waste Management Worksheet M-3.C

Provide information as component of Outcome Documentation Evaluation Form M-A.

Resources

The Minnesota Office of Environmental Assistance (MOEA) web page on C&D Waste is an excellent resource for information on reduction and management of construction and hazardous waste. Includes OEA's Recycling Markets Directory and MN Materials Exchange. Provides links to MPCA's hazardous waste rules and fact sheets for each special waste. Links to EPA's C&D Debris web site.
www.moea.state.mn.us/greenbuilding/waste.cfm

The MOEA web page on Efficient Transport Packaging Options is an excellent resource for reducing packaging waste. Includes a searchable directory on Reuseable Transport Packaging.
www.moea.state.mn.us/berc/transpack.cfm

Case Studies: Examples of recycling programs from projects in metro and outstate areas.

- Augsburg Publishing Co.
- Minneapolis Central Public Library
- DNR Fergus Falls Area Headquarters
- Ramsey County Maintenance Facility Site Demolition
- Additional Case Studies from WASTESPEC www.tjcog.dst.nc.us/wastcase.htm

Construction Waste Management Specification Language (Example: Section 01690)

Management Plans: Follow hazardous waste programs from Solid Waste Management Coordinating Board (SWMCB)

Refer to WasteSpec www.tjcog.dst.nc.us/cdwaste.htm

Suggested Implementation

Predesign-Programming

- Evaluate agency operational waste management procedures and develop implementation goals for incorporation in building program and design.
- Reduction of construction waste through deconstruction, salvage, recovery, and appropriate design and detailing are primary goals.
- Set goals for reduction/recycling/salvage/disposal for construction, packaging and hazardous waste based on project type and availability of local programs.

Schematic Design

- Establish project occupancy goals for waste management during the lifecycle of the building. Incorporate areas to support those goals through first and subsequent occupancy cycles.
- Establish goals for landfill diversion and adopt a construction waste management plan to achieve these goals.
  - Minimal list for inclusion: Recycling land clearing debris, cardboard, metals, brick, concrete, plastic, clean wood, glass, gypsum wallboard, carpet, and insulation.

Design Development

- In planning, set aside a staging area on site for collecting, storing, and processing packaging that needs to be returned to the vendor, along with an area for construction waste management (salvage/recycling/disposal.)

- Develop environmentally responsible packaging criteria. Identify suppliers that use environmentally responsible approaches to packaging. Favor suppliers which meet this criteria
- Refine selection of materials and products to reflect project team recommendations for overall environmental performance for minimal creation of construction, packaging, and hazardous waste.
- Enter evaluations and results in Outcome Documentation (Form M-A)
- Provide cost data for comparison and evaluation.

Construction Documents

- Develop specifications that support the minimization of material use and clearly require construction waste management that supports project goals.
- Develop detailing and construction recommendations that minimize material use and maximize performance of materials to support 'material resource efficiency' requirements.
- Update cost data for comparison and evaluation.

Construction Administration

- Monitor submittals to ensure project construction waste program includes materials specified; review revisions to program to ensure consistency and compliance with goals and objectives.

Next Use

- During considerations for "next use" of the facility, verify selections that can be recycled or salvaged.

M.4 Outcome Documentation for Materials and Waste

Intent

Document the environmental, economic, and community impacts related to material use and waste management in buildings. Human benefits to occupants of low-emitting materials are covered and documented under Outcome Documentation for Indoor Environmental Quality.

Required Performance Criteria

- Complete M-A Outcome Documentation Form at the end of each phase to document design decisions for those portions of the guideline implemented at that time.

Resources

Building Construction and Reuse, article, Center for Construction & Environment, University of Florida; www.cce.ufl.edu/past/deconstruction/reuse.html.

Suggested Implementation

Predesign-Programming

- The desired outcome for this guideline requirement is to build a database of the actual impacts of designing and constructing buildings following sustainable guidelines.
    - Select traditional models for buildings of similar type, size, and level of quality for use in comparison with sustainable selections. Document process for selecting representative model for project building type to use for comparison throughout entire project.
    - Where specific technical information is lacking, provide anecdotal information in the form of a descriptive paragraph for Environmental, Economic, Human, and Community Benefits or Impacts.

- Identify major areas of programming and planning, design, and construction where significant improvements in use of materials, based on examples, case studies, and design recommendations, can provide the basis for early comparisons that will lead to insightful selections.

Predesign-Site Selection

- Demonstrate evaluation of decisions to reuse buildings or materials from existing buildings
- Locating a project in a specific area might offer some benefits by reducing overall environmental impacts associated with materials which are salvaged, reusable, or locally manufactured. Evaluate that location and present evaluation information, technical or anecdotal, in the form of an LCA comparison chart. (See Appendices and Resources for examples.)

Schematic Design

- Compile information from team leaders.
  - Establish specific project goals for the proposed building regarding the use of building materials manufactured with a low environmental impact during their life cycle. The phases of the life cycle are: Raw Material Extraction, Production, Distribution, Installation, Use and Maintenance, and Eventual Reuse or Recycling. (Low environmental impact refers to reducing specified resource inputs and emissions to air, land, and water.) Provide documentation of building system selection using an analysis tool similar to ATHENA .or the M.2-B Chart for basic assemblies or major building components.
  - Provide cost estimate reflecting major system selections at SD.
- Sign off on Compliance Summary Form and Outcome Documentation Form associated with analysis requirements for each one of the "required guideline categories."

Design Development

- Compile information from team leaders. Refine evaluations for major building system components and increase inclusion of recommended materials where higher definition is available.
- Provide updated cost estimate reflecting major product selections and manufacturers' information at DD.
- Sign off on Compliance Summary Form and Outcome Documentation Form associated with analysis requirements for each one of the "required guideline categories."

Construction Documents

- Compile information from team leaders.
  a. Complete Appendix M.2-A for all major materials used on the project, highlighting materials with low environmental impact.
  b. Submit "community, human, and social" commentaries in addition to LCA and where LCA is not available.
- Provide updated cost estimate reflecting major product selections at CD.
- Sign off on Compliance Summary Form and Outcome Documentation Form associated with analysis requirements for each one of the "required guideline categories."

Construction Administration

- During construction, ensure that materials meeting the projects environmental impact goals and specified requirements for installation are installed as specified and verify the total percentage of these products installed by reviewing submittals, and reviewing and approving product substitutions to comply with stated requirements in specifications and on drawings.

Construction

- During construction, monitor proper installation of materials and that contractor is meeting the specified installation and construction/waste management requirements. Ensure that specified documentation is completed and that project goals are satisfied.

Correction Period

- Monitor performance of material and system selections for adherence to project performance goals.

Ongoing Occupancy

- Provide final "case study" report after construction, including list of selections and final installations, evaluation of decision-making process, and cost comparisons for major systems/components.

Next Use

- See Form M-A Materials and Waste - Outcome Documentation Form.

FORM M-A: MATERIALS AND WASTE — OUTCOME DOCUMENTATION
For work through phase: _________________________as of the date:___________________

LESS RESOURCE USE BY DESIGN

- Is there an existing building(s) on site? ______ Size and type ______
- Reuse of existing building (s): Shell (percent and area) ______ Interiors (percent and area) ______
- Building life cycle (years): Baseline model ________ Project design model ________
- Building program (sf): Baseline model ________ Project design model ________
- How much was program reduced by efficient planning and sharing of space? ________
- Was the project designed for flexibility or adaptability to future uses? ________ Explain ________

MATERIAL AND PRODUCT CHARACTERISTICS

- Total material on project: Volume ________ Cost ________
- Total post-consumer (PC) recycled content on project: Volume ________ Cost ________
- Total post-industrial (PI) recycled content on project: Volume ________ Cost ________
- Total materials produced within 500 miles of project: Volume ________ Cost ________
- Total materials produced from rapidly renewable sources: Volume ________ Cost ________
- Total material which can be reused: Volume ________ Cost ________
- Total material which came from salvaged sources: Volume ________ Cost ________
- Total material which can be recycled: Volume ________ Cost ________
- Total material which is biodegradable: Volume ________ Cost ________
- Total materials which are FSC certified wood products: Volume ________ Cost ________

  (Attach completed Appendix M.2-A to support information in this category)

WASTE REDUCTION

- Is there a construction waste management plan? ______
- Construction waste: Baseline (typical): % landfilled ________ % recycled ________

  Project design model: % landfilled ________ % recycled ________
- Packaging waste: Baseline (typical): % landfilled ________ % recycled ________

  Project design model: % landfilled ________ % recycled ________
- Is there a building waste management plan? ______
- Building waste: Baseline (typical): % landfilled ________ % recycled ________

  Project design model: % landfilled ________ % recycled ________

Appendix M-1 Life Cycle Term Worksheet

LIFE CYCLE TERM WORKSHEET M-1 ASSEMBLY OR COMPONENT				Project Name: ______________________ Building Type: ______________________ Projected building life cycle term: __________		
Building or Site System	**System Component or Material**	**Life Cycle Term - Baseline**	**Life Cycle Term - Design**	**END OF LIFE**		
				Reuse [%]	**Remanufacture [%]**	**Recycle/ Compost [%]**
Site pavement - roads						
Site pavement - walkways						
Substructure - wall						
Substructure - slab						
Shell - wall						
Roof Structure						
Floor Structure (multi-story building)						
Exterior Windows/Glazing						
Exterior Entrances - Monumental						
Interior partitions - Base Building						
Interior partitions - Tenant Fit-up						
Interior Finishes - Flooring (1) Corridors						
Interior Finishes - Flooring (2) Offices						

M-1 LIFE CYCLE TERM WORKSHEET – PAGE 2

Building or Site System	System Component or Material	Life Cycle Term - Baseline	Life Cycle Term - Design	END OF LIFE		
				Reuse [%]	Remanufacture [%]	Recycle/ Compost [%]
Interior Finishes - Flooring - Entries						
Interior Finishes - Flooring - Support areas						
Interior Finishes - Walls - Corridors						
Interior Finishes - Walls - Offices						
Interior Finishes - Walls - Entries/Lobbies						
Interior Finishes - Walls - Support areas						
Interior Finishes - Furnishing - Office Systems						
Interior Finishes - Furnishing - Office Chairs						

Appendix M-2.A Material/Assembly Selections Report Form

Instructions: Include information from the material/system chart (Appendix M.2-B) on the major building components for your project. Select those assemblies or components where you will have the greatest opportunity to improve the environmental impacts, either through reducing the amount of materials used or selecting materials or systems with lower environmental impacts (LCA).				**MATERIAL/ASSEMBLY SELECTIONS REPORT FORM APPENDIX M-2.A**											
				ENVIRONMENTAL IMPACTS (LCA)							**SOURCING CHARACTERISTICS**				
Assembly	**Material/ Product**	**Unit**	**Percentage of total Project by Volume**	**Primary Energy (KW/SF)**	**Global Warming Potential (Tons/SF)**	**Air Quality Indices (Index/SF)**	**Water Quality Indices (Index/SF)**	**Solid Waste (Tons/SF)**	**Resources (Tons/SF)**	**Locally Extracted/ Harvested (Distance from Project) [mi]**	**Locally Manufactured (Distance from**	**PI Recycled Content [%]**	**PC Recycled Content [%]**	**Rapidly Renewable [Y/N] [%]**	**Biodegradable [Y/N] [%]**
Substructure/ Foundation															
Shell/ Wall															
Shell/ Cladding															
Floor Structure															
Roof Structure															
Roofing System															
Interior Partitions															
Interior Finishes/ Walls (1)															

M-2.A Material/Assembly Selections Report Form Page 2

Assembly	Material/ Product	Unit	Percentage of total Project by Volume	ENVIRONMENTAL IMPACTS (LCA)							SOURCING CHARACTERISTICS				
				Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/SF)	Water Quality Indices (Index/SF)	Solid Waste (Tons/SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project) [mi]	Locally Manufactured (Distance from	PI Recycled Content [%]	PC Recycled Content [%]	Rapidly Renewable [Y/N] [%]	Biodegradable [Y/N] [%]
Interior Finishes/ Walls (2)															
Interior Finishes/ Floors (1)															
Interior Finishes/ Floors (2)															
Interior Finishes/ Ceilings (1)															
Interior Finishes/ Ceilings (2)															
Furnishings - Office Partition Systems - New															
Furnishings - Office Partition Systems - Reused															
Furnishings - Office Partition Systems – Re-manufactured															

APPENDIX M-2.B - LIFE CYCLE ASSESSMENT INFORMATIONAL CHART

Instructions: This chart uses life cycle inventory (LCI) data from ATHENA and BEES programs. Materials and building systems are listed together. Make sure, when including information on the Report form M.2-A) you do not include materials which are also represented as components of building assemblies. You can also sort by the Assembly column to collect, for example, all "Floor" or "Wall" items for ease in searching.

MATERIAL/ASSEMBLY SELECTIONS
LIFE CYCLE ASSESSMENT INFORMATIONAL CHART - APPENDIX M-2.B

Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Steel beams	Roof Structure		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Steel beams	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Steel beams	Floor Structure		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete (Poured) 100% Portland	Foundation		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 2														
Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Concrete (Poured) 100% Portland	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete (Poured) 100% Portland	Slab		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete (Poured) 25% Flyash	Foundation		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete (Poured) 25% Flyash	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete (Poured) 25% Flyash	Slab		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete plank	Roof Structure		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Concrete plank	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 3													
Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Concrete plank	Floor Structure		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
EPDM Adhered 60mil w/ Extruded Polystyrene	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
EPDM Adhered 60mil w/ Polyisocyanurate	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Built-up 4 Ply w/Aggregate & Polyisocyanurate	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Modified Bitumen APP & Polyisocyanurate	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Modified Bitumen APP & Polyisocyanurate	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 4														
Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
TPO Membrane w/Polyisocyanurate	Roof System		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Face Brick on Steel Stud Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Face Brick on CMU Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
CMU on Steel Stud Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
CMU on CMU Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Metal Panel on Steel Stud Backup	Wall		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Stone Panel on Steel Stud Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 5

Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Stone Panel on CMU Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Aluminum Curtain Wall on Steel Stud Backup	Wall - Shell		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Steel Stud w/Gyp. Board	Interior Partition		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Steel Stud w/Type X Gyp. Board	Interior Partition		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Wood Stud w/Gyp. Board	Interior Partition		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Wood Stud w/Type X Gyp. Board	Interior Partition		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Demountable Partition	Interior Partition		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 6

Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Vinyl Wall Covering	Interior Finish - Wall		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Paper Wall Covering	Interior Finish - Wall		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Low-VOC Latex Acrylic Paint	Interior Finish - Wall		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Recycled Content Paint	Interior Finish - Wall		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Carpet - Broadloom (Std. backing/glue down)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Carpet - Broadloom (Recycled content yarn, backing; low-VOC adhesive glue down)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 7														
Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS					
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Carpet - Tile (Std. backing/glue down)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Carpet - Tile (Recycled content yarn, backing; low-VOC adhesive glue down)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Ceramic Tile (2x2)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Ceramic Tile (12x12)	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Recycled Content Tile	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Quarry Tile	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data

M-2.B LIFE CYCLE ASSESSMENT INFORMATIONAL CHART Page 8														
Material/ Product	Assembly	Unit	ENVIRONMENTAL IMPACTS (LCA)						SOURCING CHARACTERISTICS				
			Primary Energy (KW/SF)	Global Warming Potential (Tons/SF)	Air Quality Indices (Index/ SF)	Water Quality Indices (Index/ SF)	Solid Waste (Tons/ SF)	Resources (Tons/SF)	Locally Extracted/ Harvested (Distance (Distance from Project)	Locally Manufactured (Distance from Project)	PI Recycled Content	PC Recycled Content	Rapidly Renewable
Terrazzo Tile w/Recycled Content	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Resilient Floor - VCT	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Resilient Floor - Linoleum	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Resilient Floor - Rubber Tiles	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data	Manufacturer's Data
Resilient Floor - Rubber Sheet	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's data	Manufacturer's data	Manufacturer's	Manufacturer's	Manufacturer's data
Wood Floor - Solid	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's data	Manufacturer's	Manufacturer's	Manufacturer's	Manufacturer's
Wood Floor - Laminate	Interior Finish - Floor		ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	ATHENA BEES DATA	Manufacturer's data	Manufacturer's	Manufacturer's	Manufacturer's	Manufacturer's

Appendix M.3-A
Construction Waste Recycling Economics Worksheet

APPENDIX M-3.A WORKSHEET

Construction Waste Recycling Economics Worksheet

Option 1: Using a Commercial Hauler

Cost of Recycling/Recovery

	Disposal			Handling Costs					
	Tons or Cubic Yards	Revenue or Tip Fee(1)	**Subtotal**	No. of Loads	Hauling Fee per load	Container Rental Day/Wk/Mo	No. of Days/ Wks/Mos	**Subtotal**	**Total Cost**
Material									
Totals									

(1) If paid a revenue for the material, enter it as a negative number.

Cost of Landfilling

	Disposal			Handling Costs					
	Tons or Cubic Yards	Landfill Tip Fee	**Subtotal**	No. of Loads	Hauling Fee per load	Container Rental Day/Wk/Mo	No. of Days/ Wks/Mos	**Subtotal**	**Total Cost**
Material									
Non-Recyclable Waste									

Option 2: Self Hauling Materials

Cost of Recycling/Recovery

	Disposal			Handling Costs				
Material	Tons or Cubic Yards	Revenue or Tip Fee(1)	**Subtotal**	No. of Loads	Hours per Load	Truck Costs per Hour incl. Labor	**Subtotal**	**Total Cost**
Totals								

(1) If paid a revenue for the material, enter it as a negative number.

Cost of Landfilling

	Disposal			Handling Costs				
Material	Tons or Cubic Yards	Landfill Tip Fee	**Subtotal**	No. of Loads	Hours per Load	Truck Costs per Hour incl. Labor	**Subtotal**	**Total Cost**
Non-Recyclable Waste								
Total Cost for Recycling/Recovery and Landfilling of Materials								

APPENDIX M.3-A ATTACHMENT
DIVISION 1 SECTION: CONSTRUCTION WASTE MANAGEMENT
EXPLANATION OF DOCUMENTATION PROCESS AND CALCULATIONS REQUIRED FOR DEMOLITION WASTE MANAGEMENT

Information for Bidders:
Preparing Estimates on Recycling

I. Estimating the amount of recyclable waste: generation rates

One method of estimating the generation of different types of waste is to get average figures of waste generation for different construction materials. The following are estimates by material:

Corrugated cardboard	7.5% of commercial construction waste (10% of residential construction waste) is scrap corrugated cardboard.
Dimensional lumber and pallets	18% of commercial construction waste (25% of residential construction waste) is scrap dimensional lumber and pallets.
Metals	4.5% of commercial construction waste (1% of residential construction waste) is scrap metal.
Gypsum wallboard:	1/2 pound per square foot of commercial floor area (1 pound per square foot of residential floor area) becomes scrap.
Concrete	15% of commercial construction waste (4.5% of residential construction waste) is scrap concrete.

(Sources: "A New Methodology for Quantifying Construction Waste", Peter Yost and John M. Halstead, in Sustainable Construction: Proceedings of the First International Conference of CIB TG 16 (1994), University of Florida College of Architecture; Construction Materials Recycling Guidebook -- A Guide to Reducing and Recycling Construction and Remodeling Waste, Metropolitan Council of the Twin Cities Area, 1993.)

Another method is to look at generation rates from similar projects. Several studies have been conducted on the amount of recyclable waste generated on commercial and multi-family residential construction projects:

Ex: Construction of a 5,000-square foot restaurant

Construction of this restaurant generated 12,344 pounds of waste, or 2.46 pounds per square foot. This waste included the following recyclable materials:

Wood	7,440 pounds	(61% of the waste)
Cardboard	1,414 pounds	(11% of the waste)
Gypsum wallboard	500 pounds	(4% of the waste)

(Source: Characterization of Construction Site Waste (1993), Metro Solid Waste Department (Portland, OR).)

Ex: Six commercial renovation projects

These six commercial renovation projects averaged the following percentages of recyclable materials:

Untreated dimensional wood	5% of all project waste
Cinderblock	19% of all project waste
Concrete without rebar	22% of all project waste
Ferrous scrap	5% of all project waste

(Source: "What's in a Building?", Demolition Age, September 1993.)

II. Estimating the amount of recyclable waste : Conversion figures

Mixed Waste	350 lbs/cu yd	0.175 tons/cu yd	5.7 cu yds/ton
Wood	300 lbs/cu yd	0.15 tons/cu yd	6.7 cu yds/ton
Cardboard	100 lbs/cu yd	0.05 tons/cu yd	20 cu yds/ton
Gypsum wallbd.	500 lbs/cu yd	0.25 tons/cu yd	4 cu yds/ton
Rubble	1400 lbs/cu yd	0.7 tons/cu yd	1.4 cu yds/ton

(Source: Resource Efficient Building (1994), Metro Solid Waste Department (Portland OR).)

III. Tips on reducing the cost of recycling

--Schedule containers for collecting recyclables only when needed. For example, rent a collection container for cardboard only during the latter part of construction, when the majority of cardboard waste is generated.

--Be sure to understand the market specifications so that recyclable materials are not rejected. For example, some markets for clean wood waste accept only dimensional lumber; others also accept plywood, particle board, and oriented strand board.

--Encourage scrap dealers to be flexible when possible. For example, a scrap metal dealer who initially refused to accept metal bands from around lumber was convinced to accept them when they were repeatedly folded and hit with a hammer, then put into an empty 5-gallon plastic bucket, so as to create a more dense item for transportation. (Creating these more dense bundles of metal bands also had the advantage of cutting down on injuries at the construction site.)

IV. Estimating the cost of waste management encompassing recycling

The following steps will help arrive at an estimate of the cost of construction waste management which involves recycling certain materials.

Step One: Estimate Total Project Waste and Amounts of Recyclable Materials.

(1) Estimate the Total Project Waste in cubic yards (cy) (1) ____ cy
(Use information from previous comparable projects.)

For each material to be recycled, estimate the amount of waste to be recycled. If necessary, use typical percentages of commercial construction waste provided in section I above and multiply percentage by Total Project Waste in line (1) above. Add lines as necessary.

(2a) Recyclable material #1(identify):_________ (2a) ____cy
(2b) Recyclable material #2(identify):_________ (2b) ____cy
(2c) Recyclable material #3(identify):_________ (2c) ____cy
(2d) Recyclable material #4(identify):_________ (2d) ____cy
(2e) Recyclable material #5(identify):_________ (2e) ____cy
(2f) Recyclable material #6(identify):_________ (2f) ____cy

(2) Add the total cubic yards in (2a) through (2f) above
to get the Total Recyclable Materials Amount (2) ____cy

(3) Subtract line (2) from line (1) to get the Non-
recyclable Material Amount (3) ____cy

Step Two: Estimate the cost of waste management if you use one recycling hauler. (Note: This service is not available in all local areas.)

(4) If you use a hauler to collect all waste and sort out the recyclables and recycle them, then record the cost per cubic yard for this service (including all hauling, container rental, and tipping fee charges). (4) $____/cy

(5) Multiply the cost from line (4) by line (1) to get the Net Total Cost of Waste Management using one hauler who separates out recyclables. (5) $____

Step Three: Estimate the cost of recycling if you separate materials on site and have them hauled separately to market. (This is an alternative to Step Two.)

Estimate the cost of transporting to market each recyclable material you plan to transport using an outside hauler who provides containers. Add lines as necessary.

(6a)Divide cubic yards of one recyclable material (identify)_______from line (2) by container capacity, round off to nearest whole number (__), and multiply by container hauling cost. Add cost of container rental if not included in hauling cost. (6a) $____

(6b)Divide cubic yards of another recyclable material (identify)_______ from line (2) by container capacity, round off to nearest whole number (__), and multiply by container hauling cost. Add cost of container rental if not included in hauling cost. (6b) $____

(6c)Divide cubic yards of another recyclable material (identify)_______ from line (2) by container capacity, round off to nearest whole number (__), and multiply by container hauling cost. Add cost of container rental if not included in hauling cost. (6c) $____

(6) Add lines (6a) through (6c). (6) $_____

Estimate the cost of transporting to market each recyclable material you plan to transport to market yourself. Add lines as necessary.

(7a) Divide cubic yards of recyclable material (identify)_______from line (2) by per load capacity, round off to nearest whole number (__), multiply by hours per trip (__) and per hour labor and trucking costs ($___). (7a) $____

(7b) Divide cubic yards of recyclable material (identify)_______from line (2) by per load capacity, round off to nearest whole number (__), multiply by hours per trip (__) and per hour labor and trucking costs ($___). (7b) $____

(7c) Divide cubic yards of recyclable material (identify)_______from line (2) by per load capacity, round off to nearest whole number (__), multiply by hours per trip (_) and per hour labor and trucking costs ($___). (7c) $____

(7) Add lines (7a) through (7c) (7) $____

Estimate the amount of revenue to be received from selling each material in lines (8a) through (8c). Add lines as necessary.

(8a) Multiply cubic yards of recyclable material identified in line (7a) by market price per cubic yard for that material ($___). (Use conversion table in section II above if necessary). (8a) $_____

(8b) Multiply cubic yards of recyclable material identified in line (7b) by market price per cubic yard for that material ($___). (Use conversion table in section II above if necessary). (8b) $_____

(8c) Multiply cubic yards of recyclable material identified in line (7c) by market price per cubic yard for that material ($___). (Use conversion table in section II above if necessary.) (8c) $_____

(8) Add lines (8a) though (8c). (8) $_____

(9) Subtract line (8) from line (7). (9) $_____

(10) Estimate the number of extra hours needed to sort and monitor separated waste (___) and multiply by per hour labor cost ($___). (10) $____

(11) Estimate the cost of disposing of nonrecyclable waste by multiplying the Nonrecyclable Material Amount from line (3) above by the cost per cubic yard of disposing of this waste in a landfill, including container rental, transportation, labor, and landfill tipping fee. (Use conversion figures in section II above if necessary.) (11) $____

(12) Add lines (6), (9), (10) and (11) to get the Net Total Cost of Waste Management using source separation of recyclables. (12) $____

Step Four: For comparison, calculate the cost of landfilling all project waste.

(13) Divide Total Project Waste in (1) above by container capacity, round off to nearest whole number ___, and multiply by container hauling cost ($____) to get Cost of Landfilling: $_____. Add all costs for container rental and all tipping fees if not included in hauling cost to get Cost of Landfilling All Project Waste. (13) $_____

END OF APPENDIX M-3.A

Appendix M-3.B Packaging Waste Recycling Economics Worksheet

Packaging Waste Recycling Economics Worksheet

Option 1: Cost of Recycling/Recovery

	Recycling			Handling Costs					
Material	Tons or Cubic Yards	Return to Manufacturer (Mode of Transport)	**Subtotal**	No. of Loads	Hauling Fee per load	Container Rental Day/Wk/Mo	No. of Days/ Wks/ Mos	**Subtotal**	**Total Cost**
Totals									

(1) If paid a revenue for the material, enter it as a negative number.

Option 2: Cost of Landfilling

	Disposal			Handling Costs					
Material	Tons or Cubic Yards	Landfill Tip Fee	**Subtotal**	No. of Loads	Hauling Fee per load	Container Rental Day/Wk/Mo	No. of Days/ Wks/ Mos	**Subtotal**	**Total Cost**
Non-Recyclable Waste									
Totals									

Appendix M-3.C Hazardous Waste Handling Worksheet

Hazardous Waste Handling Worksheet									
Cost of Handling									
	Disposal			**Handling Costs**					
Material	Gallons, Tons or Cubic Yards	Cost (Disposal Fee(1)	**Subtotal**	No. of Loads	Hauling Fee per load	Container Rental Day/Wk/Mo	No. of Days/ Wks/Mos	**Subtotal**	**Total Cost**
Totals									