Sustainable Design Guidelines Reference Manual

For Waterfront Development Projects

EMPIRE STATE DEVELOPMENT and NYSERDA

25 March, 2005

Prepared by Croxton Collaborative

Cover Photo: ©2002 Christopher Small, Lamont Doherty Earth Observatory, Columbia University.
<http://www.ldeo.columbia.edu/~small/NYC/NYCIR.html>

Cover Photo: Heat Island Mapping

This infrared satellite view of Manhattan and its surrounding areas indicates zones of heat build-up, which affects human comfort, air quality and building energy loads. The darker shades of red and purple indicate higher temperatures, which are most evident in midtown and lower Manhattan. These areas stand in sharp contrast to the cooler, vegetated areas around the dense urban core of the region. The build-up of heat increases air conditioning loads, levels of pollutants and environmental stress. In contrast, parks, gardens and grasslands have lower thermal mass; thus areas of a city with more open green space have cooler microclimates.

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WTC Redevelopment Projects

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World Trade Center Redevelopment Projects
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March 25, 2005

EXECUTIVE SUMMARY

The World Trade Center Redevelopment will include a memorial, a transportation hub, a hotel, museum cultural facilities and spaces for the performing arts, as well as office towers, and a retail center. With 10 million square feet of office space planned, and up to 1,000,000 square feet of retail space, it will be a workplace for tens of thousands of people. The concept of design excellence envisions a community that provides a safe, user-friendly and attractive atmosphere for workers, residents, visitors and tourists. By embodying the ideals of sustainable design, the Redevelopment can be an exemplar for large-scale, mixed development in the North-East and across the United States.

To this end, the agencies with an interest in the physical redevelopment of the World Trade Center, namely the Port Authority of New York and New Jersey (PANYNJ), the Lower Manhattan Development Corporation (LMDC) and New York State Energy Research Development Authority (NYSERDA), have separately and collectively developed a series of Sustainable Guidelines (Guidelines) intended to address all major components of the site. These include the Transportation Hub, the Commercial Office Buildings, the Tenant and Retail spaces, the World Trade Center Memorial, Museum Complex, the Performing Arts Complex, and the Site itself. To support the World Trade Center Redevelopment projects, a World Trade Center Sustainable Guidelines *Reference Manual (Reference Manual)*, the subject of this document, has been developed. While this single document cannot address all of the specific building-type issues in detail, the *Reference Manual* provides information and support for the majority of sustainable concerns relative to environmental/sustainable planning, construction and operation of this urban-scale development.

The *Reference Manual* is a supplement to the already published Guidelines. It has been conceived as an essential tool to facilitate all design teams undertaking sustainable design projects at the site. The objective of the *Reference Manual* is to clarify the purpose of the Guidelines by providing a clear context for each subject, a brief discussion of the relevant issues, and clarification of the various means by which the proposed environmental goals can be achieved.

The fundamental characteristics of the various Guidelines and the *Reference Manual* have been developed to respond to the urban scale, complexity and extended time frame of the entire site development, as well as to address the fact that many of the projects cannot be defined simply as a 'Building.' Further provisions support 'whole systems thinking' and the confirmation of an integrated plan for the maintenance and enhancement of sustainable performance over time.

These characteristics are summarized as follows:

- **Urban Scale and Community:** A number of unique Guidelines have been developed to address connectivity to adjoining neighborhoods, green infrastructure, transportation and pedestrian movement.
- **Implementation and Process:** The PANYNJ and/or LMDC will review the work of the design teams in order to provide guidance assistance and a determination of compliance with the Guidelines. Rather than a single review at project completion, a sequential review will occur at the traditional project phases: (SD, DD, CD and CA) to monitor progress, and determine if the design team is on track to incorporate solutions to meet the sustainable guidelines for their project.
- **Whole System Design:** In addition to quantifiable performance attributes required by the Guidelines, overall 'Plans' are included in narrative form, which demonstrate understanding of both context and sustainable opportunities that exist beyond the traditional boundaries of site.
- **Scalability:** The applicable Guidelines are assignable to a full range of projects down to small scale, non-building projects on site.
- **Exemplar Tenant Space:** Retail and Commercial: The Exemplar is the construction of a 5,000 s.f. high performance tenant space fully integrating core and shell sustainable potentials within a prototypical tenant fit-out for each major project. The exemplar provides an essential tool for the advocacy of measurable high performance tenant design, as well as a clear statement of the preferred 'Landlord Standard' fit-out supported by the quantified energy savings, environmental benefits and direction to NYC/NYS/NYSERDA grants and support initiatives. (The energy savings notably will go directly to the tenant due to the provision of 'end use' metering as a WTC Redevelopment Standard.)

Together, these characteristics project an extended framework of sustainability and a new model for urban-scale development.

This *Reference Manual* (in conjunction with the applicable LEED® Reference Manual) is intended to serve as the primary reference source for designers working to implement the Guidelines on a wide range of projects at the World Trade Center site. These projects include the Commercial Office and Retail Redevelopment, the Transportation Hub, the WTC Memorial and the Cultural Facilities. While this document elaborates on all of the sustainable goals as currently envisioned, future supplements to the *Reference Manual* are anticipated in order to capture the maximum sustainable benefit as programs are advanced and the totality of the redevelopment is clarified. In addition, the fast pace of change in sustainable methods and technology will be addressed by an 'update review' every two years.

The *Reference Manual* utilizes documents that have been developed by a number of agencies to promote sustainable design, specifically in New York State and City, as well as nationally. These reference standards include New York State's Executive Order 111 (EO-111), the New York State Green Building Tax Credit (NYSGBTC) and the US Green Building Council's LEED v2.1 Rating System. In addition, the *Reference Manual* attempts to reconcile conflicts between the various agency requirements, thereby providing a path for the resolution of these issues. As noted, the *Reference Manual* goes beyond these baseline documents by introducing language and criteria in support of the unique set of large-scale

sustainable qualities that appear under the title of "Urban Environmental Quality" (UEQ), as well as introducing issues that are specific to this locale and high-density urban settings.

Structure of Reference Guidelines

Each Guideline is organized into several basic parts with sub-headings:

Related Guidelines: Lists references to other guidelines which will influence the implementation of the guideline and chapters by providing additional relevant reference materials.

Potential LEED™ 2.1 Credit: Indicates where compliance with the appropriate set of WTC Sustainable Design Guidelines will also satisfy the requirements necessary for these related LEED Credits.

Introduction/Context: Introduces guideline goals and issues, including historical data of interest, and provides a context for later, more specific development of these issues.

Relevant Issues: The three most critical guideline impact areas, **Ecological, Economic and Neighborhood Impacts** are described for the World Trade Center Site.

Methodology: The two critical components of a sustainable design project are discussed: The environmental/sustainable and human–centered **Design Strategies** that may be used to inform the design process, and the technical **Means and Methods** by which they may be achieved. While a roadmap is provided, this is by no means the only methodology for complying with the requirements. Design teams are encouraged to introduce innovative paths to achieving higher levels of performance in their projects, and a greater degree of sustainability.

Reference: The reference section includes **Case Studies, Definitions, Standards** and an **Annotated Bibliography**. (These are provided for educational purposes and are not intended as specific directives.)

Master Certification / Master Checklist / Submittal Templates:

These are the facilitating documents for each submission to the PANYNJ and/or LMDC.

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Sustainable Design Guidelines Reference Manual
World Trade Center Redevelopment Projects
LMDC, PANYNJ, and NYSERDA
March 25, 2005

IMPLEMENTATION AND INTENT

The role of the Sustainable Guidelines, the *Reference Manual* and the funding agencies is to **facilitate and assure** the highest sustainable performance within the potentials of each project at the World Trade Center site. For this reason there is not just one submission at the end of the project to determine a 'rating', rather there is a regular sequence of four submissions that occur at the standard milestones of project completion:

1. Schematic Design – Stage One
2. Design Development – Stage Two
3. Construction Documentation – Stage Three
4. Project Completion – Final Submission

This approach provides the PANYNJ and/or LMDC the opportunity to review and confirm sequential progress, as well as to give timely input/support for the design teams' sustainable objectives.

The requirements and deliverables of the Guidelines fall into two distinctive categories:

1. Measurable/Verifiable Criteria: These are the recognizable standards of 'green' design and are predominantly the US Green Building Council's (USGBC) LEED® v 2.1 requirements, which have been incorporated into the Guidelines in order to comply with EO 111 and the related portions of the New York State Green Building Tax Credit.

   Note: **USGBC's** *LEED™ is, by its very nature, a universal list of requirements for a given building type that does not address site-specific issues. In addition, it selects only those issues of sustainability that are quantifiable.*

2. Plans/Narrative Summaries: These standards, which go beyond the requirements of LEED, address the remaining and essential components of a sustainable project that demonstrate 'whole-system' awareness and planning, as well as future-directed design for growth and change. They confirm plan strategies/attributes of connectivity to adjoining community, green infrastructure, transit systems, etc. These relationships are unique to each project and, unexamined will prevent the achievement of the project's full environmental/sustainable potential. They will be reviewed and assessed on merit by the PANYNJ and/or LMDC.

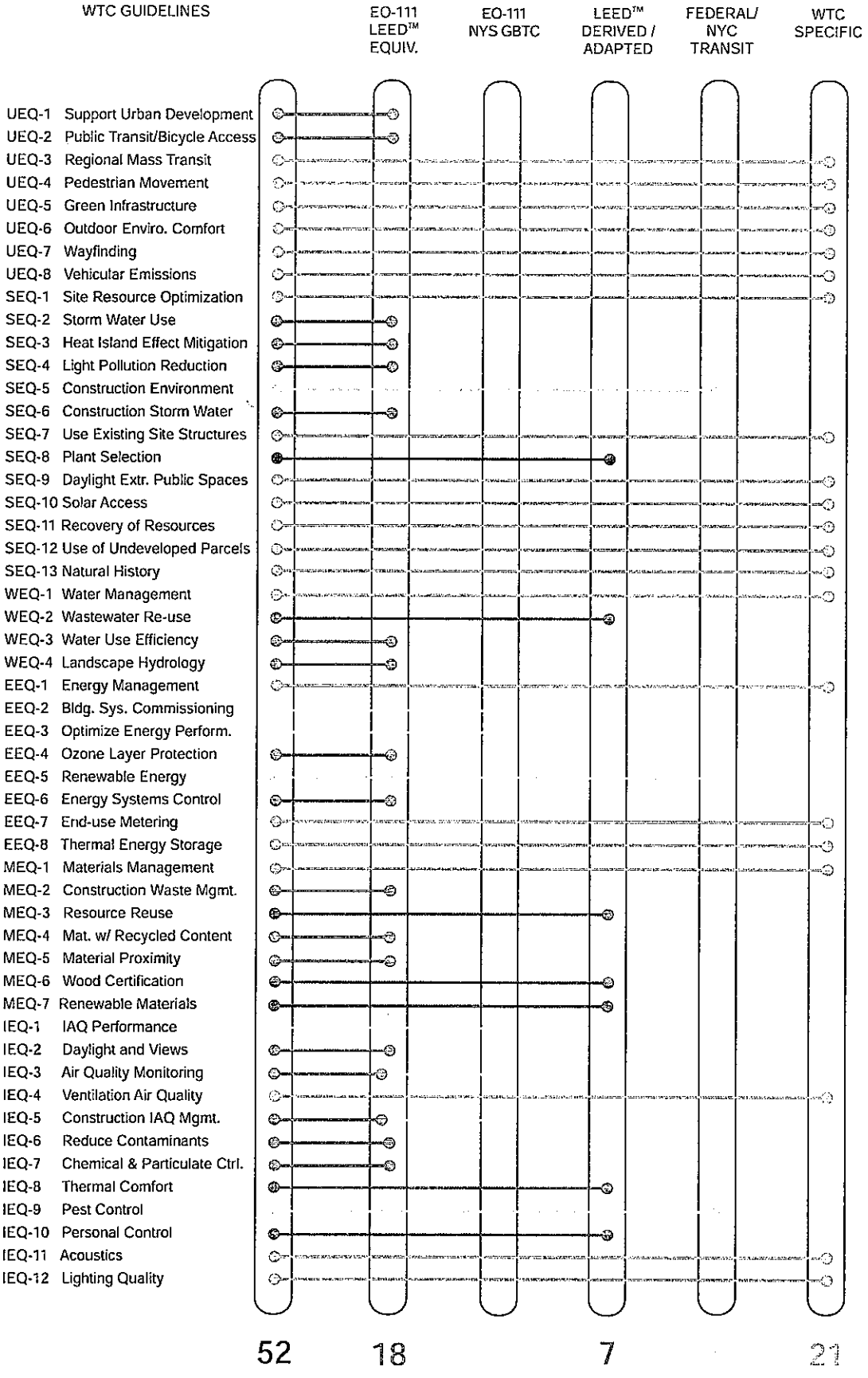
Importantly, the entire World Trade Center project will be realized over a long timeframe with many phases, and will require many 'non-building' or 'connective tissue' projects that do not constitute buildings in the traditional sense. Therefore the Guidelines, and the supporting *Reference Manual* are 'scalable' in that the PANYNJ and/or LMDC will assign an appropriate, reduced number of applicable guidelines for these multiple, small and varied projects, including the below grade complex. Similarly, inactive sites will be assigned appropriate 'core' requirements related to storm water, day-lighting, etc.

The fundamental characteristics of the World Trade Center Sustainable Guidelines and the *Reference Manual* is that among the fifty-two (52) credits or chapters, there is a 'core' of LEED or LEED derived verifiable guidelines. The basic version of LEED that is reflected in the Guidelines and the *Reference Manual* is LEED v2.1. For all future projects, the requirement is *that the then-current version of LEED applies.* This is based on the time of project initiation (i.e. award). For instance, the successor version of LEED v2.1, LEED v2.2 is currently in circulation for review as a 'public comment' draft. LEED v2.2 will be balloted by the USGBC Membership in spring 2005, and is planned for release as a full-blown version of LEED in summer 2005. LEED v2.2 and subsequent versions of LEED will automatically become the basis for World Trade Center projects undertaken after their adoption by the USGBC. Importantly, teams will only be required to meet the standards of the LEED version that is current at the time of project initiation and will not be required to meet changing requirements or versions that may be subsequently adopted.

The following chart: **'Basic Composition and Sourcing of the WTC Sustainable Guidelines'** provides a general overview of the five integrated sources constituted in the Guidelines and further elaborated on in the *Reference Manual.*

BASIC COMPOSITION & SOURCING IN THE DEVELOPMENT OF THE WTC SUSTAINABLE GUIDELINES

LMDC, PANYNJ AND NYSERDA



SUSTAINABLE DESIGN GUIDELINES IMPLEMENTATION MATRIX
WORLD TRADE CENTER REDEVELOPMENT PROJECTS
PANYNJ, LMDC and NYSERDA

Note: All requirements herein that are tied to the U.S. Green Building Council's LEED™ "Certified" building standard are to be consistent with the requirements of NY State's Executive Order 111, which mandates that projects are to be **"equivalent"** to this standard but are not required to achieve formal certification by the U.S. Green Building Council. All project teams are, however, encouraged to achieve formal certification at the "Certified", "Silver" or higher levels at their own discretion. Guidelines indicated as "Required" are mandatory and flow directly from the objectives of EO-111, LEED™ certified level requirements and the larger requirements of the PANYNJ and LMDC. The LEED™ "Silver Roadmap" creates a pathway for moving toward even higher performance. Flexibility is provided through an "Equivalency Option" which allows designers to propose an "equivalent option" for a guideline which is part of the LEED™ Calculation, as long as the number of LEED™ points remains the same or better. Guidelines indicated as "Recommended" are provided to support efforts by teams seeking additional opportunities to improve environmental performance.

● Action on Guideline **Required**

◎ LEED™ **Equivalency Option** allowed

○ Action on Guideline **Recommended**

Ⓔ **Exemplar** model to be built to provide example for commercial office and retail

Prq **Prerequisite** (under LEED™) required to meet EO-111 LEED™ Certification objectives

URBAN ENVIRONMENTAL QUALITY										LEED™ Point Potentials		
No.	Quality	Purpose	Transportation Hub	Site/ Parcel	Commercial Office	Commercial Retail		Memorial	Cultural	Certified Roadmap	Silver Roadmap	Maximum Possible
UEQ-1	Support Urban Development	Support development in existing urban areas and fully utilize and support existing infrastructure.	●	●	●	●		●	●	1	1	1
UEQ-2	Expanded Public Transit and Bicycle Access	Encourage the development of public transportation, address opportunities to connect/cross-connect systems and support and increase bicycle access.	●	●	●	●		●	●	1	1	2
UEQ-3	Regional Mass Transit	To promote regional mass transit systems.	●	●	○	○			○			
UEQ-4	Pedestrian Movement	Support neighborhood, community, visitor and commuter pedestrian pathways and facilitate pedestrian access to and through the site.	●	●	●	●		●	●			
UEQ-5	Green Infrastructure	Support the development of green infrastructure by developing and linking vegetated site areas with existing neighborhood green spaces.		●	●	●		●	●			
UEQ-6	Outdoor Environmental Comfort	To facilitate site development that supports outdoor environmental comfort.		●	●	●		●	●			
UEQ-7	Wayfinding	To facilitate both neighborhood and site-user orientation and site readability.		●	●	●		●	●			
UEQ-8	Vehicular Emissions	Reduce back-up of traffic into neighboring streets in order to minimize vehicle emissions and improve neighborhood air quality from pre 9/11 base. Minimize potential idling time for all vehicles.	●	●	●	●	Ⓔ		●			
SITE ENVIRONMENTAL QUALITY												
SEQ-1	Site Resource Optimization	Draft and implement the requirements of the Comprehensive Resource Management Plan.	●	●	●	●		●	●			
SEQ-2	Storm Water Use	To capture and utilize site storm water flows, thereby reducing storm water volume and surges through the system.	●	◎	◎	◎	Ⓔ	◎	◎	2	2	2
SEQ-3	Heat Island Effect Mitigation	Reduce site development contributions to "heat island" effects in Lower Manhattan. Seek to maximize areas of landscape planting (green infrastructure) coupled with high albedo surfaces at other areas to mitigate thermal loading of site surfaces and building roofs.	●	◎	◎	◎	Ⓔ	◎	◎	2	2	2
SEQ-4	Light Pollution Reduction	To reduce light pollution and glare to surrounding sites and night sky.	●	◎	◎	◎	Ⓔ	◎	◎	1	1	1
SEQ-5	Construction Environment	To reduce pollution, noise and vibration from construction activities and vehicles.	●	●	●	●	Ⓔ	●	◎			
SEQ-6	Const Storm Water Runoff and Pollution Prevention	Control site erosion and reduce negative impacts on hydrological and atmospheric systems produced by construction activities.	●	●	●	●		●	●	Prq	Prq	Prq
SEQ-7	Use Existing Site Structures	Encourage the re-use of existing site structures to conserve resources.	●	●	●	●		●	●			3
SEQ-8	Plant Selection	Use indigenous or acclimatized plants to reduce irrigation and maintenance requirements.		●	●	●		●	●			
SEQ-9	Daylight Exterior Public Spaces	Design buildings and site structures to consider available daylight for public open spaces and green areas (within the context of the established massing guidelines).		●	●	●		●	●			
SEQ-10	Solar Access	To optimize solar access for utilization of solar energy.		●	●	●		●	●			
SEQ-11	Recovery of Resources	To optimize utilization of site material resources and to facilitate the reduction of waste generated by building occupants that would otherwise be hauled to and disposed of in landfills and/or incinerators.	●	●	●	●	○	●	●			
SEQ-12	Use of Undeveloped Parcels	Utilize inactive and undeveloped site parcels to provide a positive contribution to site environmental qualities.		●	●	●						
SEQ-13	Natural History	Make tangible elements of site natural history (ie. geology) to educate and inform site users.	○	○	○	○		○	○			
WATER ENVIRONMENTAL QUALITY												
WEQ-1	Water Management	To optimize utilization of site water resources.	●	●	●	●	Ⓔ	●	●			
WEQ-2	Wastewater Re-use	To minimize site wastewater outflows.	●	○	○	○		○	○			1
WEQ-3	Water Use Efficiency	To maximize water efficiency within buildings and reduce the burden on municipal water systems.	●	◎	◎	◎	Ⓔ	◎	◎	2	2	2
WEQ-4	Landscape Hydrology	To maximize utilization of site water for landscape requirements.	●	◎	◎	◎	Ⓔ	◎	◎	1	1	2

ENERGY ENVIRONMENTAL QUALITY											LEED™ Point Potentials		
No.	Quality	Purpose	Transportation Hub	Site/ Parcel	Commercial Office	Commercial Retail		Memorial	Cultural	Certified Roadmap	Silver Roadmap	Maximum Possible
EEQ-1	Energy Management	To conserve and optimize building energy use and minimize air emissions, including greenhouse gases, associated with energy consumption at the site.	●	●	●	●	Ⓔ	●	●			
EEQ-2	Building Commissioning	To implement a Building Commissioning Plan.	●	●	●	●	Ⓔ	●	●	1	1	1
EEQ-3	Optimize Energy Performance	To optimize the performance of building energy systems.	●	●	●	●	Ⓔ	●	●	2	3	10
EEQ-4	Ozone Layer Protection	To reduce emission of ozone depleting chemicals.	●	●	●	●		●	●	Prq	Prq	Prq
EEQ-5	Renewable Energy	To meet a portion of site energy requirements with on site and/or purchased renewable energy sources and institute a plan for transition as renewables become more cost-effective.	●	●	●	●		●	●	1	1	4
EEQ-6	Energy Systems Control and Maintenance	To provide for ongoing verification of initial operation and energy utilization of building energy systems.	●	●	●	●	Ⓔ	●	●	1	1	1
EEQ-7	End-use metering	To maximize tenant incentives to conserve energy.		●	●	●		●				
EEQ-8	Thermal Energy Storage	To maximize opportunities for storage of thermal energy to balance large shifts in demand.	○	○	○	○		○				
MATERIAL ENVIRONMENTAL QUALITY												
MEQ-1	Material Management	To optimize utilization of site material resources and to facilitate the reduction of waste generated by building occupants that would otherwise be hauled to and disposed of in landfills and/or incinerators.	●	●	●	●	Ⓔ	●	●	Prq	Prq	Prq
MEQ-2	Construction Waste Management	To reduce the amount of construction and demolition (C&D) waste going to landfills and/or incinerators and to conserve resources through reuse and recycling	●	◉	◉	◉	Ⓔ	◉	◉	1	1	2
MEQ-3	Resource Reuse	To incorporate previously used building materials and products into new construction.	●	○	○	○	Ⓔ	○	○			2
MEQ-4	Materials with Recycled Content	To incorporate materials with recycled content and increase market demand for building materials and products that incorporate recycled content.	●	◉	◉	◉	Ⓔ	◉	◉	2	2	2
MEQ-5	Material Proximity	To reduce environmental degradation resulting from transportation impacts by increasing the demand for building materials and products that are extracted and/or manufactured in close proximity to the building site.	●	◉	◉	◉	Ⓔ	◉	◉	1	1	2
MEQ-6	Wood Certification	To specify wood which has been harvested according to sustainable forest management principles.	●	○	○	○	Ⓔ	◉	◉		1	1
MEQ-7	Agricultural materials	To encourage the specification of materials which are renewable and that grow in such a way as to support biological diversity and the health of the ecosystem	●	○	○	○	Ⓔ	◉	◉		1	1
INDOOR ENVIRONMENTAL QUALITY												
IEQ-1	IAQ Performance	Establish high indoor air quality (IAQ) for the comfort and well-being of the building's occupants by minimizing the potential for poor air quality, and by establishing minimum IAQ performance and standards.	●		●	●		●	●	Prq	Prq	Prq
IEQ-2	Daylight & Views	Provide building occupants with connections to the outdoors through the introduction of daylight into habitually occupied areas of the building. Provide building occupants with views via direct line of sight to the outdoors from regularly occupied spaces when possible.	●		◉	◉	Ⓔ	◉	◉	1	1	2
IEQ-3	Air Quality Monitoring	To retain high indoor air quality standards by establishing monitoring protocols to assist in maintaining appropriate ventilation rates for the comfort and well-being of building occupants.	●		●	●	Ⓔ	●	●		1	1
IEQ-4	Ventilation Air Quality	To provide outside air to all occupied spaces in the building to support the comfort and well-being of building occupants and as an energy conservation measure.	●		●	●	Ⓔ	●	●		1	1
IEQ-5	Construction IAQ Management	To provide minimum standards for the air quality of building areas upon occupancy.	●		●	●	Ⓔ	●	●	2	2	2
IEQ-6	Reduce Contaminants from Materials	To reduce the density of contaminants that are emitted by common building materials and which affect the comfort and well-being of building occupants	●		●	●	Ⓔ	●	●	3	4	4
IEQ-7	Chemical & Particulate Control	To minimize sources of chemical and particulate air contamination.	●		●	●	Ⓔ	●	●	1	1	1
IEQ-8	Thermal Comfort	To provide building users with a high level of thermal comfort to promote comfort, well-being and enhanced productivity.	●		●	●	Ⓔ	●	◉		1	2
IEQ-9	Pest Control	To mitigate health concerns caused by any unwanted pests, their excrement and the chemicals used to control them.	●	●	●	●	Ⓔ	●	●			
IEQ-10	Personal Control	To provide building occupants with a high level of thermal, ventilation and lighting system control to promote productivity, comfort and well-being	●		●	●	Ⓔ	○	○			2
IEQ-11	Acoustics	Minimize vibration and noise levels in indoor spaces and at exterior environments to achieve appropriate physical comfort and sound isolation for tasks and speech intelligibility, while contributing to human well-being and productivity	●		●	●	Ⓔ	○	○			
IEQ-12	Lighting Quality	To employ enhanced lighting design to maximize quality and efficiency of electric lighting and fully coordinate with daylighting	●		●	●	Ⓔ	○	○			

Notes:

1. The integrated planning and whole systems approach of this high density, mixed-use development contain a significant number of environmental/sustainable dimensions which extend beyond the boundaries of any one project and, where applicable, could be captured under the Innovation Credit category as defined by the USGBC. Although there are a maximum of four potential innovation points, shown these are very challenging points to achieve.

2. While all projects are encouraged to strive for an equivalency to LEED™ "Silver", the "Certified Roadmap" represents the minimum points possible for certification equivalency according to the requirements of EO-111 (26 is the minimum for "Certification" level, 33 is the minimum for "Silver" level and a reasonable allowance should be made for points which would be disallowed if there was an actual submission).

Additional LEED Points available but not required for WTC projects			10
LEED Professional	1	1	1
Innovation[1] (1 of 4 points) (challenging)	1	1	1
Potential LEED Points	**28**[2]	**35**[2]	**69**

Master Certification

M. Cert.

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

	Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
Project Type:	☐	☐	☐	☐	☐	☐
Required Guidelines:	42	35	45	45	42	42
Achieved Guidelines:						
Required LEED™ Credits:	28	28	28	28	28	28
Achieved LEED™ Credits:						

I _____ declare that the above "Required" and "LEED Credit" guideline requirements have been met in full (includes Equivalent and Exemplar Guidelines). The following Master Checklist indicates the specific guidelines referred to in the summary above and individual templates are attached for each guideline indicated.

_____ Signature

_____ Company

_____ Role in Project

_____ Date

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Master Checklist

C-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

SITE ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq.	Pts.
	UEQ-1	Support Urban Development		
	UEQ-2	Expanded Public Transit and Bicycle Access		
	UEQ-3	Regional Mass Transit		
	UEQ-4	Pedestrian Movement		
	UEQ-5	Green Infrastructure		
	UEQ-6	Outdoor Environmental Comfort		
	UEQ-7	Wayfinding		
	UEQ-8	Vehicular Emissions		

SITE ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq.	Pts.
	SEQ-1	Site Resource Optimization		
	SEQ-1P	Site Resource Optimization Plan		
	SEQ-2	Storm Water Use		
	SEQ-3	Heat Island Effect Mitigation		
	SEQ-4	Light Pollution Reduction		
	SEQ-5	Construction Environment		
	SEQ-5P	Construction Environment Plan		
	SEQ-6	Construction Storm Water Runoff and Pollution Prevention		
	SEQ-6P	Construction Storm Water Runoff & Dust Prevention Plan		
	SEQ-7	Use Existing Site Structures		
	SEQ-8	Plant Selection		
	SEQ-9	Daylight Exterior Public Spaces		
	SEQ-10	Solar Access		
	SEQ-11	Recovery of Resources		
	SEQ-12	Use of Undeveloped Parcels		
	SEQ-13	Natural History		

Master Checklist

C-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

WATER ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq.	Pts.
	WEQ-1	Water Management		
	WEQ-1P	Water Management Plan		
	WEQ-2	Wastewater Re-use		
	WEQ-3	Water Use Efficiency		
	WEQ-4	Landscape Hydrology		

ENERGY ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq.	Pts.
	EEQ-1	Energy Management		
	EEQ-1P	Energy Management Plan		
	EEQ-2	Building Commissioning		
	EEQ-2P	Building Commissioning Plan		
	EEQ-3	Optimize Energy Performance		
	EEQ-4	Ozone Layer Protection		
	EEQ-5	Renewable Energy		
	EEQ-5P	Renewable Energy Transition Plan		
	EEQ-6	Energy Systems Control and Maintenance		
	EEQ-7	End-use metering		
	EEQ-8	Thermal Energy Storage		

Master Checklist

C-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

MATERIAL ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq.	Pts.
	MEQ-1	Materials Management		
	MEQ-1P	Materials Management Plan		
	MEQ-2	Construction Waste Management		
	MEQ-2P	Construction Waste Management Plan		
	MEQ-3	Resource Reuse		
	MEQ-4	Materials with Recycled Content		
	MEQ-5	Material Proximity		
	MEQ-6	Wood Certification		
	MEQ-7	Renewable materials		

INDOOR ENVIRONMENTAL QUALITY			LEED™	
√	No.	Quality	Prq	Pts
	IEQ-1	IAQ Performance		
	IEQ-1P	Indoor Air Quality Management Plan		
	IEQ-2	Daylight & Views		
	IEQ-3	Air Quality Monitoring		
	IEQ-4	Ventilation Air Quality		
	IEQ-5	Construction IAQ Management		
	IEQ-5P	Construction Indoor Air Quality Management Plan		
	IEQ-6	Reduce Contaminants from Materials		
	IEQ-7	Chemical & Particulate Control		
	IEQ-8	Thermal Comfort		
	IEQ-9	Pest Control		
	IEQ-9P	Integrated Pest Control Management Plan		
	IEQ-10	Personal Control		
	IEQ-11	Acoustics		
	IEQ-12	Lighting Quality		

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Support Urban Development UEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Support development in existing urban areas and fully utilize and support existing infrastructure.

Action: Channel development to urban areas. Provide development that supports and maximizes the use of existing infrastructure and exceeds a minimum development density of 60,000 SF/acre.

Related Guidelines: UEQ-2, UEQ-3, UEQ-4

Potential LEED™ 2.1 Credits: 1 possible with SSc2 (see Submittal Template)

Introduction/Context

With over 12 million square feet of development planned for the 16 acre WTC site this project clearly meets the urban development goals of the 60,000 SF/acre LEED™ criteria described above. The full WTC redevelopment will, in fact, be 10 times this density.

As one of the densest urban centers in the United States, New York City is a model of the efficiencies gained through compact development. According to the 2000 census there are 66,940 people living on each square mile in Manhattan, compared to a national average of 80 people per square mile. This density allows 82% of Manhattan's residents to travel to work by public transit, bicycle or on foot. While good comparative energy use data for NYC is difficult to isolate, New York State's per capita energy use is the lowest in the continental United States. This is largely attributable to the fact that more than 40% of the state's population lives in New York City.

(Note: This LEED™ 2.1 Credit is automatically achieved, however the sustainable context has been described as it impacts other Guidelines and identifies inherent qualitative potentials.)

Relevant Issues

Ecological

The World Trade Center site offers a unique opportunity to build a sustainable city within a city: a new urban center that is designed with ecological considerations informing the planning process from the beginning. As a result of the great tragedy of 9/11, most of the physical history of the original World Trade Center site has been destroyed. It is therefore the responsibility of those of us who come after to make exceptional efforts to plan and develop the site in a manner that is respectful of the immediate past, while looking to the needs and well-being of the millions of people who will use it in the future. The World Trade Center site is planned to be a vital and exciting hub in Lower Manhattan. Developing it in step with the natural environment, and fully optimizing the natural assets offered by its unique location, provides a powerful opportunity to make this site an ecological exemplar of environmental quality. Such a singular approach to large-scale infrastructure and construction demonstrates that the built environment can work in harmony with the natural environment and need not pollute or degrade the atmosphere, waterways and surrounding land.

Many of the concepts that inform sustainable site planning have been incorporated in the Master Plan. The redevelopment of the World Trade Center site is planned to offer green infrastructure, parks and plazas, as well as greenways leading to and from its center, and connecting to other city parks. It will be important for each project within the complex to continue this mission, and to sustain the effort to make the entire site a paradigm of environmental/sustainable and human-centered design.

Economic

The redevelopment of the World Trade Center site is of enormous importance to the economy of the city and the state. Centered on the confluence of public transit systems where services arrive from upstate New York, Manhattan and New Jersey and the more industrial south, this site brings together the business and financial interests of the nation. The recent losses in revenue from businesses and real estate, as well as many thousands of individual jobs, have had a significant impact on the economy of New York. The repair, completion and addition of new transportation services, the rise of compact, high density, new structures at the site and the return of the work force and many businesses will have a large economic impact.

The site is ideally located to draw upon a large, well educated work force from the city, the surrounding counties and nearby states. With the new transit systems in place, attractive buildings, planned services and good paying jobs, the pre-conditions for the viability of the project are in place.

Neighborhood

Although the actual site under consideration in these Guidelines represents an area of approximately 16-acres in size, some 36-acres of land were deeply affected by the terrorist attacks of 9/11. Much of this area has, of necessity, been off-limits to the public, including nearby residents, for the last three years. As infrastructure and

utilities are rebuilt and access to public transit improves, access to this site will increase.

The World Trade Center Master Plan establishes a high density mix of commercial, retail, memorial, transportation, civic and cultural uses for the site. This mix of facilities provides a dynamic program for rebuilding, which will bring a great deal of activity and commerce to Lower Manhattan and the immediate neighborhood. Despite the high density program a large amount of green space has been incorporated. This park-like mix of green and open plazas and squares, along with tree-lined streets and linking greenways, will increase connections to natural systems, provide a canvas for the changing seasons and support a more diverse community of city flora and fauna.

Methodology

Design Strategies

While the WTC Master Plan and existing built environment relationships have largely addressed the requirements of this Guideline, it is important for design teams to be aware that these project parameters include a significant sustainable design strategy.

These high density goals can be accomplished and still provide significant opportunities for public plazas and green spaces, view corridors to the neighborhood, adjacent green areas and the River and connections to the underlying transportation infrastructure. By providing a continuum – a sense of connection to other areas -- the site will become a tightly integrated destination within the context of the greater city. The sustainable strategies throughout the remainder of the Guidelines are essential to the humanization of this highly efficient density.

Means and Methods

While design teams have already addressed the density issue, planning for a successful high density development at the World Trade Center site will need to include flexibility and the ability to adapt buildings as conditions change. According to Staley and Scarlett in '*Market Oriented Planning*', future "...planning will have to incorporate the evolutionary and dynamic aspect of communities to be successful". The objective is to create conditions where communities are allowed to evolve with time, responding to both economics and consumer preferences.

For specific, primary occupancies, this suggests that a 'loose fit, long life' approach to designing office space would be appropriate. The ability to convert a typical, corporate office building to an alternative occupancy, such as multi-family housing or education facilities, with minimal demolition or teardown, encompasses smart planning and sound economics. To achieve this goal, buildings will need to be flexible, and consideration should be paid to design and structural issues, such as depth of floor plates, slab-to-slab clearances, egress capacity, etc. For the mix of corporate, financial and state and city governmental offices that might be expected to represent a profile of the initial occupancy of the site, flexible options will help to guarantee the continuing viability of the buildings. Their potential to change with demand and community needs will provide a substantial return on investment.

Care should be exercised to ensure that all buildings designed for the site are responsive to their role in the greater community and seek to enrich the mix of occupancies. Other considerations might include ground floor retail/shopping spaces, restaurants or spaces that provide services with an inherent extended "street life" and enhancement of safety/security. An auditorium, designed for a specific building client, might also be designed to accommodate community uses. The design of each project can be seen as a vital piece of the jigsaw puzzle, which will be enhanced if each contributes to improving the quality of the urban setting, street life, the community and ecological systems.

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Support Urban Development

UEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 2: Development Density)*
This certifies that this development is in an urban area, supports and maximizes the use of existing infrastructure and exceeds a minimum development density of 60,000 square feet per acre, as defined by the USGBC in the LEED™ 2.1 Reference Guide.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Expanded Public Transit and Bicycle Access UEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Encourage the development of public transportation, address opportunities to connect/cross-connect systems and support and increase bicycle access.

Action: Integrate and encourage utilization of public transportation. Follow the recommendations of the NYC Department of City Planning (DCP) 1999 Bicycle Parking Needs Study and the 1997 NYC Bicycle Master Plan. Reduce parking from pre 9/11 levels and implement a Parking Management Plan to reduce future parking demands. Site parking for commercial uses is not to exceed 1300 cars. For Towers: Support bicycle use by providing bicycle racks or secure and convenient storage. For Site: Support bicycle use by providing bicycle racks near transportation, retail and cultural centers.

Related Guidelines: UEQ-1, UEQ-4, UEQ-7, UEQ-8

Potential LEED™ 2.1 Credits: 2 possible with SS cr. 4.1, and SS cr. 4.2. (see Submittal Template)

Introduction/Context

The World Trade Center site has always been a focal point for mass transportation in lower Manhattan, bringing together regional rail, the PATH train and bus routes from New Jersey and Staten Island, and providing a network of subway and bus connections North into Manhattan and to the extended five-borough region. Good connections to Penn Station, Grand Central Station and the Port Authority Bus Terminal have allowed for easy access beyond the city limits and suburban areas to national transportation services. With the rebuilding of the World Trade Center infrastructure, these services are again becoming available, expanded and enhanced to meet the needs of a growing, ever more mobile public.

Plans call for a central 'World Trade Center Transportation Hub' which will be at the very core of the complex. A cross-linking Connector Corridor will provide easy, underground access to a new Ferry Terminal currently under construction. A new link to the Long Island Railroad is also under consideration.

All of these public transit amenities help to diminish reliance on vehicles, which are predominantly cars driven by single individuals working in or near the confines of the World Trade Center. The bicycle path infrastructure can link to an expanded network of bike paths extending completely around Manhattan. Secure storage for bikes will need to be a priority within the World Trade Center redevelopment area, in order to further encourage the use of non-vehicular transportation.

Relevant Issues

Ecological

The combination of convenient, low-cost public transportation and bicycle access provides viable alternatives to 'driving to work' and reduces the number of vehicles in the city. Reductions in vehicular traffic translate directly to reductions in exhaust and air pollution. By offering convenient, viable public transportation options to the many people who frequent the site, less fuel is consumed by private or single-occupancy vehicles. Fewer cars will also reduce the need for impervious parking areas, decreasing storm water runoff and lessening heat island effects.

Bicycles are, of course a preferred sustainable means of individual transportation where appropriate. Therefore, the provision of amenities necessary to make cycling in the city safe, convenient, and comfortable for anyone who wishes to do so, is an important sustainable goal under this credit.

Economic

By providing convenient, comfortable public transportation, individual automobile use becomes a less attractive option for many commuters. As gasoline and parking expenses rise, this has become more evident, particularly in Manhattan. The potential for storm water surge and resulting sewage overflow can be lessened by reducing the typical urban center parking ratios.

The World Trade Center's proximity to mass-transit access points is an attraction for many business people and contributes to tenant job satisfaction, retention and productivity. Fundamentally, the economic viability of the entire complex flows from its integrated multi-mode transit system. People who live reasonably close to the site may choose to bicycle to work, given that appropriate amenities are made available. Bicycling reduces impacts to infrastructure, has no deleterious impact on air quality and, as a healthy human activity, may help to ward off health care costs.

Neighborhood

Easy access to mass-transit and well-placed interconnections via bicycle and foot paths translate to better connectivity for the residents who live and work around the World Trade Center site. They also facilitate an enhanced exchange of ideas and cultural activities between the local community and those who live in the greater metropolitan region. By providing alternatives to automobile access at the site, vehicle exhaust emissions are also reduced, providing cleaner air and a healthier environment. As an additional benefit, with less vehicle exhaust fumes and particulate clouding the air, building exteriors will require less maintenance and less frequent cleaning.

Methodology

Design Strategies

The design of an enhanced mass transit infrastructure on multiple levels, with multiple modes of transport, is now well defined at the World Trade Center site. Access points at strategic street locations have been designed into the Master Planning documents. Additional access points may be located within or near new structures planned for the redevelopment, and are an important consideration in capturing the full potential of this credit.

One way to provide optimum opportunities to encourage bicycle use is through the provision of convenient facilities for secure bicycle storage. These facilities may be of a temporary nature, such as free-standing, outdoor racks, or more permanent, and secure, such as a bicycle room within each building. These strategies may be further enhanced by the provision of showers and changing rooms for use by cyclists, located near the bicycle storage area.

Site circulation routes and bike paths running between buildings, amenities such as shopping areas and restaurants, mass-transit access points, and bicycle lock-up facilities can also be designed to maximize the potential for cycling within the complex, and to avoid additional vehicular congestion. Programs such as 'Public Use Bicycles' (PUB) and 'Bike-in-Transit', which are designed for temporary use of bicycles, can be employed to great advantage on the 16-acre World Trade Center site, perhaps in conjunction with Battery Park City. To tie this sustainable initiative closely to the overall goals for easy site access and neighborhood pedestrian flow patterns, the location of such bicycle facilities would ideally also be located near mass transit access points.

Although bicycles generally require little day-to-day maintenance, the notion of cycling to work would be well-supported by the existence of a bicycle maintenance facility within a short distance of the main site structures.

Means and Methods

Restrict vehicle access, movement and parking on the site.

Secure bicycle racks for general outdoor use are readily available in the marketplace, or can be designed for the site. PUB programs provide their own locking kiosks, with bicycles being accessed via the use of pre-purchased cards or codes. Early planning might incorporate a bike storage room with secure facilities, and an option for showers and changing facilities in each major structure. These programs support both private ownership and use of bikes and public programs such as PUB.

Public Use Bicycle (PUB) programs have been in existence for 35 years in Europe, and are generally well-used and successful in diminishing the need for private transportation within a city or compound. The installation of a PUB, or public-private program such as ClearChannel Adshel's 'Smartbike' or Deutsche Bahn's 'CALL A BIKE', will provide an innovative and attractive means of non-vehicular, on-demand transportation within the 16-acre World Trade Center site. Some of these systems

are provided free of charge by their sponsors, depending on advertising as the sole means of revenue. Advertising on the locking kiosks and bikes helps to reduce bike theft. Kiosks located both near the entrances and exits of commuter rail and subway stations, and near large office complexes and entertainment centers, will increase access and encourage use of these short term rental bicycles. Bicycles can help reduce the need for non-pervious infrastructure as well as automobile use. However any such program will depend on the inclusion of dedicated bike paths, which will enhance safety factors and contribute to efficiency of movement and speed.

Case Studies

ClearChannel Adshel 'SmartBike' Program

This system provides a network of public use bicycles distributed through locking kiosks placed throughout a city. The SmartBike system helps mitigate traffic congestion and air pollution because it makes cycling a convenient alternative to driving. This program has been adopted in cities including Rennes, France, Bukit Batok, Singapore, and Drammen, Norway. Annapolis, Maryland is in the process of implementing an Adshel system and other US cities are considering implementation of the program as well. A city wishing to implement this system contracts with Adshel for its initial setup. Adshel does not sell the necessary equipment to the cities, rather they retain ownership of system components and are responsible for their maintenance. Adshel uses the bicycles and their racks to generate revenue through advertising. This is the sole source of funding for the system. Locally manufactured bicycles are typically employed. The basic function of the program remains the same no matter where it is instituted. People unlock a bicycle from one of many docking stations placed in convenient locations around the city using a Smart Card. The Smart Card tracks an individual bicycle and keeps a record of user identity. On-line monitoring deters theft and vandalism and can pinpoint a specific Adshel bike anywhere in the city. The advertising on the bicycles also reduces vandalism, making an Adshel bike easily identifiable to the casual observer. When a person is finished using a bike, they return it to the nearest docking station and lock it in place with their Smart Card. The embedded tracking technology supports overall system management and updates the central controller with the number of bicycles available at each docking station. Using this information, system attendants can be dispatched to transfer bikes from overloaded stations to nearly empty ones. (Community Bike 2002)

The Plaza at PPL Center, Allentown, Pennsylvania

The PPL Energy Company chose to erect this facility on a previously developed, urban site rather than consolidating all of the company's operations into a single suburban campus. This put their new building in a location where it could exploit existing urban infrastructure, including structured parking and a public transportation hub adjacent to the site. The designers of the new plaza incorporated elements that support pedestrian commutation. The site is equipped with enough covered, secure bicycle storage for 5% of the building's occupants, as well as shower and changing facilities for use by all employees. No new parking was constructed as part of this project and the existing lot which serves the building's occupants was retrofitted with 24 electric vehicle recharge stations. All lines of a regional bus system stop within one block of the building, with most of the buses stopping directly beside the facility. (USGBC 2003)

Reference

Definitions

Definitions have not been included for this guideline.

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Expanded Public Transit and Bicycle Access UEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
A Bicycle Access diagram is attached and indicates
- Location of secure bicycle storage areas
- Access points to mass transit and pedestrian paths
- Existing and proposed new bicycle paths

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 4.1: Alternative Transportation - Public Transportation Access)*
This certifies that the project is located within ½ mile of a rail station or ¼ mile of two or more public bus lines usable by building occupants.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Sustainable Sites Credit 4.2: Alternative Transportation - Bicycle Storage and Changing Facilities requirements)*
Secure bicycle storage with convenient changing/shower facilities (within 200 yards of the building) will be provided for at least 5% of the regular building occupants as follows:

Number of regular building occupants:	
Number of bicycle storage slots provided within 200 yards of building:	
Number of showers and changing facilities provided:	
Percentage of occupants served	

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Regional Mass Transit UEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To promote regional mass transit systems.

Action: Provide inter-modal connection facilities for regional transportation system, ferries, subways and buses with clear connections between the various transportation systems. Allow for future integration of other regional transportation systems.

Related Guidelines: UEQ-1, UEQ-2, UEQ-4

Introduction/Context

The first observation one might make about the WTC Redevelopment is that the entire development is shaped by a "movement infrastructure" of mass transit, roadways, rail, footpaths, escalators and elevators. This transportation infrastructure transports tens of thousands of people arriving by ferry, rail, subway, bus, van pools and private vehicles, as well as by bicycle and on foot, to and through this unique community of spaces in the heart of the nation's densest urban center. This infrastructure, in turn, enables very high levels of development density and supporting services.

This measure is intended to ensure that the full site development is coordinated with, and linked to this infrastructure, to maximize mass transit potentials, connect the downtown Manhattan area with the surrounding region and make both commuting and traveling easier. The new PATH station is a centerpiece of this project, but the overall character and the experience of the average user on the site will be greatly enhanced by supporting the full network of mass transportation. This should include the new ferry terminal located to the north of the World Financial Center, regional buses which serve both commuters and visitors to the memorial, possible future connection to the LIRR, as well as the subway system.

All future projects, including ones of smaller scale, can respond with planning strategies that facilitate (physically and visually), the efficiency and clarity of the overall system. This can be clearly demonstrated in pedestrian circulation pathways, the location of entry/exits, view corridors and the inclusion of wayfinding/graphics. Another useful strategy is the provision of a way for people to monitor the current operational status of mass-transportation systems. For example, if people can see that a particular subway line is experiencing delays before they actually board that train's platform, congestion can be curtailed as they choose alternate routes before entering the system and avoid backtracking.

Relevant Issues

Ecological

Ecological benefits from improved regional transit systems linked to Lower Manhattan include increased transportation energy efficiencies, reduced pollution and reduced regional and local land development pressures. An efficient and improved regional transportation system includes high speed linkages between high density urban areas, allowing the creation of green belts and open space to preserve important ecological functions from groundwater recharge, habitat preservation and the support of increased biodiversity to local agriculture and heat island effect mitigation.

Economic

Economic growth is significantly tied to a transportation infrastructure that can grow, change form and become more efficient to meet its users' needs. The North East region saw two major building expansions in the last century. The first was brought about by the growth of rail transportation in the latter part of the 19th century and the first part of the 20th century. The second expansion was the direct result of highway building following WWII. These two initiatives created the necessary conditions for development to spread outward from city centers and rail corridors.

Today the Regional Plan Association (RPA) and others are calling for what might best be described as an optimization of New York's vast existing transportation network to significantly increase its potential to move people and goods in an efficient manner. The Third Regional Plan outlines 16 targeted transportation objectives, a number of which are focused on improving regional mass transit connections. The ultimate goal of this ambitious plan is an expansion in growth equivalent to the first two building expansions, without a loss of environmental quality.

Neighborhood

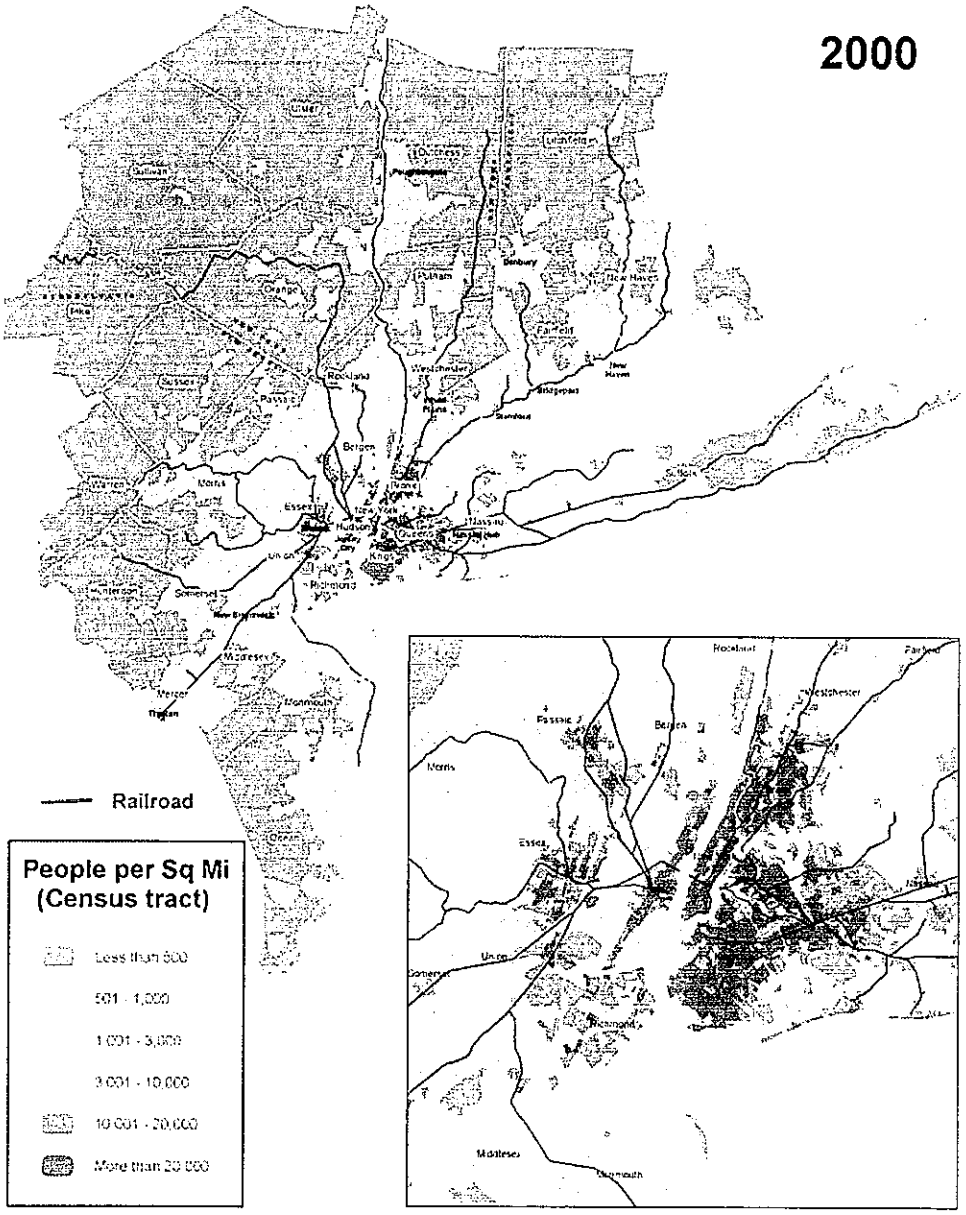
Access to a comprehensive network of interconnected transit systems offers commuters and visitors to the World Trade Center a choice of transportation means and more efficient travel options. Planning that looks to enhanced accessibility encourages people to make full use of available public transportation, especially those who travel to and from the site daily. Conveniently located connections to mass transit systems promote increased use as people realize that they can arrive either inside or close to their building, avoiding the hassle of congested city streets and tough parking conditions. The associated reduction in pollution from personal vehicles provides cleaner air, more livable neighborhoods and improved flow of goods and services. Good transportation links will also provide access to retail and cultural events, supporting diversity at the site and creating a 'destination' for many who come for reasons other than work.

Methodology

Design Strategies

Major access locations have been determined as part of the site master plan. The intent of this guideline is to acknowledge the importance of good access to regional transit systems and provide strategies to support and supplement connections.

Supplemental access points may be provided in coordination with security requirements and changing numbers of commuters and/or visitors. Architects, landscape architects and planners who receive commissions to design buildings, parks and other projects at the WTC site need to be aware of the overall planning accessibility objectives. Consideration of existing and planned access points close to each project site can identify those areas which are well served, as well as those that are underserved by access to mass transit. Where appropriate additional entrances at building lobbies or close to exits can link commuters directly to the greater Transportation Hub. Links can be stairs or escalators to subway entrances or the underground corridors that lead to other inter-modal transit connections.



New York-New Jersey-Connecticut Metropolitan Region (RPA 2004)

Means and Methods

Review existing and projected pedestrian traffic and mass transportation access patterns, in conjunction with project planning. Determine potential impacts of new linkages on increasing system efficiency, promoting greater use (see RPA's Third Regional Plan) and creating flexible, responsive designs.

Provide legible signs with interactive video or LED displays to provide updated transportation information. These are ideally located in public plazas and lower level mass-transit lobbies of each building, where they are immediately visible to commuters, indicate if transportation systems are running on schedule. Visually attractive and easily available to all site occupants and visitors, these display panels can provide real-time traffic reporting, offering re-routing information when necessary, thereby encouraging the use of mass transportation in lieu of automobiles.

Case Studies

Transbay Terminal, San Francisco

The city of San Francisco is planning a new central terminal in the downtown area to better connect the city with two existing local commuter rail lines, existing Amtrak and new high-speed rail lines that will connect San Francisco and Los Angeles. In addition, the station will be a new hub for express and local buses and provide retail and dining facilities. The station is designed with many sustainable goals including maximization of natural daylight and ventilation and the capture of rainwater for maintenance and irrigation. It is also intended to revitalize the downtown area, encourage growth and is part of a larger plan to bring a higher density of residential, retail and commercial building to the area. (Metropolitan Transportation 2001)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Regional Mass Transit

UEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	○	○		○

☐ **Required Component:**
The attached narrative describes how this project enhances connections to existing and potential future regional mass transit systems.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Pedestrian Movement UEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Support neighborhood, community, visitor and commuter pedestrian pathways and facilitate pedestrian access to and through the site.

Action: Diagram anticipated pedestrian pathways that are coordinated with plans for WTC Redevelopment Projects. Enhance pedestrian pathways, both above and below ground, to facilitate and support pedestrian traffic. Describe and illustrate enhancements including connections to buildings, additional pathways and transportation nodes, path size, adjacent area uses, public art, vegetation, access to daylight and direct sun, furnishings, wayfinding, paving materials and patterns and view corridors.

Related Guidelines: UEQ-1, UEQ-2, UEQ-5, UEQ-6, UEQ-7

Introduction/Context

Pedestrian traffic is integrated throughout New York City streets to a greater extent than in any other North American city, yet the city does not always provide pedestrians with the amenities they need for their safety and comfort. In this great metropolis, multiple sidewalk vendors, artists, musicians, store displays, street theater and drama, constantly play to and attract the attention of pedestrians, to a greater extent than any other city in the western hemisphere. Yet these same pedestrians are exposed to confusing traffic crossings, a toxic brew of vehicle exhaust and ground level ozone, mounds of sidewalk trash, and a lack of public restrooms. Moreover, sunlight available at street level often consists of mere slivers, even on days when the city is not experiencing heavy rain or winds, from which there is little shelter. Street grids reflect Cartesian precision which expedites real estate transactions and the location of one's coordinates, but frequently does little to improve the pedestrian experience.

Designing amenities for pedestrians includes the provision of basic accommodations that encompass all typical activities -- going to work, going home, looking for a meal, going to school, shopping, sight-seeing, or just plain walking. It requires a plan which addresses physical comfort, allows for reasonable safety, and supports environmental well-being, including a connection to natural systems (time of day, seasonal changes) and way-finding.

Relevant Issues

Ecological

Walking is healthy: not only is it good exercise, but for each person who walks, a car may be removed from the street or a seat on a bus vacated. Remove enough cars and empty enough bus seats and soon an asphalt lane can be replaced with a planted median. This scenario invites more pedestrians to the sidewalk, and as the noise and fumes from traffic diminish, the cycle will continue with extended ecological and health benefits for all. Europe has embraced this concept successfully and created pedestrian thoroughfares through key, central shopping areas in many of its major cities, from Lille in France to Copenhagen in Denmark.

Economic

Increasing pedestrian access to and through the site will inevitably mean more business for commercial, retail and service establishments positioned near or alongside pedestrian pathways. Coordinating these pathways with transportation access points, outdoor open spaces and other places of interest will further increase pedestrian traffic, bringing people to the site for business, shopping and relaxing in a pleasant, safe environment.

Neighborhood

In a neighborhood setting, pedestrian activity increases social interaction and can help to build a sense of community. This activity can both create and extend these same qualities from the surrounding community. Lots of people attract street artists and vendors, and increased population on the street is a recognized way to minimize street crime. The provision of some minimum shelter from the weather at outdoor bus stops, parks and open plazas, for example, will further enhance the quality of the area and contribute to a sense of human well-being.

Methodology

Design Strategies

Analyze and study existing pedestrian movement in the larger neighborhood surrounding the site. Diagram existing pedestrian pathways which are coordinated with the WTC Site redevelopment plans, and enhance pedestrian access through additional walkways at new structures. Develop an understanding of the spatial / programmatic needs of the inhabitants in and around the site and provide pedestrian infrastructure to meet those needs.

Commercial, retail and cultural venues need to be well served by sidewalks and other means of access. Consider including provisions for safe, out-of-the-traffic stream, drop-off/pick up locations for pedestrians near all major buildings. Develop a system of pathways (pervious, if possible) for pedestrians through any large green spaces, and locate shady and/or sheltered places for people to walk and sit, protected from traffic. Provide adequate outdoor lighting at sidewalks and pathways, with light output focused down to brighten the pedestrian area while avoiding night-sky pollution. Include minimal weather-related shelters, street furniture at sidewalks, and appropriate trash disposal containers to keep streets and sidewalks clean and free of rubbish and vermin.

Means and Methods

Enhance pedestrian pathways below, on, and above ground. Provide new pedestrian connections in strategic locations to ease congestion, improve circulation at the site, connect buildings where appropriate, and support access to mass-transit systems. Study provision of pedestrian amenities such as public art, adjacent open spaces for non-circulation uses, street furnishings, wayfinding, view corridors, access to parks, and access to natural light and direct sunlight, and incorporate these where appropriate. Design pedestrian infrastructure in an aesthetically pleasing and functionally comfortable manner. Consider textures, patterns, colors, materials, and the shapes and dimensions of pathways, appropriate to locale and function.

When possible, design pedestrian infrastructure to help provide relief from harsh natural elements such as wind, rain and snow. Minimal, open structures with roofs can be appropriate. Structures that offer greater protection should be considered in windy locations.

Implement traffic control features to define clear pedestrian zones and provide protection for pedestrians in areas that they must share with vehicles. In association with authorities such as the traffic police, establish speed limits within the WTC complex and pedestrian 'right of way' at crossings to further safeguard those on foot.

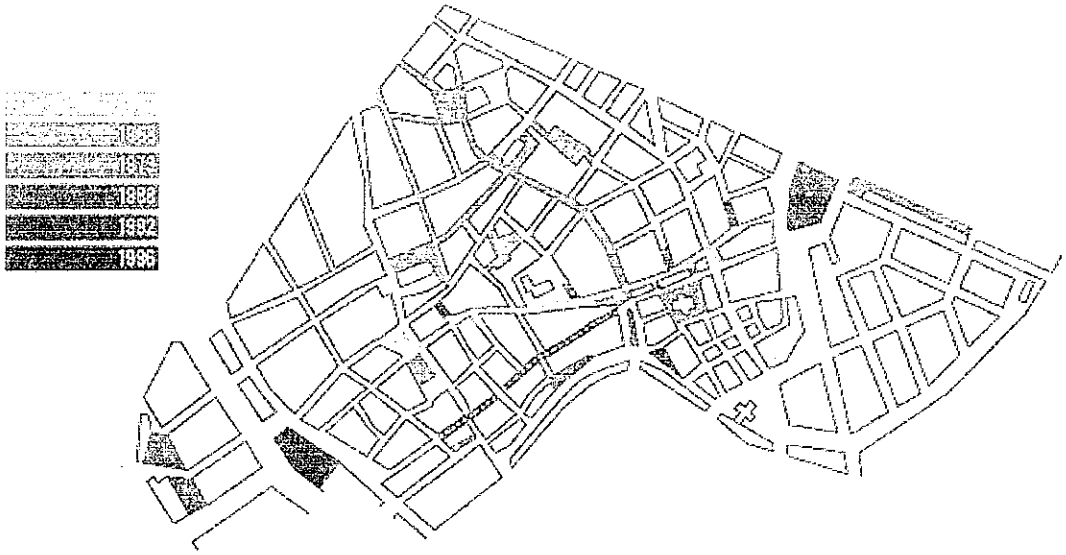
At underground concourses, introduce maximum daylight to provide a connection to the natural world above. The use of daylight creates an optimum interaction between built and natural systems, contributing to an easier and more enjoyable experience of wayfinding. Architectural wayfinding elements that utilize daylight and floor patterning, balanced with structure, interior volumes, and placement of circulation elements, can be incorporated to articulate the major spaces and connections, and to reduce the dependence on signage.

Case Studies

Copenhagen, Denmark

Copenhagen is a leading city in the campaign to support both increased pedestrian traffic and greater use of public spaces for personal enjoyment, health and wellbeing. The historical development of Copenhagen, being organized with a narrow medieval street grid, provided the city with an easier starting point from which to develop enhanced pedestrian infrastructure. Making the most of this innate characteristic, city leaders have made a concerted effort to continually enhance the quality of the pedestrian experience. Informed by rigorous research into human behavior in urban spaces, city planners have instituted a series of strategies designed to create a more pedestrian-friendly city. Jan Gehl, a Danish architect involved in these efforts, reported on research showing that four times more public activity occurs in Copenhagen's city center than in comparable cities with fewer pedestrian amenities. In 1962, the city converted its main street, Stroget, into a pedestrian thoroughfare. In the following years more streets were slowly converted to pedestrian traffic only. Pedestrian-priority streets were also created, where walkers and cyclists have right-of-way while vehicular traffic is allowed only at limited speeds. The city stabilized the level of vehicular traffic by gradually reducing the available number of parking spaces by 2-3 percent per year. (Makovsky 2002)

In the decade between 1986 and 1996, 600 parking spaces were phased-out. The parking lots left empty by these design moves were given new life as public squares. Smaller scale pedestrian enhancements, such as places to sit, and support of general comfort and security on city streets, continues to enhance Copenhagen's efforts. The development of pedestrian zones over time are indicated in shades of blue on the diagram below. (Makovsky 2002)



Copenhagen City Center (from MetropolisMag.com August/September 2002)

Reference

Definitions

Definitions have not been included for this Guideline

Standards

Standards have not been included for this Guideline.

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Pedestrian Movement

UEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
The attached diagram indicates enhanced site pedestrian pathways, connections to adjacent existing and proposed pedestrian patterns, pathways and transit hubs.

☐ **Required Component:**
The attached narrative description explains how proposed new pathways and nodes will improve pedestrian circulation to and through the site. Path size, adjacent area uses, public art, vegetation, access to daylight and direct sun, furnishings, wayfinding, paving materials and patterns, and view corridors are included in the description.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Green Infrastructure

UEQ-5

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Support the development of green infrastructure by developing and linking vegetated site areas with existing neighborhood green spaces.

Action: Diagram "green" infrastructure within 1000' of site boundary. Create site vegetated areas to enhance site contributions to natural ecological processes, sustain air and water resources, promote biodiversity and reduce heat island effects. Facilitate creation of green infrastructure linkages in conjunction with adjacent neighborhood green spaces.

Related Guidelines: UEQ-4, UEQ-6, UEQ-7, SEQ-3, SEQ-8, SEQ-13

Introduction/Context

The allocation, placement and specification of site vegetation offers significant opportunities, which extend beyond planted areas to enhance Urban Environmental Quality. In dense urban areas ecological systems are under severe stress. Physical or visual linkages to adjacent green areas offer extended value in supporting ecological systems by providing important green 'corridors', which allow for movement and greater biodiversity for insects and wildlife (songbirds, butterflies, etc.). In addition, adjacent or nearby parks and green spaces, which may not be physically linked, but are visually connected, constitute a patchwork or mosaic of green locales which also constitutes a recognized sustainable initiative. The dynamics of these types of urban "patch" habitats are just beginning to be understood and offer designers both an opportunity and a valuable tool to contribute to the quality of the ecology of this specific urban site.

In the steel, glass and concrete canyons of lower Manhattan, parks and plazas serve to provide the human population with an important reminder of the natural processes which sustain all planetary life. Plants and trees represent a key connection to seasonal changes in the natural world. In these two respects, plants serve as important environmental indicators in dense urban areas. They remind us that human beings are but a small part of a much larger eco-system and the visible state of health of these living organisms serves as a sensitive barometer of environmental wellbeing.

As living landscapes, green areas require separate design considerations, which differ significantly from a sustainable approach to designing buildings. Thought must be given to how the landscape will change over time as maturation will affect its form, ability to function and provision of shelter and shade. The landscape's potential to add visual pleasure and provide food and wildlife habitat in five, ten and even fifty years must also be considered.

Relevant Issues

Ecological

The ecology of plants in a dense urban environment is very different from the naturally propagated systems that occur in deep woodlands or natural meadows. These plants, which occupy small, isolated patches in city parks and gardens, present enormous challenges to insects and all forms of wildlife. Birds and insects are involved in the dispersion of seeds, and are responsible for natural pollination. Planning for maximum green spaces, preferably with physical and/or visual connecting green corridors, helps to support biodiversity and to alleviate potential ecological interruptions.

In urban environments, plants are subjected to stresses which are heightened by the built structures and human activities around them. At the same time, they are helpful in moderating some of the worst conditions associated with microclimates, such as 'heat island effect', which is created by heat build-up in the impervious built environment. Trees and vegetated areas mitigate heat island effect by providing natural shading and enhanced opportunities for evaporative cooling, while reducing areas of heat absorbing materials. In addition, plants and trees offer a natural air quality enhancement by absorbing significant quantities of carbon dioxide (CO_2) generated by building and automobile exhausts, reducing particulate loads and producing oxygen.

Trees, shrubs, vines and flowers contribute to people's sense of well being, health and pleasure. Urban gardens and green spaces tend to moderate temperature, cooling the ambient air significantly. In hot summer months, shade trees with their characteristic broadleaf structure provide pools of cooler air, bringing welcome respite from the heat. Many parks and plazas include fountains and water displays, and these too contribute to wildlife habitat, while providing a cooling effect on local temperatures.

Economic

Real estate values in Manhattan are always higher for property in close proximity to parkland and green spaces. Green corridors, at best, provide tangible links to other neighborhood parks and, at least, offer the perception of extended greenspace. Mosaic or patchwork areas of green enhance the perception of open space. In either case, these win-win, environmental/sustainable strategies serve to increase the physical and visual quality of the entire locality, increasing real estate values, as well as providing community amenities and enhanced ecological benefit.

Neighborhood

Green spaces are important to the well-being of people and neighborhoods. They improve air quality, mitigate heat-island effect and enhance human well-being through the increasingly well-documented and accepted restorative effects resulting from reinforcing connections to nature. Trees planted in close proximity serve as 'buffer zones', reducing noise pollution and protecting pedestrians from wind. Parks and plazas, linked loosely together by green corridors -- tree-lined streets, sidewalk planters, planted roadway medians, etc. -- serve to support pathways for wildlife. Insects, butterflies and birds, particularly the small indigenous songbirds common to this North East region, are able to thrive, finding in these multiple islands of green,

sufficient diversity, food and habitat to maintain the strength of their species and to support their natural habits. People enjoy these connections to nature and find natural sights and sounds to be fundamental qualities of enrichment in urban spaces.

Methodology

Design Strategies

Diagram 'green' spaces within 1,000 feet of the site boundary and identify important existing or planned neighborhood green spaces for linkage to site green spaces. Consider the design of *physical* green corridors in the planning of the site, via streets and thoroughfares leading from the center to regional neighborhoods. Green corridors need not be elaborate or demanding of dedicated space. Tree-lined streets provide one traditional means of linking green spaces. Large planters can also be designed to maintain a ribbon of plant-life from site green spaces to neighborhood parks or plazas. Wherever feasible, include vegetated areas, at roofs, terraces, ground level plazas and parks, and in open wells and areaways. These will serve to enhance the site, mitigate heat island effect and provide habitat for wildlife. Built-up site development will be measurably enhanced by maximizing this program.

Means and Methods

Employ strategies for strengthening the ecological functions of green space patches as outlined in Landscape Ecology Principles in Landscape Architecture and Land-Use Planning. (Dramstad 1996) This handbook of ecological planning principles analyzes structural patterns in landscapes through three types of elements: patches, corridors and matrices. Clear diagrams are provided of how patterns of these three universal elements can be structured to improve ecological function in the landscape. The dynamics within these universal elements are further developed and explained through the qualities of their sub-elements which include edges, boundaries, barriers, stepping stones, networks and meshes. Applications of these strategies are schematically demonstrated in different scales and settings.

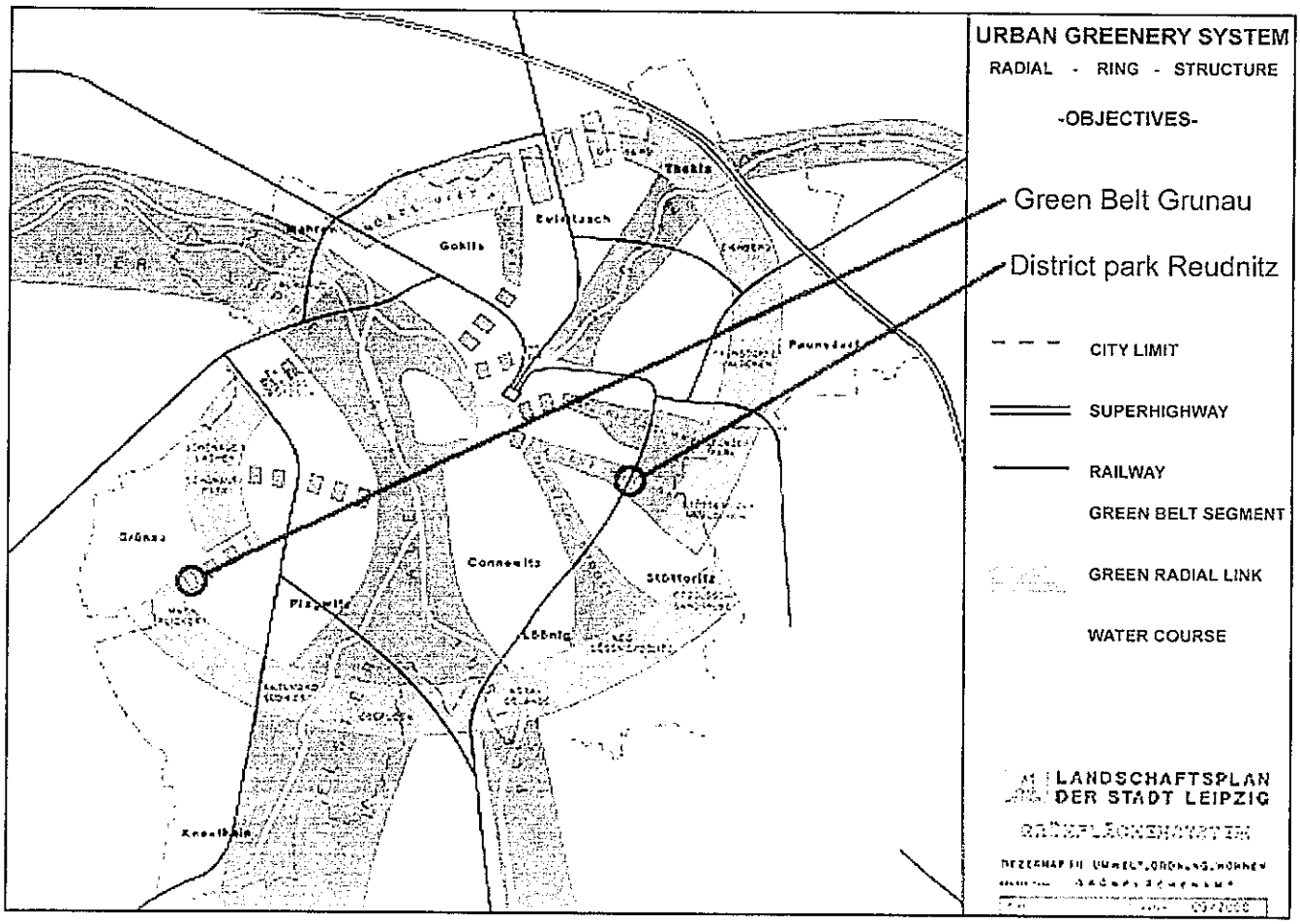
Include buildings in this analysis and consider the use of green walls and roofs when possible to extend green space potentials.

Case Studies

Urban Green Environmental Project, URGE, European Commission
Leipzig, Germany

Modern Leipzig was developed with belts of housing tracts around the historic city center. Many of these houses are now derelict and others have been left vacant by a mass exodus to the suburbs. As these structures are demolished, the city is making an effort to replace them with sustainable green spaces. Some of these efforts have coalesced into smaller campaigns within particular neighborhoods. One example is the Green Belt of Grunau in Western Leipzig. The area where this green tract was created had been set aside for a new road and tram tracks before the Berlin Wall was taken down. Afterward, those plans were abandoned and the land lay unused for several years. The local government, with the help of neighborhood residents, developed a project to turn this land into public open space with playgrounds, walking paths, and other recreational areas. In Eastern Leipzig, a plan was devised to create a 'green finger' to replace former railway infrastructure within

this densely populated part of the city. The district park, Reudnitz, was created to develop open public space of ecological significance, improve the quality of life, provide recreation areas for local residents, and support the development of an advanced network of cycle tracks and footpaths. These projects are merely two examples of city-sponsored efforts to building new green infrastructure in Leipzig. The map below shows the overall scope of these projects as of the year 2000. (URGE 2004)



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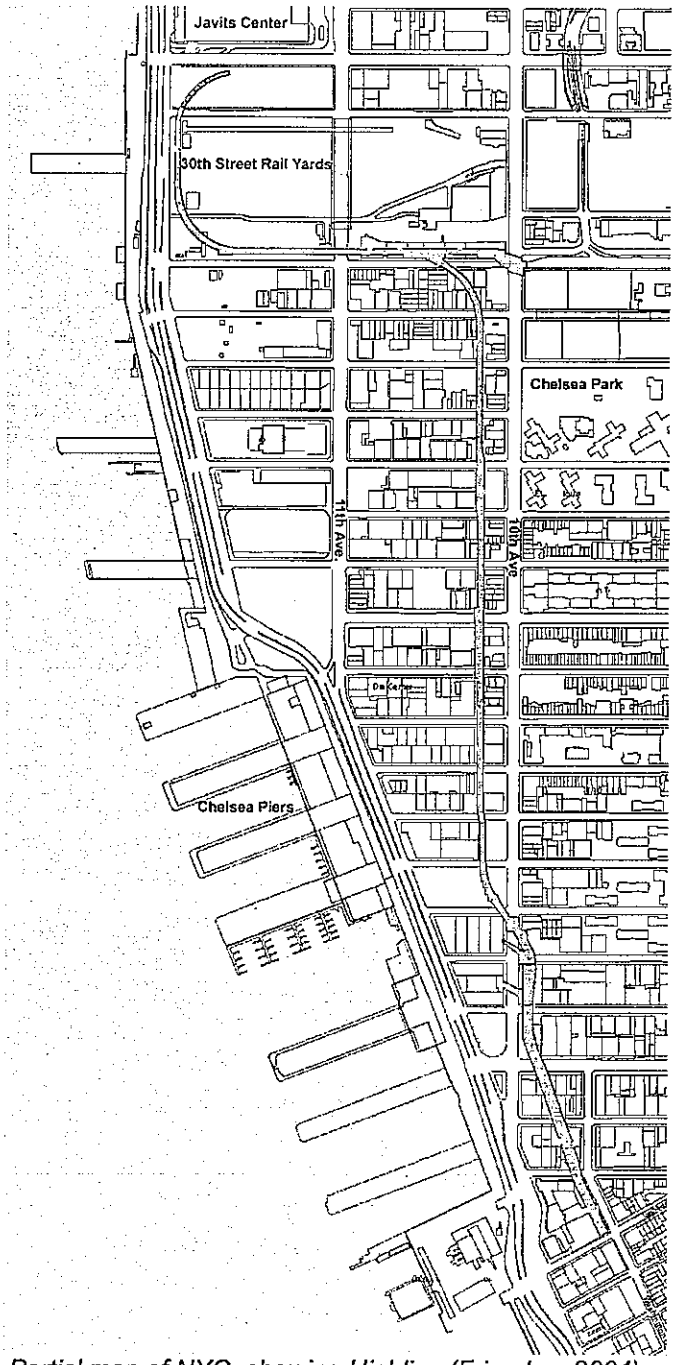
Map of green infrastructure in Leipzig in the year 2000 (URGE 2004)

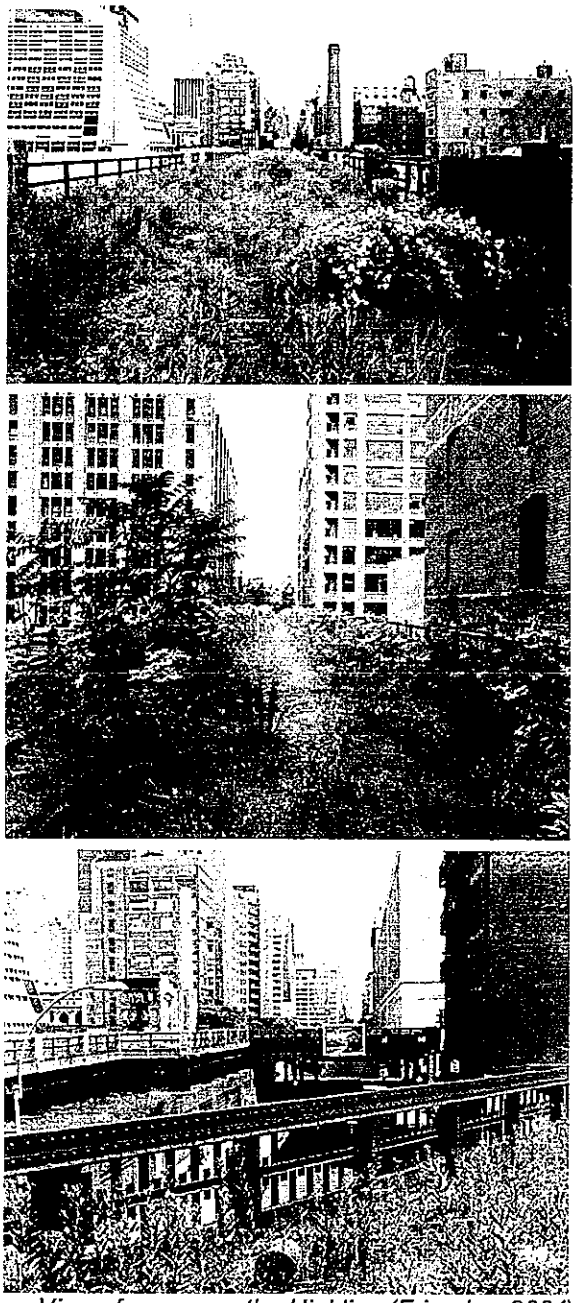
New York City, Highline project

Friends of The High Line was formed as a non-profit group to promote the conversion of a 22 block long, abandoned elevated railroad running from 34th Street to Gansevoort Street into a public green corridor. They feel it offers an opportunity to create a unique recreational amenity for New York City. As a result of their efforts, New York City has pledged capital support to help push this venture forward. If the vision of this project is realized, it will create a tranquil, elevated public green space that offers views of the Manhattan skyline, the

Hudson River, and gardens that are currently "hidden" inside various city blocks. This public promenade will also offer various recreation programs. Some potential ideas proposed have been a public urban beach, music venues, and botanical gardens. (Friends of The High Line 2004)



Partial map of NYC, showing Highline (Friends... 2004)



Views from up on the Highline (Friends...2004)

Reference

Definitions

Green Infrastructure is an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations (Benedict 2002)

Standards

Standards have not been provided for this Guideline.

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Green Infrastructure

UEQ-5-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	●

☐ **Required Component:**
The attached plan diagrams existing and proposed green spaces within a 1,000 foot radius of the project site, highlighting proposed new green spaces.

☐ **Required Component:**
A supporting narrative is attached and confirms how proposed new green spaces on the site will strengthen the overall system of green infrastructure. It includes details on ecological patch dynamics, habitat creation and how these specific strategies are being supported over time.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Outdoor Environmental Comfort

UEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To facilitate site development that supports outdoor environmental comfort.

Action: Design site structures, materials and landscape to enhance comfort and functionality of outdoor spaces and mitigate the effects of heat islands. Extend outdoor comfort levels further into the Spring and Fall seasons with passive strategies that maximize natural assets. Design structures with consideration for site environmental wind conditions where pedestrians would be affected and seek to moderate any such effects.

Related Guidelines: UEQ-4, UEQ-5, SEQ-3, SEQ-8, SEQ-9, SEQ-10

Introduction/Context

Shaping the environment to increase comfort predates the building of early settlements more than 10,000 years ago. This strategy is instinctive, and was first reflected in the choices of early nomadic peoples, when they selected a south-facing cliff to warm themselves on a wintry day or a shady glen to cool themselves on a hot summer day. Throughout the last 10,000 years there have been many excellent examples of environments that were specifically shaped to optimize human comfort. In 1963, Victor Olgyay was one of the first to mine this wealth of environmental comfort knowledge when he published his now classic book, Design With Climate. Olgyay examined traditional and indigenous shelters from around the world to develop a checklist for designers on how to moderate the effects of climate. These traditional architectural forms were fully integrated into their environments and shaped by the need to maximize thermal comfort and minimize the amount of construction material required. This economy of means has created a wealth of information on the creation of comfortable outdoor environments.

Calculating outdoor environmental comfort is not an easy task. The sun moves through the sky, changing position and the intensity of solar radiation it delivers to the Earth. "Sensible Temperature", or the temperature one perceives, is determined by changing air temperatures, humidity levels and temperatures of nearby surfaces. Winds shift in both intensity and position throughout the day and also impact thermal comfort. People wear different weight clothing, engage in different levels of activity and have different personal comfort levels. In indoor spaces we constrain many of these variables. In outdoor spaces these controls are not possible or desirable. We can, however, move about more in the outdoors, and people do. Given a sunny or shaded bench on a brisk November day, people will nearly always choose the sunny bench. On a summer afternoon, in all likelihood the other bench will be more popular.

This variety is essential to good outdoor environmental comfort design. By creating areas that will provide comfort at different times of the day and season, we can increase the potential for people to use these spaces throughout the year.

Relevant Issues

Ecological

Bringing people outdoors reduces demands on indoor spaces and provides increased opportunities for connection to the natural world. Reduced demand on indoor spaces reduces indoor light and air conditioning energy requirements.

The act of bringing people outdoors for longer periods of time improves their health. People tend to move about more, opportunities for exercise are increased and fresh air and daylight are especially important to city dwellers who spend a large portion of their time indoors. Increasing people's connection to the natural world has also been demonstrated to reduce stress and provide opportunities for rest and relaxation.

Bringing people outdoors and into connection with natural systems also increases awareness of those systems and their role in sustaining us.

Economic

Increasing and extending the amount of time that outdoor spaces are comfortable provides increased and extended opportunities for outdoor retailing, dining and performances. Improvements to health from bringing people outdoors and increasing opportunities for exercise have direct economic benefits in both increased productivity and reduced medical costs.

Neighborhood

Outdoor spaces that are welcoming can enhance the level of social interaction that occurs in a neighborhood as more people linger outside. A comfortable outdoor space is likely to be used more frequently and the increased presence of people outside works to deter crime.

Methodology

Design Strategies

Analyze the local microclimate to illustrate site environmental conditions including proposed and existing building locations, wind patterns, solar access, and shading patterns, vegetated areas and water features. The analysis should include local climate data for temperature, humidity, wind speed and direction, solar radiation, rainfall and cloud cover.

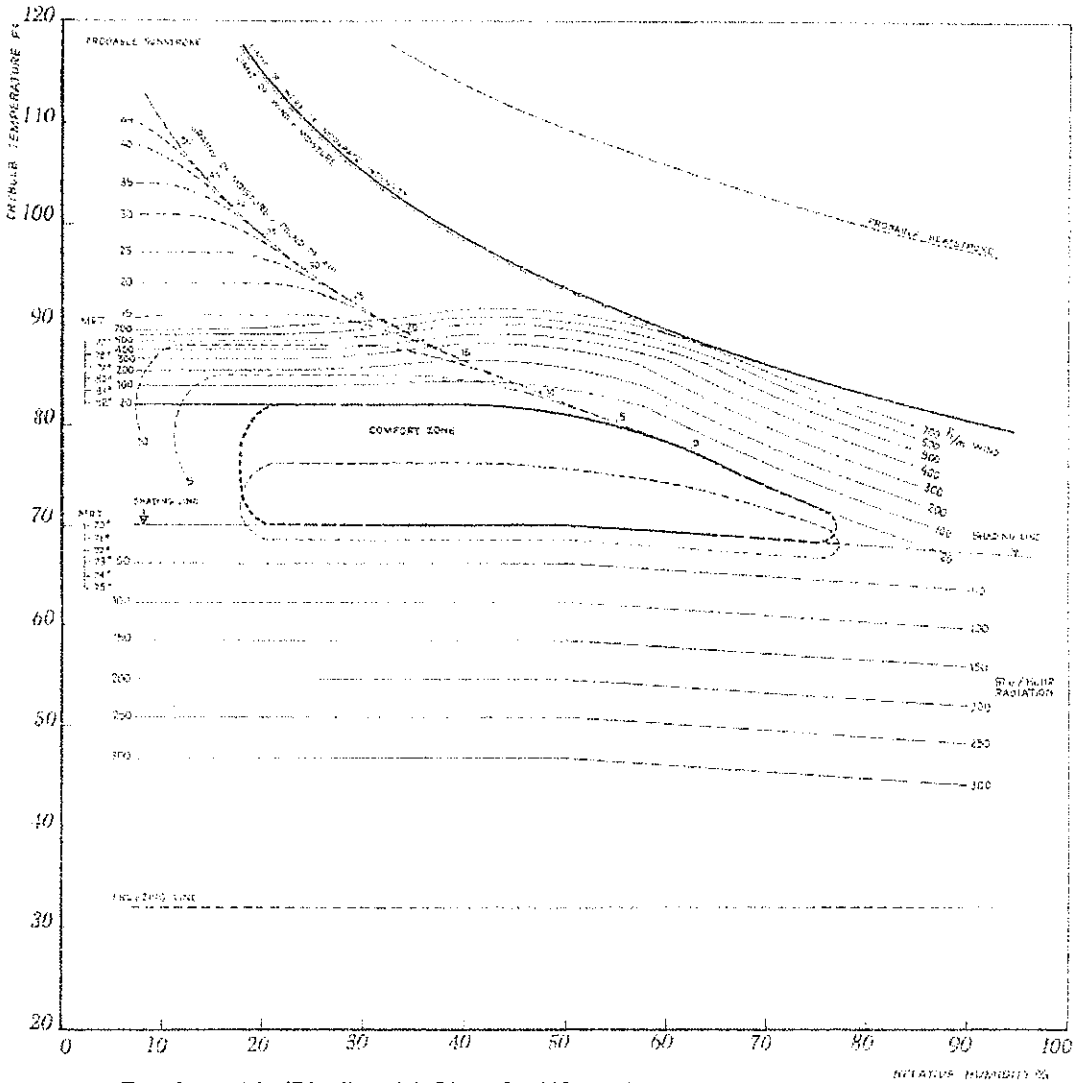
Outdoor Thermal Comfort strategies should provide a variety of comfort levels to ensure there are areas for different times of day and season. Include consideration of activities, ages, and clothing levels.

Researchers at the Center for the Built Environment, University of California, Berkeley have developed an Advanced Thermal Comfort Model based in part on Dr. Zhang Hui's PhD dissertation, "Local Thermal Comfort in Asymmetrical and

Transient Environments". The model distinguishes itself from previous environmental comfort models in its ability to model human comfort and sensation in non-uniform and changing thermal environments. While still in development, the model does have potential as useable tool for better understanding outdoor environmental comfort.

Means and Methods

The Bioclimatic chart shown below was developed by Victor Olgyay in the early 1960's to illustrate how different climatic conditions affect environmental comfort. The chart maps out an average environmental comfort zone and demonstrates how this comfort zone shifts as environmental conditions change. It includes solar radiation (btu's per hour), dry bulb temperature (degrees Fahrenheit), relative moisture content (actual density over saturation density), actual moisture content (grains of moisture per lb of air) and wind (feet per minute).



Psychometric (Bioclimatic) Chart for US moderate zone inhabitants (Olgyay 1963)

Solar radiation strategies:

Locate and orient outdoor areas and furnishings to take advantage of solar exposure, when desired, while providing areas of shade for times when the sun is too intense. Shade provided by deciduous trees during the warmer months will open up to sunshine during winter months, increasing opportunities for outdoor environmental comfort. Consider thermal mass, use of vegetation and light and dark colored materials to optimize material properties in thermal comfort design and reduce heat island effects. Consider night-covering or phase-change material potentials to retain heat in certain cases.

Wind strategies:

Locate and orient outdoor areas and design site features and plantings to moderate pedestrian level wind effects in areas where people walk or congregate. Consider seasonal shifts in winds. An increase of wind by 1 mph is equivalent to a 2 degree drop in temperature (a breeze moving at 100 ft/min is equivalent to 1 mph). This suggests that outdoor environments which will be used on summer afternoons should be placed to maximize cooling breezes and that even a gentle breeze can have a very significant effect on thermal comfort.

Provide ledges or breaks along tall building faces to reduce wind effects at the pedestrian level on the windward side of buildings.

These issues are ideally studied in wind tunnel tests that quantify environmental wind conditions during the design phase. It is very difficult to predict wind effects of tall buildings at ground level. Much can be done with dense plantings, walls, canopies and other methods, but rules of thumb become difficult to apply in dense urban settings.

Acoustic Strategies:

Enhance acoustic comfort through passive strategies such as flowing water features and landscaped areas that absorb urban noises or provide more pleasing noise masks.

Moisture strategies:

During certain times of the year the potential may exist to use site water features to improve environmental comfort levels. When relative humidity levels are low and air temperatures are high, adding moisture to the air will reduce sensible temperature because heat energy is required to evaporate water.

Temperature:

Sensible temperature is determined by both air temperature and nearby surface temperatures. Include radiant surface heating considerations to increase thermal comfort opportunities. Avoid using reflective materials and surfaces that may create uncomfortable glare for outdoor users.

The avoidance of local heat island effects is paramount for outdoor comfort in summer months. Limit large expanses of unbroken paving and use light-colored paving when possible. Planted areas and water features can both aid in reducing heat island effects.

For winter comfort, mitigating wind and capitalizing on sun are most important. While deciduous trees give good solar access in winter, their effectiveness as windbreaks is reduced when the leaves fall, so windbreaks should use lower evergreen plantings.

Bodies produce heat from food energy; 20% of food energy is converted to work, while 80% is converted to heat. This heat leaves our bodies through convection (40%), radiation (40%) and evaporation (20%). Heat production is also very dependent on activity level, as illustrated in the following chart.

290 btu/hr	At Rest	1400 btu/hr	4 mph
400 btu/hr	Sitting	3-4,000 btu/hr	Sustained exertion
760 btu/hr	2 mph	8,000 btu/hr	Olympic Athlete

Case Studies

Urban Form and Climate Study, Toronto, Ontario

This joint Urban Design Study was conducted by the Berkeley Environmental Simulation Laboratory and the Centre for Landscape Research at the University of Toronto, to examine the effect that new development in downtown Toronto might have on pedestrian comfort in urban spaces. The study sought to investigate the shadows and wind patterns that would be produced by new buildings. These investigations focused on sidewalk level. Combined effects of sun and wind conditions were of special interest for evaluating potential pedestrian comfort. The study was divided into three areas, coordinated with three specific zones of proposed urban development in Toronto. These areas were studied in detail through physical models and computational techniques. Physical models were subjected to wind tunnel testing and shadow analysis and computer simulation predicted how both existing and future buildings might effect human comfort.

This analysis resulted in the following recommendations:

Proposed building heights were adjusted to produce 3, 5 and 7 hours of daily sunlight at street level from March to October. Three hours was deemed adequate for commercial streets in the central business district. The five hour window was recommended for other downtown areas, including pedestrian connectors, shopping, historic and tourist areas. Seven hours was proposed for residential streets on the edge of downtown.

Building height recommendations were also made as part of the wind study. To reduce high winds at building bases, a series of gradual setbacks and height rises were recommended and abrupt changes in height were discouraged.

The methods employed by this study can also be applied to other cities as part of their urban planning methodologies. (Wright 1995)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Outdoor Environmental Comfort

UEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	●

☐ **Required Component:**
A microclimate analysis study is attached that illustrates site environmental conditions, including proposed and existing building locations, wind patterns, solar access and shading patterns, vegetated areas and water features. The analysis includes local climate data for temperature, humidity, wind speed and direction, solar radiation, rainfall and cloud cover.

☐ **Required Component:**
Plan(s) and supporting description(s) of the site's preferred "outdoor room(s)" are attached, illustrating strategies which will be used to support human environmental comfort at specific outdoor spaces on the site. This description addresses the four diverse seasonal periods of the year, the influence of the environmental condition factors noted above, anticipated activity levels of people using the space, and adjacent material treatments.

☐ **Optional Component:**
For major high-rise components, an environmental wind condition analysis is attached and addresses cumulative wind effects at pedestrian level on the site.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Wayfinding

UEQ-7

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To facilitate both neighborhood and site-user orientation and site readability.

Action: Integrate wayfinding as an integral design quality when developing green corridors, visual corridors and memorable place markers in conjunction with surrounding neighborhoods.

Related Guidelines: UEQ-2, UEQ-3, UEQ-4, UEQ-5, SEQ-9, SEQ-13

Introduction/Context
Clarity of direction may not normally be associated with sustainable design, yet site orientation and understanding is essential to basic environmental stewardship. Well designed way-finding strategies, integrated with landscape and built forms, can do more than provide a guide through the site. They can also be engaged to inform site users about the unique features and systems that characterize different localities within the site.

Universal diagrams and multilingual signs are essential components of any campus or building neighborhood plan or map; however, there are any number of 'memorable' sensory experiences that are more powerful and more intuitive. The attractive power of a large, strongly day-lit space, for instance, perceived from a less brightly lit corridor, "This way out." In a similar way, views between buildings provide memorable prospects or spatial sequences for people navigating a site, and are immediately recognized on repeat visits, reminding people of where they are within the complex. Changes in paving materials can act as subtle reminders far more powerful a signs. A strong integration of built form and wayfinding goals are essential at the WTC Site.

Urban designers might consider taking cues from some prescient healthcare designers who have been exploring ways to improve wayfinding for disabled and elderly patients. To-date, these strategies have focused on *shaping* the environment, providing natural light at key locations and using water and plants to distinguish one particular setting from another. This reduces the disorienting effect of uniformity in contemporary hospital interiors. Similarly, at the World Trade Center site, specific scenes, angled views of landmark features, and reinforced natural and supplemental light at critical underground junctures, will inform and remind site users of their location and orientation.

Relevant Issues

Ecological
A clear wayfinding strategy integrated into the landscape and built environment assists users in site orientation. It also helps them become familiar with the icons and orderly features, as well as distinguishing landmarks, that characterize the community and the visible neighborhoods beyond. A well-integrated system of pathways tells a story about the site. As site users first find their way, they begin to learn about inherent site systems and rhythms. A 'sense of place', which develops as an understanding of the site and how it should be through all its seasonal changes, provides a level of comfort for most people.

Economic
Retailers are keenly aware of the importance of a clear and easily understood wayfinding techniques. Easily found and/or memorized pathways, often realized through visual, or even subliminal, sensory responses are essential to attracting and maintaining customers.

Neighborhood
Legible and understandable pathways through sites and neighborhoods assist visitors, service and emergency personnel in reaching their destinations efficiently. Such systems not only provide clarity, welcoming those unfamiliar with the site, but may also save lives in an emergency. Clear pathways, separation of vehicular, bicycle and pedestrian traffic, and attractive venues will all contribute to maintaining a lively, interactive bustle at the redeveloped World Trade Center site. This will ensure the success of its commercial, retail, restaurant, cultural and entertainment venues.

Methodology

Design/ Means and Methods Strategies
Provide outdoor light-wells between underground spaces and covered atria to provide opportunities for views to the outdoors and daylight penetration at lower levels. Place day-lit apertures to reinforce important crossings or nodes and to draw people to key locations, such as escalators to other levels, or amenities, such as shopping areas, restaurants or underground building entrances.

Develop a plan which defines the site according to a visual language similar to that of Kevin Lynch's in The Image of the City, to include:

Paths – predominant elements, streets and walkways, characterized by special use, continuity and directionality.

Edges – linear boundary elements, strongest edges are impenetrable, e.g. building edges or waterfront edges.

Districts – Relatively large areas which can be mentally "entered and understood" to have a common character relating to texture, form, detail, symbol, building type, use, activity, inhabitants, degree of maintenance, topography.

Nodes – foci which can be entered, junctions of paths or concentrations of small characteristic points, may be large squares or extended linear shapes.

Landmarks – external prominent point reference visible from many locations.

Use a consistent language of wayfinding cues throughout the entire site to avoid confusion.

Means and Methods

Use line-of-sight connections as cues between locations where appropriate. Wherever possible, introduce natural light to help direct people. Incorporate memorable place markers to function as orientation points. Use materials, patterns, and textures to demarcate spatial zones. When connecting multiple buildings, coordinate floor numbers. Clearly distinguish between public and non-public spaces and identify arrival points. Locate public information stations in logical and highly visible locations. When needed, augment architectural wayfinding cues with clear and concise graphic indicators, such as signage.

Case Studies

Bristol Legible City Project, Bristol, United Kingdom

This project was conceived by the Bristol City Council in 1996 to make the city more easily navigable by both residents and visitors. The keystone of this plan was a system of wayfinding implemented by a core development team lead by the city council and comprised of urban planners, product designers, information designers, traffic engineers, and public art consultants. This team delivered over 40 individual projects throughout the city that were coordinated to create an overall system of legibility. The first step of this program involved the redesign of signage throughout Bristol, although the scope of the urban intervention was much greater. The projects developed as part of this program linked together diverse parts of the city through consistently designed information in order to make attractions and destinations easier to locate. Other goals were to promote a clear, positive identity for the city of Bristol, to reinforce the character of distinct neighborhoods, and to encourage a shift toward the use of public transportation. The infrastructure of the system includes clear, succinct directional signs with simple to understand 3D maps, on-street information panels, printed walking maps, and art projects. A visual language was developed to include easily understood symbols, a unified color palate, and legible text. Another key aspect of this project was to rectify traffic problems. A new signing hierarchy was proposed to discourage through traffic at the city's center, improve access to city attractions, and promote various modes of public transportation.

Reference

Definitions

Wayfinding is a term that was coined by an architect named Kevin Lynch in the Sixties to describe devices and techniques used to increase the legibility and ease of navigation of a space or site.

Standards

Standards have not been included for this Guideline.

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Wayfinding

UEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐ ●	☐ ●	☐ ●	☐ ●	☐ ●

☐ **Required Component:**
A wayfinding plan is attached that highlights proposed wayfinding elements. The plan addresses how buildings, their elements and the landscape are employed to enhance site legibility and ease of navigation. The plan includes a clear description of the visual language which has been developed and how these wayfinding elements work to orient site users in simple and consistent ways.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Vehicular Emissions

UEQ-8

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Reduce back-up of traffic into neighboring streets in order to minimize vehicle emissions and improve neighborhood air quality from pre a 9/11 base. To minimize potential idling time for all vehicles.

Action: Optimize traffic flow of all vehicles coming to the site to reduce the amount of time that vehicles must idle. Seek to reduce traffic backups through scheduling and onsite accommodation. Design bus stops to minimize traffic backups and potential vehicle idling times.

To the extent that there is a NY State Agency and/or other governmental presence on site, at least 50% of light duty fleet vehicles will be alternative fuel or hybrid vehicles by 2005 and 100% by 2010.

Related Guidelines: UEQ-1, UEQ-2, SEQ-1, SEQ-3, SEQ-5, SEQ-6, EEQ-1, EEQ-5, MEQ-1, MEQ-5, IEQ-5, IEQ-7

Introduction/Context

The size and density of the World Trade Center Redevelopment will require a large number of service and delivery vehicles. Many of these will be heavy duty trucks, buses and vans. A unique opportunity exists to reduce the environmental and acoustical impact of these vehicles by requiring the use of cleaner fuels, scheduling deliveries at night, limiting the permissible idling time for engines, and minimizing required trips. Neighborhood air quality is directly affected by these vehicles, therefore strategies to restrict their emissions will have extended benefits, including a reduced potential for smog (ground-level ozone) carbon monoxide and particulate releases.

Air Quality in Lower Manhattan is monitored by both the New York State Department of Environmental Conservation (DEC) and the US Environmental Protection Agency (EPA). Carbon monoxide, sulfur dioxide, nitrogen dioxide, sulfates and nitrates, particulates, ozone and lead concentrations are all currently sampled on Canal Street as representative of Lower Manhattan. At this time New York County does not meet federal standards on ozone, carbon monoxide and particulate matter, all generated to a large extent by vehicular traffic emissions. Non-attainment, as defined by the Clean Air Act and Amendments of 1990, defines a locality where air pollution levels persistently exceed the National Ambient Air Quality Standards for pollutants that are harmful to public health. 'Non-attainment' is an official designation, which is applied only after an area's air quality has exceeded these standards for several consecutive years. According to a 2001 European study, over 50% of air pollution in cities is generated by vehicle emissions, which now also account for more deaths than road accidents. The Third Ministerial Conference on Environment

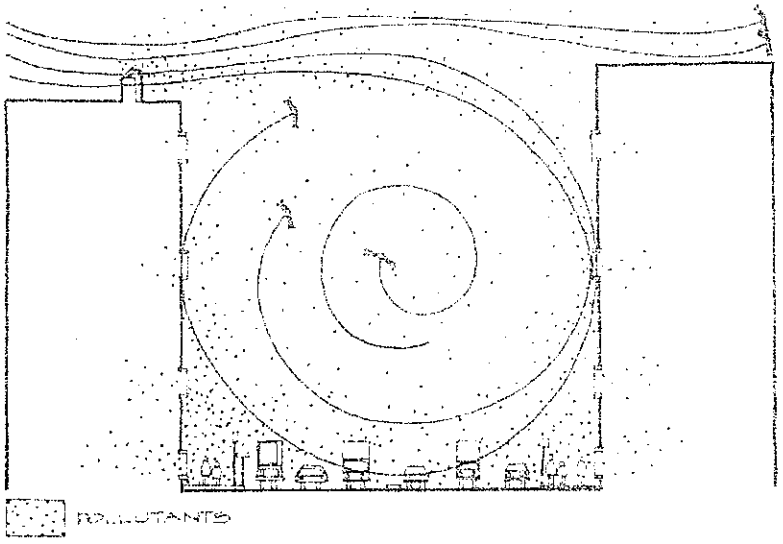
and Health, organized by the World Health Organization (WHO), also noted that road traffic was the most rapidly growing source of pollution in Europe, and "car exhaust is causing a rise in respiratory conditions, heart disease, bronchitis and asthma".

Local weather plays a significant role in the manner in which vehicle pollutants affect air quality, and variations in climate and temperature cause different impacts. Heavy traffic during the hot, sunny summer months causes ozone levels to spike: nitrogen oxides and hydrocarbons, the chief "precursors" of ozone, react in the presence of sunlight to produce ground-level ozone, or smog. Smog is recognized as a significant contributor to asthma and other serious respiratory illnesses. In cold weather, higher levels of carbon monoxide are released because fuels do not burn as efficiently. Historically, the worst air quality months in New York City are June, July and August.

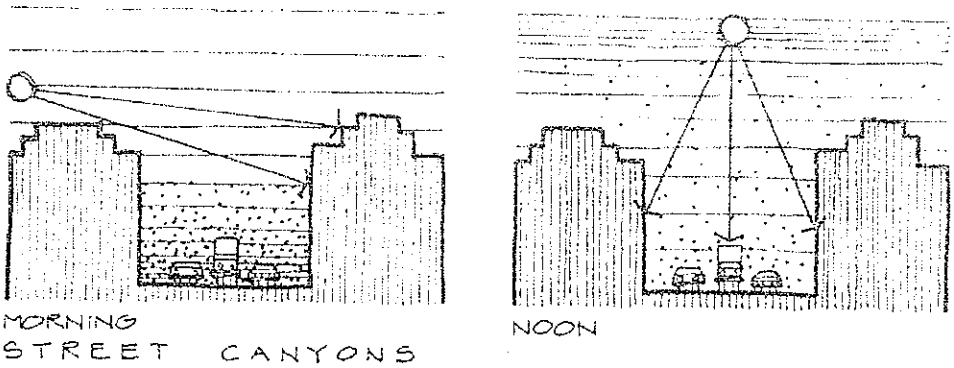
Relevant Issues

Ecological

Vehicle emissions have been shown to have direct and detrimental effects to human health and the health of ecological systems. Pollutants emitted by trucks and cars become trapped in city canyons and collect at street level. Additional pollutants can be blown from rooftops to the streets below when the temperature at the bottom of the 'canyon' is lower than the temperatures above. This occurs when a warm air mass moves over cooler air or when air near the ground is cooled from below at night. The cooler air becomes trapped, retaining a concentrated soup of pollutants in the narrow canyon at street level.



Pollutant trapping in Street Canyons (Spirn 1984)



Effect of air temperatures in pollutant trapping in Street Canyons (Spirn 1984)

These conditions are dangerous to human health. According to David Gee of the EU-funded European Environment Agency: "We've known about lead and its ability to damage the IQ of children at quite low levels, like lead in petrol (gasoline) getting into the ordinary atmosphere, onto vegetation, onto soil and then into children. . . There is increasing evidence about low levels of contamination being part of a causal chain, in things like attention disorders and hyperactivity, and those sort of neurological symptoms which seem to be associated with low-level toxic pollution." Vehicle emissions also contribute to a major increase in premature death from heart and respiratory illnesses.

Economic
Poor air quality resulting from traffic congestion and idling engines reduces the visual quality of the site, making it less attractive to visitors. These factors increase the amount and severity of respiratory, heart and cognitive related health problems, which in turn incur significant medical costs. In addition, heavy diesel traffic and idling/revving engines create noise pollution in the streets, which also has a negative impact on the acoustical quality in nearby buildings. A lesser known impact is the soiling and erosion of building facades and materials that result from the acidic nature of hydro-carbon emissions from vehicles. Dirty, unkempt building facades are unattractive and costly to clean and/or repair.

Traffic back-ups create delays and cause loss of time and efficiency in the exchange of goods and services, producing negative affects for local commerce.

Neighborhood
Clearly, the detrimental nature of vehicle emissions extends to the entire neighborhood and beyond. The objective is to minimize impacts to human health and building fabric by establishing pre-approved, enforceable guidelines. Only essential service and delivery vehicles should be allowed on the site during working hours; they should perform their services at times when there is less opportunity for traffic back-ups – i.e. late evening, night-time, early morning. Both the type of fuel(s) permitted, and the manner in which each vehicle is operated, should be controlled to minimize the potential for deleterious emissions.

Methodology

Design Strategies

Consider including auxiliary building service lanes and delivery zones dedicated to these activities to keep service vehicles out of the mainstream traffic and to minimize loading/unloading time. Coordinate site strategies with city traffic management.

Accommodate needs of alternative fuel vehicles based on EO-111, Section 8, Alternative-Fuel Vehicles requirements.

Study wind effects and design buildings and street intersections to reduce the potential trapping of airborne pollutants at ground level. Allow for better air circulation while carefully avoiding wind tunnel effects.

Means and Methods

A key strategy to better ambient air quality is to simply minimize the need for vehicular traffic within the site. Maximize opportunities for building occupants and regular visitors to have easy access to public transportation systems. Schedule large volume public events at "off-peak" times. Schedule major service deliveries and moving/relocation at "off peak" times as well. Locate street level bus stops in a manner that prevents negative impact on traffic flow, and does not contribute to traffic back-ups and idling time.

Where building programs include accommodations for state government vehicles, provide facilities to ensure that alternative fuel and/or hybrid vehicles can be serviced at the site, in accordance with EO-111, which notes: '*State agencies and other affected entities that operate medium- and heavy-duty vehicles shall implement strategies to reduce petroleum consumption and emissions by using alternative fuels and improving vehicle fleet fuel efficiency*'.

In addition, it is recommended that the requirements of the Battery Park City Authority be considered for adoption by construction teams at the World Trade Center Site. They require that all construction vehicles over 5 tons use ultra-low sulfur diesel fuel or compressed natural gas (CNG), and diesel fuel vehicles over 5 tons must be equipped with high performance engines and catalyzed diesel particulate filters. These requirements also affect generators at the site.

Site planners are encouraged to coordinate their work with that of the City's Traffic Planners. Instigate requirements which employ 'Urban Traffic Management Control' systems to help keep traffic moving smoothly. Use of 'Traffic Calming' techniques helps to reduce vehicle emissions (frequent acceleration and deceleration generate much greater levels of emissions). Coordinate with city efforts to design traffic routes through the complex and greater neighborhood that help prevent back-ups, and develop a plan that keeps heavy vehicular and service traffic out of the site during daylight hours.

Case Studies

The Vauban District, Freiburg im Breisgau, Germany

This model district was one of the first residential developments in Germany to institute a low car traffic concept. The goal of this endeavor was to curtail the amount of private, vehicular traffic throughout the entire district to reduce pollution and support pedestrian programs. Large sections of the residential areas have policies prohibiting the construction of parking spaces on private property. Instead, communal parking lots are provided at the edges of the residential zones and financed by a system of taxation. Car-less residents may sign a declaration that they do not own a vehicle and become exempted from that tax burden. One of the projects conducted according to these policies was the "Optimization of the Traffic Concept of the District Freiburg-Vauban during Implementation" which was sponsored by the German Federal Foundation for Environment. As part of this they funded a study by the Institute of Transportation Research to evaluate the success of the traffic-reducing policies in the district. One significant conclusion from this study was that it fostered a high amount of car-sharing. Although merely 0.1% of drivers in Germany, as a whole, share a car, the percentage of people sharing cars in Vauban is a much greater 33%. (Nobis 2004)

Reference

Definitions

Traffic Calming refers to the act of slowing traffic to create more humane urban environments better suited to non-vehicular transportation modes such as walking and bicycling.

Urban Traffic Management Control (UTMC) describes a system that tracks traffic patterns and dynamically adjusts traffic light patterns to keep traffic moving smoothly.

Standards

Standards have not been included for this Guideline.

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Vehicular Emissions

UEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ		●

☐ **Required Component:**
A description (with plan diagrams where appropriate) is attached that illustrates specific measures that will be taken to reduce vehicular traffic (from pre 9/11 norms) on and around the site. The description includes anticipated vehicular service requirements for the project and scheduling design strategies which have been employed to reduce these requirements.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Site Resource Optimization SEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To draft and implement the requirements of a Site Resource Optimization Plan.

Action: The Site Resource Optimization Plan provides a tool for an integrated consideration of water, material and energy resources with the goal of identifying, evaluating and optimizing utilization of all resources on the site. The plan overlays information from the individual water, material and energy management plans and identifies integrated opportunities for resource conservation.

Related Guidelines: UEQ-8, SEQ-2, SEQ-3, SEQ-5, SEQ-6, SEQ-7, SEQ-11, WEQ-1, WEQ-2, WEQ-3, WEQ-4, EEQ-1, EEQ-3, EEQ-5, MEQ-1, MEQ-2, MEQ-3, MEQ-4, MEQ-5, MEQ-7, IEQ-1, IEQ-6

Introduction/Context

The observation of natural ecosystems offers a unique means to understanding resource flows, and through the emulation of these models, how these flows may be interpreted to inform a sustainable approach to the built environment.

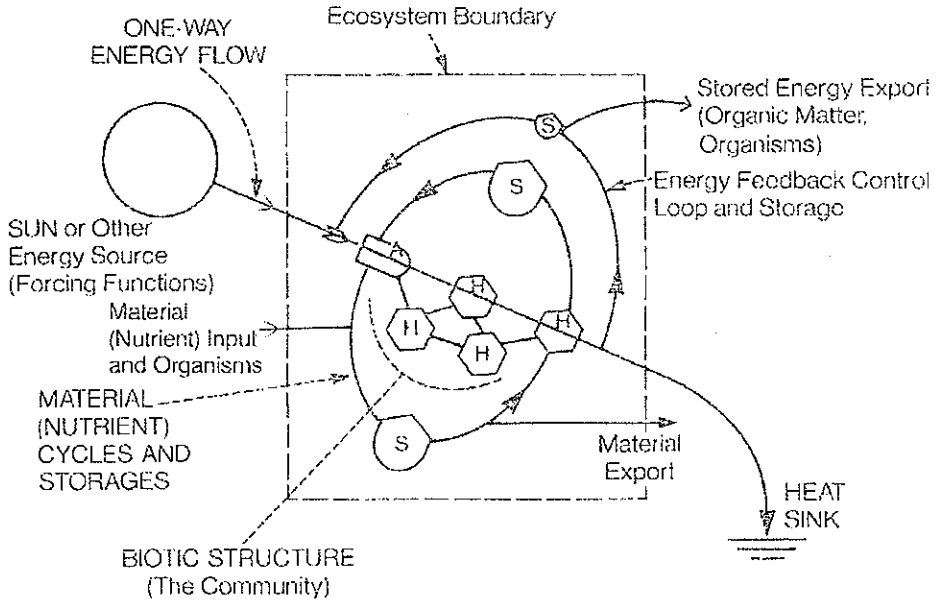
Ecosystem is a term that was first used in 1935 by an English botanist, Sir Arthur Tansley, to demonstrate how the living world is tied to the non-living world. Ecosystems came to be understood as organized conceptual units with interdependent living and non-living components. Ecosystems are never closed or entirely balanced systems. While internal ecosystem components may work toward equilibrium, inputs, outputs, and the external environment often work against it. The goal of sustainable design is to minimize these imbalances, and studying how ecosystems have evolved to sustain themselves provides us with a model for integrated resource management. Energy, water, material and air resources are interrelated in important ways and an integrated consideration of these elements is an essential process of sustainable design.

Energy moves through an ecosystem in a linear way, using the sun as its primary source. As energy moves through the system, it is both slowly dissipated and transformed into more highly ordered forms. Plants 'fix' solar energy, concentrating it in the form of food or plant matter, through the process of photosynthesis. Organisms that cannot synthesize their own food consume this plant matter, creating even more concentrated forms of energy and dispersing energy through heat loss to the external world.

These simple relationships are relatively clear in a pond or prairie ecosystem. They become more complex in an urban industrial ecosystem. Existing urban ecosystems have a much higher appetite for energy and more demanding appetite for materials than pre-industrial systems. Cities, for instance, are largely constituted of materials that originated in distant mines and quarries and which were processed in distant factories, before being transported over great distances, all at large energy cost. Food is manufactured in energy intensive agro-ecosystems and transported by ship, rail and truck to inner city dwellers. All cities are dependent upon thousands of miles of electric cable, gas lines, water mains, sewer pipes, roads and rails, stretching across bridges and through tunnels, together with vast fleets of cars, trucks, buses, trains and planes, all essential to move energy and nutrients through the system. Without this infrastructure, cities would not be able to maintain their complex, highly ordered structures. The major source of this energy is currently non-renewable fossil fuel, which is extracted from the Earth, transported long distances and burned, with concomitant environmental consequences.

Among contemporary American urban industrial ecosystems, New York City is a model of efficiency because of its density and closely integrated transit systems. Urban industrial ecosystems rely on concentrated inputs of energy in the form of fossil fuels to maintain largely industrialized life support systems. This is in contrast to natural plant or forest communities, which are primarily sustained by a renewable and non-polluting source of energy, the sun.

This guideline requires that the complex relationships between energy, water, material and air resources on the World Trade Center Site be studied to maximize opportunities for resource conservation.



A functional diagram of an ecosystem. Energy flow, material cycles, the community and feedback control loops are the four major components. (Odum 1983)

Relevant Issues

Ecological
Good resource management is essential to sustainable design and when resources are considered in an integrated way, many opportunities which might normally not be apparent become visible.

Industrial ecology is a new field which attempts to provide this framework for industry. Ecologists working in this field look for opportunities to bring different industries together in symbiotic relationships. This paradigm departs from the traditional linear method for the industrial process which begins with the input of raw materials and ends with a finished product, while byproducts are sent to a landfill. Instead it promotes a more circular process where the waste from the manufacturing of one particular object becomes raw material for another. This sets up and maintains a cradle-to-cradle resource conservation approach, where there is no waste and materials are used indefinitely. It contributes to sustaining the Earth's limited material resources.

Economic
The re-use of natural resources and the recycling of end-products for use elsewhere reduce the capital spent on obtaining and processing virgin resources. The ratio of energy saved by doing so can be significant. For example, only 5% of the energy used to obtain and process raw materials associated with the manufacturing of aluminum is expended in the recycling of that metal. The capture of "free" resources such as daylight, solar energy, wind and rainwater saves capital that would otherwise be spent on the purchase of replacement resources or services. The re-use of free and/or salvaged resources often eliminates disposal costs and can save on the construction capital associated with the use of such materials.

Neighborhood
When overall resources are conserved and used efficiently, it is more likely that a community will have more resources available and not be forced to cope with a shortage (e.g. brown-outs during the hottest days of summer, and drought conditions when the reservoirs run low).

Methodology

Design Strategies
Develop a method for identifying potentials for resource reuse based upon the individual management plans developed for site water resources, energy, and materials.

Seek to close resource loops in designing systems that use available resources in a highly efficient manner, and capitalize on the re-use potential of waste outputs from one part of the system by other parts.

Include life cycle analysis considerations in material, equipment and systems decisions.

Means and Methods

Use rainwater catchment and wastewater recycling systems to reduce the outflow of tainted water from the site and provide graywater for use on the site and in its buildings. (refer to SEQ-2 and WEQ-2) Explore the potential for waste-to-energy conversion systems to reduce the amount of material sent to landfills while exploiting this renewable source of power. (see SEQ-11) Compost biodegradable materials to obtain free fertilizer for the maintenance of site landscaping and reduce trash hauling and tipping fees. Develop renewable energy programs to promote the site's ability to generate electricity, save money on utility bills, and contribute less pollution to the surrounding environment. (see EEQ-5) Use energy and heat recovery technologies to recover used power and heat for use throughout the site. Incorporate daylight dimming and occupancy sensors to further save energy and money. (refer to EEQ-1 and EEQ-3) Material recovery technologies, cradle-to-cradle purchasing plans, and local/regional purchasing can all further contribute to site efficiency both economically and ecologically. (see MEQ-1)

Case Studies

Kalundborg Industrial Park, Kalundborg, Denmark

This industrial park has been in operation since the 1970's and includes a power plant, an oil refinery, a plaster board manufacturing plant, fish farms, a large pharmaceutical plant and a district heating, power and water system for the municipality of Kalundborg. The coal-fired power plant pipes surplus steam to both the pharmaceutical plant and oil refinery and waste heat to a district heating system for 3,500 nearby homes. Additional waste heat is used in the operation of on-site fish farms. The power plant also recovers fly ash and gypsum from the coal-to-energy process and sells these materials to a cement manufacturing facility and a wallboard plant, respectively. Sulfur, a waste product from the refinery's processing of natural gas is sold to a sulfuric acid manufacturer. Sludge from the pharmaceutical plant is used as fertilizer for local agriculture. (Garner 1995)

Reference

Definitions

Industrial Ecology is the study of the physical, biological and chemical interactions and interrelationships both within and between industrial and ecological systems (Garner 1995).

Life Cycle Analysis involves the examination of the manufacture, use, and disposal of a product, from raw material extraction to the end of its useful life in order to identify and evaluate all of its environmental impacts.

Standards

Standards have not been included for this Guideline.

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Site Resource Optimization Plan

SEQ-1-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Site Resource Optimization Plan provides a tool for an integrated consideration of water, material and energy resources with the goal of identifying, evaluating and optimizing utilization of all resources on the site. The plan overlays information from the individual water, material and energy management plans and identifies integrated opportunities for resource conservation (i.e. high capture and utilization of stormwater at upper levels of tower reduces pump energy required for lifting equivalent amount of water).

Plan Components

I. Project Description (Plan Summary)

A. Based on the basic plan provided by the PANYNJ and LMDC, provide a physical description of each specific project site with emphasis on energy, water and material system interconnections.

II. Resources Inventory

A. Provide a detailed inventory of site resources.
B. Provide a detailed description of site resource interconnections.

III. Site Resource Management Strategies

A. Develop the following resource management plans in an integrated way.
   1. Water Management Plan
   2. Material Management Plan
   3. Construction Waste Management Plan
   4. Energy Management Plan
   5. Renewable Energy Transition Plan

B. For each Resource, describe the plan to utilize it on-site in terms of consumption, distribution, process, regulatory controls, economic concerns, reuse, etc. To the extent plausible, implement a resource recovery strategy to reclaim as much of the resources as possible on site and integrate them to optimize their use.
   1. How are these resources used?
   2. How do they get to the site?
   3. What happens to the resource while on site?
   4. What is the intended end use of the resource and is this the best/highest use?
   5. Are resources leaving the site under-utilized?
   6. Can the amount of resources leaving the site be minimized or eliminated?

C. Describe resource flows and interactions in relationship to the larger urban ecosystem. Identify opportunities to increase urban ecological sustainability. Include matrix of trade-offs in optimizing one resource over another.

IV. Targets

Establish and describe project targets for the following

A. First year of operation.
B. 5 year and 10 year plans.

V. Evaluation

A. Outline the ways that the resources are being handled and the ways in which they have been optimized.
B. Implement ongoing monitoring for all systems.
C. Document the systems and the results after the plan has been implemented.

Site Resource Optimization

SEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
A Site Resource Optimization Plan is attached. This plan includes specific information regarding the interrelationship of the individual water, material, and energy management plans that are part of the overall Sustainable Guidelines Reference Manual. Examples and calculations are attached to quantify the positive environmental and economic benefits as required by the Optimization Plan.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Storm Water Use

SEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To capture and utilize site storm water flows, thereby reducing storm water volume and surges through the system.

Action: Implement a plan for stormwater management as part of the Water Management Plan that reduces the post-development flow of stormwater by a minimum of 25% from the site pre-9/11 base. Construct treatment systems to remove 80% of total suspended solids (TSS) and 40% of total phosphorous (TP) per EPA Document (840-B-92-002) Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (based on the average annual loadings from all storms less than or equal to the 2 year/24 hour storm).

Site/Parcel: Design site surfaces to allow collection of site storm water flows from other than street surfaces. Provide storage and filtration infrastructure. Fully use captured water as appropriate and in conjunction with Water Management Plan.

Towers: Consider towers with ledges, roofs and setbacks, which will assist in capturing water sheeting off buildings at high elevations to capture potential energy of water and reduce water pump energy requirements. Provide storage and filtration infrastructure near point of capture. Use water, as appropriate, for toilet flushing and as part of building water systems.

Related Guidelines: UEQ-1, UEQ-8, EEQ-1

Potential LEED™ 2.1 Credits: 2 possible with SS cr. 6.1, and SS cr. 6.2. (see Submittal Template)

Introduction/Context

Precipitation averages 47.25 inches a year in New York City, including 23" of snow (Central Park Weather Station). This means over 20 million gallons of water [(696, 960 ft^2 x 3.9375 ft = 2,744,280 cubic feet) x 7.481 gallons/ft3 = 20,529,958] will fall on the 16 acre World Trade Center Site over the course of a year. Much of this water can be captured and reused at the site as gray water for irrigation purposes and/or the flushing of toilets and urinals, following appropriate treatment. Pre 9/11, this water was funneled into the city's combined storm/sewage system. This system often becomes overwhelmed during storms, releasing combined, untreated storm water/sewer outflows into the Harbor estuary.

There are more than 450 combined sewer outfalls in New York City therefore, capturing storm water at all possible locations is an important sustainable strategy. Collecting this water, for reuse on the project site, will be a significant positive contribution to the local marine ecology.

Relevant Issues

Ecological
Reducing site storm water discharges reduces the likelihood that untreated sewage will enter the harbor or the river estuaries. Stormwater captured on site can be used, after treatment to tertiary standards, for irrigation, maintenance purposes, in cooling towers and for toilet and urinal flushing, reducing the need for, and pressure on, potable water. Capturing stormwater run-off at rooftops and high terraces, and using it at these elevations near where it is collected, will save on pump energy, while minimizing environmental pollution from conventional power generation.

Economic
The use of captured stormwater lessens the demand for potable or first use water, and supports water 'cascading' – where all water is used at the optimum quality necessary and appropriate for each task -- and reduces water utility costs. Maximizing use of this resource at the site generates considerable savings by lessening the need for potable water, thereby lowering water rates.

Cleanup and liability from untreated storm/sewer outflows can be expensive for the city. By retaining the stormwater portion as a resource at the site, the need for these costs may well be averted. Additionally, this strategy begins to establish a city-wide approach to conserving water, which will eventually reduce the current pressure on infrastructure. Both water supply mains and storm/sewer pipes and tunnels will be less pressured, reducing the need for maintenance and repairs, and for the construction of new infrastructure. Concentrated sewage is more easily handled and requires less treatment than the mixed volumes of stormwater and sewage which is typically delivered to the treatment plants after a heavy rainfall in Manhattan.

Neighborhood
Reducing the damage to natural waterways by reducing stormwater/sewer pollution preserves the quality of receiving water bodies for wildlife, fishing and recreational enjoyment.

Sites requiring minimal stormwater processing by the municipality are also economical to manage. There are precedents for these reduced operating costs being passed on to community members in the form of reduced taxes.

Enhanced handling of stormwater, and retention on-site, reduces the potential liabilities related to flooding, and for outflows of untreated biological materials with their resulting unsanitary conditions and threat to community health.

Methodology

Design Strategies
Implement a stormwater management plan (as part of the Comprehensive Water Management Plan) that reduces the post-development flow of stormwater from the site (9/11 base) by a minimum of 25%.

Design systems that make visible the storm water collection and re-use process to aid in site user education and tell a story about natural processes.

Means and Methods

Site/Parcel:
Design surfaces to allow collection of site stormwater flows from other than street surfaces, (i.e. water from pedestrian sidewalks and plazas) Provide storage tanks or cisterns at high elevations and at ground or basement level. Install on-site filtration infrastructure. Include an on-site treatment facility to treat gray water (storm water and, if applicable, water from sinks, showers, etc.) to tertiary standards. Re-use captured stormwater/gray water for irrigation and maintenance applications.

Buildings:
Consider using ledges, roofs, terraces, and all applicable setbacks to assist in capturing water sheeting off building surfaces at high elevations. Capture the potential energy of this high elevation rainwater to reduce water pump energy requirement. Provide storage, filtration and treatment near the point of water capture, when possible. Use captured water for such applications as at toilet flushing, urinals, and for cooling tower make-up and in building mechanical systems where appropriate.

Case Studies

The Solaire, New York, New York
A storage tank located in the building's basement is used to capture stormwater as it runs off the building and falls on the site. The system was designed to meet the irrigation load of the site thus saving material resources by not over sizing the tank. Consequently, 100% of the stormwater captured on the site is used to irrigate the gardens on the building's roof. The roof itself was also designed to retain rainwater, about 70% of the amount that falls on it. This water is used by the roof plantings and is prevented from becoming stormwater runoff. It is estimated that roughly 170,000 gallons of rainwater will be collected and used on the site each year. (USGBC 2004)

Philip Merrill Environmental Center, Annapolis Maryland
The prevention of stormwater runoff on this site was critical because of its proximity to Chesapeake Bay. The rainwater collection system begins with the building's roof, designed as a shed to allow rainwater to runoff in one direction and be captured by a single gutter. This gutter directs the water through a series of filters and into cisterns. Sand filters are used to condition the rainwater and make it suitable for use in washing hands and equipment, laundry, irrigation, and fire suppression. This natural source of water was much welcomed because the existing city infrastructure was not capable of supplying the volume of water that a building without rainwater harvesting would need. The majority of parking needs for the building are accommodated underneath it. However a small outdoor parking lot was also needed. This lot was designed with a permeable surface that permits stormwater to be collected and directed through a bioretention system for treatment before being expelled into the bodies of water adjacent the site. The manmade wetlands that comprise this filtration system remove particulate matter and oils from the runoff. (USDOE 2005)

Reference

Definitions

Site Stormwater is any water that falls on site surfaces from a precipitation event.

Total Phosphorous (TP) consists of organically bound phosphates, poly-phosphates and orthophosphates in stormwater, mostly originating from contamination by fertilizer. The standard method for removing phosphorous from water is by chemical precipitation.

Total Suspended Solids (TSS) are particles that are so small and light that they do not fall settle out of stormwater under gravity alone. Filtration is a common way to correct this condition.

Gray Water Gray water is made up of two typical components: recycled water from non-sanitary appliances, such as lavatories, showers, washing machines, and captured stormwater. Either, or a mixture of both, may be called gray water. All gray water must be treated to tertiary standards prior to reuse for building purposes e.g. as cascaded water in toilets and urinals, or in cooling towers.

Tertiary Standards for wastewater treatment produces higher quality effluent through the further removal of contaminants such as nitrogen, phosphorus, heavy metals, residual suspended and dissolved solids, and synthetic organic chemicals. Tertiary treatment can involve processes such as carbon adsorption, reverse osmosis, micro-filtration, and biological nitrogen and phosphorus removal.

Standards

United States. Environmental Protection Agency. Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters. January 1993. 29 September 2004 <http://www.epa.gov/owow/nps/MMGI>

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United States Department of Energy. "The Phillip Merrill Environmental Center: Highlighting High Performance". National Renewable Energy Laboratory. April 2002. United States Department of Energy. 13 January 2005. <http://www.nrel.gov/docs/fy02osti/29500.pdf>

United States Green Building Council. "LEED Certified Project Case Study : 20 River Terrace – The Solaire." USGBC – LEED Case Study. 2003. USGBC. 22 September 2004. <http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=273>

Storm Water Use

SEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

☐ **Required Component:**
A stormwater management plan is attached and outlines how stormwater will be captured on the site and subsequently used to reduce potable water dependence.

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 6.1: Stormwater Management – Rate and Quantity)*
Supporting calculations are attached and verify that stormwater runoff from the site has been reduced by 25% or greater from a pre-9/11 base.

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 6.2: Stormwater Management – Treatment)*
The attached outline describes the specific methodology that will be used to treat site stormwater and includes calculations that demonstrate this treatment is effective at removing 80% of total suspended solids (TSS) and 40% of total phosphorus (TP). (In accordance with EPA Document 840-B-92-002 Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters and based on the average annual loadings from all storms less than or equal to the 2 year/24 hour storm).

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Heat Island Effect Mitigation SEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Reduce site development contributions to "heat island" effects in Lower Manhattan. Seek to maximize areas of landscape planting (green infrastructure) coupled with high albedo surfaces at other areas to mitigate thermal loading of site surfaces and building roofs.

Action: Provide green infrastructure coupled with high albedo surfaces to mitigate thermal loading of site surfaces and building roofs.

Site/Parcel: Provide shade and/or use light-colored/high-albedo materials (reflectance of at least 0.3) or open reinforced grid pavement for at least 30% of the site's walkways, plazas and open spaces.

Tower: Use ENERGY STAR® compliant AND high emissivity roofing (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. Combinations of high albedo and vegetated roof can be used providing they collectively cover 75% of the roof area.

Related Guidelines: UEQ-5, UEQ-6, UEQ-8, SEQ-1, SEQ-9, EEQ-1, IEQ-1

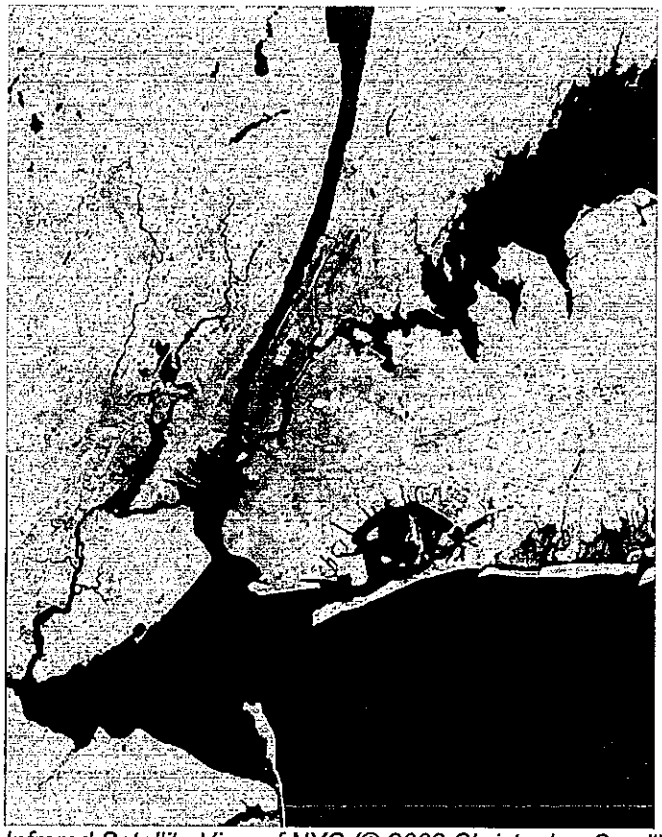
Potential LEED™ 2.1 Credits: 2 possible with SS cr. 7.1, and SS cr. 7.2. (see Submittal Template)

Introduction/Context

"Urban Heat Islands" are phenomena in which dense urban environments, like New York City, create microclimates, which are significantly warmer than regional patterns. These microclimates result from a combination of factors, including waste heat from buildings and vehicles, reduced evaporative cooling (hard, absorptive surfaces vs. vegetated areas) and most importantly, the trapping of solar radiation. Heat island effect is foremost a problem in New York City in the summer months and can vary across the city depending upon the local microclimate.

The infrared satellite view of Manhattan and its surrounding areas (shown on the next page) indicates zones of heat build-up, which affects human comfort, air quality and building energy loads. The darker shades of red and purple indicate higher temperatures, which are most evident in midtown and lower Manhattan. These areas stand in sharp contrast to the cooler, vegetated areas around the dense urban core of the region. The build-up of heat increases air conditioning loads, levels of pollutants and environmental stress. In contrast, parks, gardens and grasslands have lower thermal mass allowing for the rapid loss of daytime heat gains to the cooler night air. Therefore, areas of a city with more open green space have cooler microclimates.

(Note: there is an intelligent application of the reverse effect to crate an "outdoor room" that can remain comfortable during cooler periods of spring and fall. Here you select masonry or stone surfaces that will store solar energy and re-radiate the warmth for enhanced comfort.)



Infrared Satellite View of NYC (© 2002 Christopher Small)

Relevant Issues

Ecological

Reducing heat island effect greatly decreases energy demand for cooling. Since the predominant means used to generate electricity in the United States -- fossil fuels and nuclear fission -- both pollute the environment, fewer heat islands will lessen emissions of SO_2 and NO_X, as well as reducing the amount of highly toxic nuclear wastes generated.

The presence of higher temperatures in urban environments stimulates chemical reactions that turn airborne pollutants into ground-level ozone (smog). A reduction of heat islands can lead to lower ambient temperatures and lessen the potential for smog, with its associated health problems.

One of the most effective methods for reducing urban heat island effect involves increased use of vegetation, such as gardens or green roofs, which also provide positive contributions to site ecology.

Economic

Reducing the amount and intensity of urban heat islands can lower the ambient air temperature in a city by anywhere from 3 – 7 °F, in turn reducing the amount of money spent on energy for cooling buildings. (For cost benefit see Rosenfeld 1996) Monetary savings may also be realized by the electric utilities that would otherwise need to increase their power generation and infrastructure to meet higher peak energy demands.

Smog, which is generated as a direct result of sunlight mixing with hydrocarbon fumes and particles, and heat, are ubiquitous in any major urban center. Any reduction in smog has the potential to diminish respiratory and other health complaints that are known to be, in part, a result of heat island effect. Reduced costs for health insurance premiums, along with increased worker productivity and less absenteeism resulting from a healthier workforce, are significant. The reduction of smog-related illness among the city's workers, and especially among the uninsured, contributes to keeping the cost of *all* health insurance down. Vegetated areas used to replace surfaces that create heat island effects also reduce the need for stormwater infrastructure.

A more comfortable outdoor urban environment is attractive to both shoppers and businesses. It provides a means for corporate and retail employees to refresh themselves at breaks and lunchtime. New studies, such as the Heschong Mahone Group's study on views to green spaces, indicate that a connection to nature is critical for human well-being.

Neighborhood

The potential reduction of ground level ozone commensurate with a reduction in heat islands and ambient air temperature can have positive health effects on neighborhood air quality and reduced respiratory problems.

An improved and more pleasant outdoor environment will also encourage people to spend time outside, increasing opportunities for exercise and social interaction. Busy streets with lots of human activity increase security and diminish opportunities for street crime.

Methodology

Design Strategies

Incorporate vegetated surfaces wherever possible, including areas of "green" roof where appropriate.

Use ENERGY STAR ® compliant AND high emissivity roofing (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" roof for at least 50% of the roof area. Combinations of the two types of roof may be used, providing that they collectively cover 75% of the total roof area.

Provide shading, especially that which is created by trees, for at least 30% of non-vegetative site surfaces, such as walkways and open plazas. Where shading or vegetated surfaces are not used, specify light-colored, high emissivity materials (a reflectance of at least 0.3).

Means and Methods
There are two areas of endeavor within this chapter: Roof and non-roof surfaces must both be considered.

Roof
Consider the inclusion of green or garden roof systems wherever possible for the buildings within the complex. To achieve compliance, at least 50% of the roofing area of any project in question must be vegetated. There are two main types of green roofs – those planted with low-growing grasses and plants that require little maintenance and no watering after becoming established, and those that are more garden-like, with plants and shrubs, etc. that provide the multiple benefits of being aesthetically pleasing and retaining stormwater at the site, while providing the humanitarian benefits of open green space. Some roof-gardens include public or building occupant access, with walkways and benches as well as flowering plants. Such roof gardens must be equipped with appropriate safety railings in accordance with New York City code requirements.

On roofs where vegetation is inappropriate, use high albedo roofing solutions with a reflectance value of at least 0.3 maintained, and an emissivity of 0.9 minimum when tested in accordance with ASTM 408, for 75% of the roof area. There are several options available, such as an Energy Star membrane or a high reflectance coating over a polymer substrate. Concrete tiles may also be considered, and for steep roofs, white asphaltic shingles may be applicable.

A combination of green roof and high albedo roofing can be used as long as the two together cover 75% of the roof area.

Non-Roof
In high traffic areas, where planted areas are inappropriate, use high albedo paving solutions with a reflectance value of at least 0.3 maintained for a minimum of 30% of the site's impervious surfaces. There are several options available, including use of white concrete mix, light gravel and/or reflective pavement coatings, or a combination of these materials. Also, high albedo areas may be interspersed with open grid pavement of more than 50% perviousness.

Three other options may be considered to achieve this initiative, however, on a busy commercial site such as the World Trade Center, they present a greater challenge than those listed above:

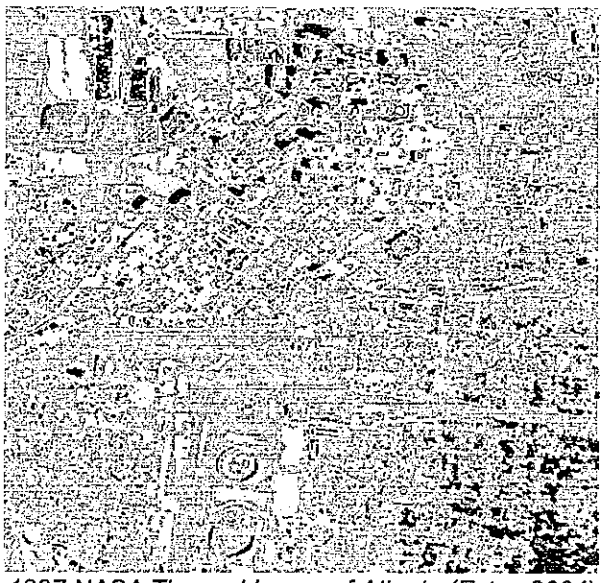
- Plant trees so that 30% of the site's impervious areas are fully shaded within five years. Trees that line roadways, walkways and parking areas, or that provide shade in public plazas, etc, may all be considered. This requires coordination with both the site Master Planners and Landscape Architects.

- Include pervious materials such as plastic or concrete open-grid paving systems, or porous concrete or asphalt, for a minimum of 30% of the site's typical non-pervious surfaces: i.e. roadways, parking areas.
- Provide underground parking for 50% of the building's parking requirements, or provide parking areas with an open-grid pervious surface for a minimum of 50% of the parking requirements.

Case Studies

NASA's Project ATLANTA (Atlanta Land use Analysis: Temperature and Air Quality)

In 1997, NASA's project ATLANTA was created to study urban heat islands and their relation to changes in land usage over several decades in Atlanta, a city experiencing air quality concerns at the time. NASA is using remote sensing technology to identify areas of significant heat. The image below shows one of these analyses, with hot areas shown in red and cool areas in blue. The study of the materials and surfaces that corresponded to these areas is intended to provide design input for how to mitigate the urban heat island effect during the future development of Atlanta. The data and its implications for public policy making will be investigated by a team comprised of various agencies other than NASA including the US EPA, The Environmental Office of the City of Atlanta, and the National Park Service over an ongoing 20 year period that began in 1997. Further results have not yet been published at this time. (Estes 2004)



1997 NASA Thermal Image of Atlanta (Estes 2004)

Salt Lake City Cool Communities Program and the Urban Heat Island Pilot Project

In 1995 Salt Lake City, Utah joined the Cool Communities Program, a collaboration between local and federal agencies targeted at improving urban air quality through heat island reduction. As part of this program, the city began to heavily promote the use of light-colored roof and street surfaces. It also began to deploy vegetative matter in specific locations to provide shading and enhance evaporative cooling. By joining the Urban Heat Island Project in 1998, the parties involved were able to see the effectiveness of their strategies. At the time, the UHIPP, a partnership between

the US EPA, US Dept. of Energy, and NASA (among various other local partners), was using remote sensing to study heat islands from high above the earth. By comparing the thermal imagery taken with the locations of light-colored surfaces and plantings, the effectiveness of the Cool Communities Program could be evaluated. The image below shows hotter surfaces in red and cooler surfaces in blue. Large blue areas throughout the image are most likely green spaces such as parks and cemeteries. This is an ongoing project and additional data is will be published by its stakeholders as the study progresses. (Estes 2004)

1998 NASA Thermal Image of Salt Lake City (Estes 2004)

Reference

Definitions

Albedo or Solar Reflectance is the ratio of reflected solar radiation to incident solar radiation (within wavelengths of 0.3 to 2.5 micrometers). For example, a reflectance of 100% would indicate that all of the energy striking a particular surface is reflected, with none being absorbed by the surface.

Emissivity describes the amount of energy that is re-radiated from an object as long-wave radiation (heat), as compared to the amount of short-wave radiation (solar, U.V.) that originally fell upon the surface.

The Heat Island Effect describes the phenomenon where urban areas experience higher ambient temperatures than adjacent rural areas. This is a result of the absorption of solar energy that is re-radiated as heat from constructed surfaces, particularly those that are dark in color.

Standards

ASTM. ASTM E408-71(1996)e1: Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques. ASTM International, 1996.

ENERGY STAR. ® "Energy Star® Program Requirements for Roof Products: Eligibility Criteria." ENERGY STAR ® 30 Sep 2004 <http://www.energystar.gov/ia/partners/product_specs/eligibility/roofs_elig.pdf>

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Rosenfeld, A. H., J. J. Romm, H. Akbari, and M. Pomerantz. 1997. "Cool Communities: Strategies for Heat Islands Mitigation and Smog Reduction," Submitted to *Energy and Buildings*. Also Report No. LBL-38667, Lawrence Berkeley National Laboratory, Berkeley, CA.

Urban Heat Island Pilot Project. Diane Samuelson, Ed. 05 Aug 1999. NASA 30 Sep 2004 <http://www.ghcc.msfc.nasa.gov/uhipp/urban_uhipp.html>

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Heat Island Effect Mitigation

SEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

Site/Parcel:

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 7.1: Heat Island Effect – Non-roof)*
The attached documentation and calculations demonstrates that a minimum of 30% of the site's open space has been covered by vegetation, is comprised of materials of at least 0.3 reflectance, or is shaded.

Buildings:

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Sustainable Sites Credit 7.2: Heat Island Effect – Roof)*
The attached documentation and calculations demonstrates that a minimum total of 75% of the roof area of all building coverage on the site consists of vegetated surfaces OR roofing that is ENGERY STAR® compliant AND has an emissivity of at least 0.9 when tested in accordance with ASTM 408.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Light Pollution Reduction SEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce light pollution and glare to surrounding sites and night sky.

Action: Satisfy Illuminating Engineering Society of North America (IESNA) recommended practice per manual (RP-33-99) for exterior illumination. Design exterior lighting such that all exterior luminaires with more than 1000 initial lamp lumens are shielded and all luminaires with more than 3500 initial lamp lumens meet the Full Cutoff IESNA Classification. The maximum candela value of all interior lighting shall fall within the building (not out through windows) and the maximum candela value of all exterior lighting shall fall within the property. Tower tops will not be constrained by these requirements. Minimize glare from reflected sunlight by minimizing use of highly reflective materials on building facades. Incorporate lighting controls to minimize energy use during unnecessary periods.

Related Guidelines: EEQ-1, EEQ-3

Potential LEED™ 2.1 Credits: 1 possible with SS cr. 8. (See Submittal Template)

Introduction/Context

Some thirty years ago, 'good' quality lighting, both indoors and outdoors was judged on the *quantity* of luminance (light output), rather than on the *quality* or appropriateness of light levels provided. Fortunately, since then, much has changed in New York City and across the country, and designers, as well as those who benefit from well-designed indoor and outdoor lighting, have become more sensitive to the critically important role played by supplemental lighting. Today, consideration is given to how such lighting can best be used to augment natural day-light levels, enhance mood, enliven spaces and most importantly, provide appropriate levels of illuminance wherever supplemental lighting is needed. While outdoor lighting is still seen as a necessary visual enhancement and safety strategy, this consideration is now understood to be only one of many factors that address personal security. Over-lighting, or outdoor light pollution as it is often called, affects the night sky, where the artificial brightness of the city at night limits visual access to the stars and astronomical phenomena. Further, over-lighting is known to adversely affect the natural habitat surrounding the site and to create imbalance in the lives of birds and animals.

Relevant Issues

Ecological

Light pollution, at its most simple, is wasted light. The energy used to produce unneeded light releases environmental pollutants as byproducts of its generation and contributes to the depletion of natural resources. Abnormal amounts of light can obstruct growth in certain types of vegetation and negatively alter natural behavioral patterns in some animals. This can cause major disruptions to the ecosystem and is even known to lead to premature death in extreme cases.

Economic

As misused energy, light pollution wastes available power, spends money needlessly and consumes resources. One of the primary objectives of a sustainable approach to the built environment is the 'conservation' of energy and available natural resources. While nighttime lighting of outdoor facilities such as streets, parking lots, pathways and plazas is a vital function for any urban complex, over-lighting these facilities is simply self-defeating.

Subtle, well-placed luminaires, with shielded lamps of a luminance matched to their function, can save on both energy and maintenance costs. In addition, when less electrical power is used, the fossil fuel base is conserved for future use, while less pollution is generated at the utility. Any reduction in pollution contributes to cleaner air quality in the city and opportunities for enhanced human health, with all of the associated monetary benefits.

Neighborhood

The extreme contrast created between an over-lit location and the dark night sky, when light levels at ground level are completely unshielded, adversely affects visibility and denies visual access to the night sky. Increased ambient brightness caused by light pollution may also interfere with sleeping patterns.

Luminance values which are higher than those comfortable to the human eye generate a condition known as 'glare'. Glare has two common forms, the first being reflections off specular surfaces, such as shiny metal panels on a building façade. The second form of glare results from an intense contrast between low, ambient light levels and the artificial brilliance of an over-lit area, such as a shopping mall or flood-lit parking lot. Exposed, unshielded light sources are a typical source of glare. This can be especially problematic in an urban setting where street lights are found in greater quantity and closer together. Glare is another form of light pollution and can cause serious both visual discomfort and loss of visual acuity.

High levels of light outdoors at night attract insects, including those which represent potential health-risks, such as mosquitoes.

Some studies have shown a relationship between extended periods of darkness and the production of hormones critical to human health and well-being. The reduction of these periods of darkness in the presence of light pollution may have adverse health effects. (BuildingGreen.com 2004)

The over-lighting of a site has aesthetic implications. The interplay of light and shadow – chiaroscuro -- does much to create a sense of depth and render buildings, urban landscaping, and street objects in a dramatic and appealing manner. In the presence of too much light, all of these 'objects' tend to appear flat and washed-out, less visually compelling and inherently uninviting.

Methodology

Design Strategies

Design site-lighting to satisfy the recommended practice of the Illuminating Engineering Society of North America (IESNA) as specified in their manual for exterior illumination (RP-33-99). Specify the minimum light levels necessary to ensure site safety and security as well as specific aesthetic goals.

Consider the lighting design of a site in relation to the light levels of surrounding areas. Extreme contrast in light levels and bright light spilling from one area into a darker one create many of the conditions known as light pollution. A site which requires a certain level of bright lighting, and which is located in a dark neighborhood, for instance, should attempt to provide light levels that meet the minimum requirements for the safety and function of that specific area, while observing a respect for the surrounding neighborhoods. Avoiding light 'spillage' is also an important consideration.

Many of the buildings at the World Trade Center are being designed with highly reflective skins, usually of metal and glass. Every effort must be made to mitigate the potential glare from these buildings, especially at ground level. Designs should avoid the creation of glare from both reflected sunlight during the day and reflected artificial light at night. Where possible, use landscaping, low-reflective ground cover and trees to soften views across open spaces and deflect direct reflectance and glare from these building facades. Make sure that all night lighting luminaires selected meet the criteria described in IESNA RP-33 and RP-22 for the minimum recommended illuminance values and appropriate shielding to prevent light trespass, while enhancing visual acuity. Fixtures located close to a building with a reflective skin should be of lower wattage than those that are free-standing in an open area.

Means and Methods

Precisely aim the optics of all site fixtures so that light falls exactly where required and does not spill over into neighboring areas. Specify luminaires with shielding devices, and where appropriate, full cut-off technology. Provide shielding on all luminaires with more than 1000 initial lamp lumens. When using luminaires with more than 3500 initial lamp lumens, be sure they satisfy IESNA's classification for full cut-off. Incorporate control devices in all site luminaires, such as photocells and timers, so that they are weather and time-of-day responsive, in order to conserve energy. Motion sensors should be considered so that site lighting devices which are automatically turned off late at night may be responsive to the presence of people at the site by providing fail-safe lighting, even after a pre-determined curfew.

Wherever possible, use down-lighting instead of up-lighting as a strategy to prevent extraneous light from escaping skyward. Consider internal edge lighting, or shielded downward illumination for signs, to prevent light leakage to the night sky. Use solid building canopies with incorporated down lighting or fully shielded up/down-lighting within the canopy itself, to minimize sky glow.

In landscaped areas, lighting should be minimal. Shielded luminaires on standards can provide soft, uniform, ambient light, and walkways can be lit with low, bollard-type fixtures that clearly indicate the path by providing local bright spots without lighting large tracts of garden or lawn. Planting beds with ground cover have naturally low reflectance and will absorb much of the glare of landscaping illuminance, while still offering a brighter glow to indicate the path.

Design fenestration and interior building lighting to insure that the points of maximum luminous intensity (measured in Candelas) occur within the building envelope (rather than spilling out through the windows).

While the Guidelines permit lighting the tops of the towers of WTC site buildings, the preferred environmental approach is to do so only on the rarest of occasions in order to avoid night glow. Every effort needs to be made to manage this high level, tower top lighting plan by not permitting light to escape above the buildings, minimizing the direct view into light sources when looking up from the plaza and maintaining an even, non-glare wash rather than bright spots of light on all exterior walls.

Refer to ASHRAE 90.1 2001 for information concerning façade lighting, which should be minimal if used at all. This standard also provides guidance for lighting controls and minimum lamp efficiency and power limits. Site lighting is part of the commissioning process and must be considered in order to comply with EO-111 and the NYSGBTC requirements, as well as the LEED Prerequisite EAp1, Fundamental Building Systems Commissioning.

Case Studies

Sundeck Restaurant at Aspen Skiing Company, Aspen, Colorado

As part of the sustainable goals of the Aspen Skiing Company, this restaurant is outfitted with various light pollution control measures. Both the building and site plans were designed to help contain light to its target areas. Specific luminaires were specified for their ability to eliminate direct and indirect glare from anticipated viewing angles. Interior surface reflections are limited to a 40 degree viewing angle for people off-site. Blackout curtains help prevent interior light from escaping during the nighttime. Dark colored materials used under the windows prevents any interior light that does escape from being reflected off the ground and up to the sky. The building's roof was designed with large overhangs to prevent snow from accumulating under the windows, reflecting light upward. Exterior lighting was limited to that which was required to satisfy local codes. None of the exterior lighting fixtures can be seen from adjacent sites. A lighting control system shuts all exterior lighting off at 11 P.M. (National Ski 2004)

Reference

Definitions

A Candela is the basic unit for measuring luminous intensity from a light source in a given direction.

A Footcandle is a measure of the amount of lighting falling on a surface, with one footcandle being equal to the amount of light falling on a one-square foot area from a one candela light source that is one foot away from the surface.

A Full Cutoff Luminaire has a zero value for luminous intensity at and above an angle of 90 degrees above the vertical axis. In addition, the candela per 1000 lamp lumens does not numerically exceed 100 at an angle of 80 degrees above the vertical axis. This applies to all lateral angles around the luminaire.

Glare is a sensation that causes visual discomfort. It occurs when the field of vision has a significantly higher level of luminance than that to which the human eye is adapted.

Illuminance is the amount of light falling on a surface. This is measured in either footcandles or lux.

Light Pollution refers to stray light that is escaping from luminaires or reflecting off of surfaces and not serving a lighting purpose. The term also refers to light that falls without its intended target area, often onto surfaces or areas where it causes disturbance and is not desirable. This condition is known as 'light trespass', and is essentially wasted light.

Luminaire is the trade term for what is more commonly called a lighting fixture.

Luminance, commonly referred to as "brightness", is a measure of the light coming from a surface or light source, also called the 'out-put' of light from a fixture. Luminance, measured in footlamberts (or candela per square meter) measures the amount of light that is directed towards the eye from a surface or light source with respect to its initial intensity.

Luminous Intensity is a measure of the energy emitted by a light source in a particular direction. It is measured in candelas.

Lux is the International System unit of illumination, equal to one lumen per square meter.

Sky Glow is a condition where lighting escapes upwards, reflecting of water vapor and debris in the air, and polluting the night sky. It cuts down on visibility, dimming the stars and astrological events, and causes an adverse impact on wildlife, and nocturnal ecosystems. Sky Glow wastes energy and does not contribute to the quality or amount of light available at a site.

A Specular Surface has the qualities of a speculum, or mirror; a smooth, reflecting surface.

Standards

Illuminating Engineering Society of North America (IESNA). Lighting for Parking Facilities (RP-20-98). IESNA, 1998.

Illuminating Engineering Society of North America (IESNA). Recommended Practice Manual: Lighting for Exterior Environments (RP-33-99). IESNA, 1999.

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The International Dark Sky Association. <http://www.darksky.org>

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National Ski Areas Association. "Visual Quality: Aspen Skiing Company". The Green Room: The Ski Industry Environmental Database . 2004. National Ski Areas Association. 1 October 2004. <http://www.nsaa.org/nsaa/environment/the_greenroom/index.asp?mode=greenroom&mode2=full&caseid=291&topic=T19>

Light Pollution Reduction

SEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

☐ **Required Component:**
Measures have been taken to mitigate uncomfortable glare, caused by highly reflective materials used on a building façade or site surface, for site/building occupants or neighbors.

☐ **Required Component:**
A lighting control diagram and schedule demonstrating that lighting will be minimized during unnecessary periods is attached.

☐ **Required Component:**
Catalog cut sheets are attached for all exterior luminaires with more than 3500 lumen lamps. These demonstrate that the luminaires meet the Full Cutoff IESNA Classification and indicate lamp type, distribution type, and any additional shielding provided. Catalog cut sheets are also attached for all exterior luminaires with more than 1000 lumen lamps. These demonstrate that the luminaires are appropriately shielded for the project's Environmental Zone (as defined by IESNA)

☐ **Required Component:**
Interior lighting design drawings are attached showing the building's perimeter areas and demonstrating that the maximum luminous intensity of interior lighting (measured in Candelas) falls within the building and not out through the windows.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Construction Environment SEQ-5

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce pollution, noise and vibration from construction activities and vehicles.

Action: Implement a Construction Environment Plan, which reduces pollution, noise and vibration from construction activities and vehicles to adjoining neighborhoods.

Develop a materials staging and construction access plan prior to start of construction. Truck staging zones are to be placed for minimum disruption and impact. Limit unnecessary idling times on diesel powered engines to 3-minutes. Consider bio-diesel fuel as an alternative to pure diesel.

Non-road construction equipment of 50hp or greater to include diesel emissions control technology according to EPA diesel retrofit recommendations, unless not technically feasible. All non-road diesel equipment to utilize ultra low sulfur diesel fuel (limit sulfur levels to 15ppm). Explore accelerated implementation of proposed EPA emission standards for non-road diesel equipment. Locate fixed diesel powered exhausts away from fresh air intakes.

Reduce noise and vibration impacts through scheduling and coordination with adjacent construction activities. Consider noise barriers where practicable.

Consider condition of surrounding buildings, structures, infrastructure and utilities where appropriate. Coordinate construction activities in adjacent and nearby locations to avoid or minimize impacts and communicate plans with the public.

Prepare contingency measures in the event established limits are exceeded

Related Guidelines: UEQ-8, SEQ-1, SEQ-5, SEQ-6, MEQ-2, IEQ-1, IEQ-3, IEQ-5, IEQ-11

Introduction/Context

Construction sites are notoriously dirty and noisy. Yet with some forethought, much of the pollution generated and noise associated with construction activities can be averted. This becomes increasingly important as the aging infrastructures and built environment of most American cities begins to reach the end of their useful lifespan, and are in need of major renovation or replacement. It is also a critical consideration at the World Trade Center site, where most of the infrastructure and all of the buildings will be new, involving heavy construction phased over several years. For the benefit of those who live and work nearby, for early occupants of the site, and for the construction workers themselves, every effort needs to be made to make the construction process less wearing, less stressful and quieter,

while also reducing the dust, pollution and toxic emissions usually associated with work on a project of this unprecedented scale.

Many of the strategies intended to make a construction site more humane are just now being developed and brought into the mainstream. These include mufflers on all engine driven equipment, quieter methods of construction through the use of equipment that reduces both noise and vibration, and a more extensive use of alternative fuels, which generate much less pollution. The EPA has proposed changing their standards in order to reduce pollution via the use of bio-diesel and compressed gas for all non-road construction vehicles. Intended to reduce the devastation caused by diesel fumes, this proposal offers the World Trade Center site a prime opportunity to advance market transformation by adopting the new standards ahead of a legislative requirement.

Relevant Issues

Ecological

Exhaust from diesel engines contains particulate matter, soot, nitrogen and sulfur oxides, and toxic air pollutants in large quantities. These pollutants contribute to decreased air quality, acid rain and global warming. According to Mark Z. Jacobson, Associate Professor of Civil and Environmental Engineering at Stanford University: "Soot exacerbates global warming. Reducing soot emissions will slow global warming faster than by reducing carbon dioxide, methane or other greenhouse gases". It is, he maintains, the second largest contributor to global warming after CO_2.

Use of emissions control technologies and ultra-low sulfur fuel for construction vehicles is important, as it lessens the amount of air pollution at the site and in the surrounding neighborhood. Limiting idling times for these vehicles further reduces air pollution. Restricting their operation to staging areas located away from site occupants and fresh air intakes decreases people's exposure to exhaust fumes. The negative contribution of a construction site to neighborhood air pollution can be decreased further by operating equipment on alternative fuels such a bio-diesel and compressed natural gas.

Excessive noise is a form of pollution. Efforts to manage noise by using state-of-the-art equipment and scheduling activities that are acoustically disturbing at the least disruptive time of day, will help to alleviate this condition.

Economic

According to the National Biodiesel Board, one of the great advantages of bio-diesel fuel is that it can be used in existing engines and fuel injection equipment with little impact to operating performance. It costs little more than regular diesel fuel and offers enormous benefits in terms of human health and well-being, as well as environmental quality. In using a low-blend of bio-diesel fuel, any increase in cost will be off-set by an increase in diesel quality, since low-blend levels of bio-diesel greatly enhance the lubricity of diesel fuel.

Other alternative fuel vehicles are also available. In order to minimize pollution and noise, alternatives such as electric and hybrid cars and vans, compressed natural

gas buses (already successfully running on New York's streets), etc. should be considered for use at this site. While there is still a premium in first cost for these vehicles, looking at the larger picture, the cost savings in avoided health impacts such as respiratory, cardiovascular and pulmonary disease, as well as asthma, which can be directly linked to fuel emissions, will be significant, and strongly uphold the intent of these guidelines.

Beyond these impacts, the emissions associated with diesel and other fuels affect buildings, layering their facades with a sticky residue of soot that is difficult to remove, and eating into the fabric of the building materials themselves. The nitrogen (NOx) and sulfur oxides (SOx) generated in diesel fuel emissions represent two of the most damaging acid rain components, often carried on the wind so that they fall in the North Eastern United States, where they are responsible for the stripping of trees and foliage. These oxides are also active at the most local level, where they can destroy architectural stonework and pit aluminum surfaces. The costs of cleaning and repairing building facades that have been affected by such emissions are enormous – consider the recent clean-up that the City of Paris has had to undergo for just this reason.

Neighborhood
Excessive noise and vibration from construction activities can be greatly disturbing to the community. Use of newer equipment with appropriate mufflers, and the provision of adequate warnings when any especially noisy or disruptive work is planned at the site, and maintenance of the established schedule for its completion, can help community residents to plan around any necessary disruptions, which will in turn, help to alleviate concern. Changes in traffic patterns and disruptions in utility services are also likely to negatively affect people who live and work in the area surrounding the World Trade Center construction site. Careful planning to limit these disturbances will provide a safer, healthier and more tranquil environment. All the emission control strategies mentioned above will be key to the maintenance of the most valuable neighborhood asset: clean air.

Methodology

Design Strategies
Perform an analysis of the vulnerabilities of buildings, structures, and the utility infrastructure surrounding the site. Make provisions to protect these elements from damage during the construction process.

Noise
Implement measures to reduce noise from construction activities. Scheduling should be the first step of this process. Combining noisy activities into a limited time period reduces the total number of hours of sound disturbance. The simultaneous scheduling of noisy activities does not create a significantly louder environment during concurrent hours (Harris, 1995). Attempt to schedule the noisiest construction operations during the least offensive time period. In neighborhoods with residential buildings, nighttime will be the period in which to avoid the loudest construction activity. However, in a strictly commercial neighborhood with limited evening occupancy, nighttime may be the least disruptive period .

Another important strategy to reduce sound pollution on the construction site is to avoid major noise-generating, building methods whenever possible. For example, drilling piles or driving them with a sonic or vibratory pile driver is a quieter approach than using impact machines. Also, certain alternative demolition methods, such as sawing or disassembly rather than impact demolition, can limit noise production. Construction equipment itself can also be altered to limit noise and particulate pollution by installing mufflers on all engines. Yet another means for deadening construction noise is through the use of sound barriers. These can be mounds of excavated earth, dense areas of vegetation, or temporary building materials such as sheet piling or concrete barriers. Finally, as part of the construction staging plan, the loudest site machinery and construction tasks should be as "remote" (via scheduling or placement) from noise sensitive areas as possible.

Vibration

Implement construction methods that reduce the impact of vibration on and around the site. Scheduling is the most effective strategy to this end. As in the case of noise management, schedule high-vibration construction operations during the periods when they will be least offensive. In neighborhoods with residential buildings, daytime will be the opportune time, while in a strictly commercial neighborhood with limited evening occupancy, nighttime may be the least disruptive period during which to perform construction activities that cause high vibration. Unlike noise, vibration levels are additive (Harris, 1995), so processes such as ground-impacting and earthmoving should be scheduled in a staggered fashion. Alternative construction methods can also help limit vibration. The avoidance of impact pile-driving and wrecking ball style demolition, when possible, can do much to curtail excessive vibration. Vibratory rollers should also be used sparingly, especially in vibration sensitive areas of the site.

Materials Staging

Develop a materials staging and construction access plan prior to the start of construction. The intent of this plan is to limit disruption to the normal operation of the neighborhood as much as possible. Locate truck staging areas where they will have the least impact on traffic and air quality. Enforce a 3-minute limit on all unnecessary diesel engine idling. Employ road-borne construction and delivery vehicles which use a bio-diesel fuel alternative.

Air Pollution Controls

Air pollution controls are a critical component of the Construction Environment Plan. Less-polluting fuels such as bio-diesel or compressed natural gas for non-road construction equipment provide a means of accelerating the implementation of the proposed EPA emission standards. Any non-road machinery of 50hp or greater must be equipped with diesel emissions control technology according to the standards delineated by the EPA's Voluntary Diesel Retrofit Program, unless not technically feasible. Ultra-low sulfur diesel fuel (15ppm) must be used in all non-road diesel equipment. (Both of these requirements are commensurate in intent with New York City's recently passed, groundbreaking Local Law 77, which is intended to reduce pollution from non-road construction vehicles by up to 90%. It requires the use of ultra-low sulfur diesel and the best available retrofit emissions control technologies on every city-funded construction project. (*League of Conservation*

Voters, 2004). As a planning and operations principle, locate any fixed sources of diesel exhaust away from, and down-wind of, fresh air intakes.

The EPA's Voluntary Diesel Retrofit Program, which was started in September 1998, mandates the installation of an oxidation catalyst on all large off-road diesel construction equipment. (An oxidation catalyst is a device that limits emissions by converting diesel pollutants including particulate matter, hydrocarbons, and carbon monoxide into less harmful emissions such as water and carbon dioxide).

Case Studies

Central Artery/Tunnel Project, Boston, MA.

Several hundred heavy-duty off-road diesel construction vehicles were used during the construction of the Central Artery/Tunnel Project, more commonly known as the "Big Dig", in Boston, Massachusetts. Those in charge of this project implemented a strict plan to control construction pollution which was especially important on a project of this magnitude. The main focus of this particular plan was to mitigate air pollution as a result of construction vehicle emissions. Each contractor was responsible for keeping their machinery properly tuned to reduce emissions. All diesel engines were required to be turned off when not in use for more than five minutes. This included a prohibition on the common practice of letting dump trucks idle while waiting to unload. In addition, a special staging zone was created for trucks waiting to load or unload materials for the project. This area was established in a location where the diesel emissions would not directly affect the public and away from sensitive areas like building air intakes and windows. Many of the vehicles used in this project were operated by companies who also participated in a voluntary diesel retrofit program implemented by the Massachusetts Turnpike Authority and the Massachusetts DEP in September of 1998. This program promoted the retrofit of large off-road diesel construction machines with an oxidation catalyst to transform harmful diesel pollutants such as particulate matter, hydrocarbons, and carbon monoxide to less harmful emissions such as water and carbon dioxide. (Central Artery 2004)

Reference

Definitions

Bio-diesel is a diesel-like fuel made from renewable resources including vegetable, soy, or canola oil. It can even be made from used cooking oil and animal fats. The combustion of bio-diesel produces far fewer air pollutants and greenhouse gases than petroleum diesel. It is also biodegradable.

Ultra-low sulfur diesel (ULSD) is a diesel fuel that has been refined to contain much less sulfur than standard diesel fuels. The sulfur content of today's ULSD fuel ranges from 15-30 parts per million (ppm). This is in contrast to standard diesel fuel which is currently allowed a sulfur content of 500 ppm. Beginning in 2006, diesel fuel sold for on road use must meet the new USEPA requirement for ULSD, which caps sulfur content at 15 ppm. The lower sulfur content of ULSD creates far fewer sulfate emissions during combustion and facilitates the use of further emission-reducing technologies such as particulate traps and catalytic converters to curtail emission of nitrogen oxides and

particulates. The use of these fuels has reduced emissions of fine particulate matter by up to 90 percent. (Diesel Technology, 2004)

Standards

NYC Local Law 77 (2003) requires that all diesel engines of more than 50 hp on city construction projects employ ULSD and "best available technologies" (BAT) to reduce emissions. These requirements took effect in Lower Manhattan effective June 19, 2004.
< http://www.nyccouncil.info/pdf_files/bills/law03077.pdf >

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Diesel Technology Forum: New Technologies. 2000-2004. Diesel Technology Forum. 12 October 2004 < http://www.dieselforum.org/factsheet/ulsd.html >

Harris, Miller, Miller & Hanson, Inc. "Chapter 12: Noise and Vibration During Construction." Transit Noise and Vibration Impact Assessment. Burlington, MA: U.S. Department of Transportation, 1995.

New York City Department of Design and Construction. Local Law 77: DDC Ultra Low Sulfur Diesel Manual. June 2004. <http://www.nyc.gov/html/ddc/html/ddcgreen/documents/lowsulfur.pdf >

Construction Environment Plan

SEQ-5-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Construction Environment Plan provides a tool to reduce pollution, noise and vibration from construction activities and vehicles to adjoining neighborhoods.

Plan Components

I. **Project Description (Plan Summary)**
   A. Summarize project construction requirements, ramifications to adjacent buildings and neighborhood traffic patterns and construction timetable.

II. **Management strategies**
   A. Develop a materials staging and construction access plan prior to start of construction. Truck staging zones are to be placed for minimum disruption and impact.
   B. Limit unnecessary idling times on diesel powered engines to a maximum of three (3) minutes. Consider bio-diesel or low-sulfur fuels as alternatives to pure diesel.
   C. Non-road construction equipment of 50hp or greater should include diesel emissions control technology according to EPA diesel retrofit recommendations, unless not technically feasible. All non-road diesel equipment to utilize ultra low sulfur diesel fuel (limit sulfur levels to 15ppm). Explore accelerated implementation of proposed EPA emission standards for non-road diesel equipment. Locate fixed diesel powered exhausts away from fresh air intakes.
   D. Reduce noise and vibration impacts through scheduling and coordination with adjacent construction activities. Consider noise barriers where practicable.
   E. Consider condition of surrounding buildings, structures, infrastructure and utilities where appropriate. Coordinate construction activities in adjacent and nearby locations to avoid or minimize impacts and communicate plans with the public.
   F. Prepare contingency measures in the event established limits are exceeded.

III. **Targets**
   A. Provide coordinated schedule which includes simultaneous adjacent construction activities.

IV. **Implementation**
   New York City Mayor Michael Bloomberg has put forward legislation, which provides the first comprehensive overhaul of the New York City Noise Code in over 30 years. Noise is the number one complaint to the City's 311 citizen service hotline, currently averaging nearly 1,000 calls a day. As a result of this code, city agencies,

including local police have greater authority to 'shut down' a project based on unreasonable level of noise.

For exterior locations, all projects must comply with the New York City Noise Control Code. In accordance with the code requirements:

- Establish uniform best management practices for all work sites.
- Mandate 'noise management plans' that include portable sound barriers and noise jackets for jackhammers at all construction sites.
- Use noise meters and other means to determine the level of noise produced by equipment operation, and cease work immediately if the noise level exceeds the code. Develop a less disruptive and quieter approach before recommencing work.

New York City's Noise Control Code

Ambient noise quality zone	Day-time standards (7am - 10pm)	Night-time standards (10pm - 7am)
Noise quality zone N-1 (Low density residential RL; land-use zones R-1 to R-3	Leq=60 dB(A) measured for any one hour	Leq=50 dB(A) measured for any one hour
Noise quality zone N-2 (High density residential RH; land-use zones R-4 to R-10)	Leq=65 dB(A) measured for any one hour	Leq=55 dB(A) measured for any one hour
Noise quality zone N-3 (All Commercial and manufacturing land-use zones)	Leq=70 dB(A) measured for any one hour	Leq=70 dB(A) measured for any one hour

Construction Environment

SEQ-5-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	◉

☐ **Required Component:**
A Construction Environment Plan is attached and includes measures to reduce pollution, noise, and vibration from construction activities and vehicles. This plan also highlights specific areas of sensitivity in the surrounding context including neighboring buildings, structures, and utility infrastructure, indicating what protective measures will be taken during construction on their behalf. As part of the plan, a coordination schedule that includes other simultaneous construction activity in the area has been developed to minimize disruption to the neighborhood

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Construction Storm Water and Pollution Prevention SEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Control site erosion and reduce negative impacts on hydrological and atmospheric systems produced by construction activities.

Action: Provide a Construction Storm Water Pollution Prevention Plan conforming to US EPA document NO. 832/R-92-005. This plan must also take measures to prevent air pollution from dust and particulate matter during the course of construction. Utilize sprayed suppression agents (nonhazardous, biodegradable) for containment of fugitive dust and adjust strategies per meteorological conditions. Coordinate with SEQ-5 Construction Environment Plan.

Related Guidelines: UEQ-8, SEQ-1, SEQ-2, SEQ-5, WEQ-1, WEQ-2, IEQ-1, IEQ-5

LEED™ 2.1 Requirement: SS Prerequisite 1. (See Submittal Template)

Introduction/Context

Construction is an intense, invasive process that inevitably disturbs the site and nearby environment wherever it occurs. Careful planning and management of construction activities can prevent major damage to both the site and surrounding neighborhood. Construction pollution is caused by both natural and anthropogenic forces. As earth is exposed, operations including excavation and water from rain may carry some soil off the site suspended in stormwater runoff. This erosion is harmful to both the site and regional waterways. Runoff can also transport potentially toxic debris from a construction site to neighboring water bodies. Wind plays a significant role in spreading materials such as dust and soil around a site and out into adjacent areas. Two comprehensive sets of strategies can be used to help mitigate pollution during construction. The first layer of defense against construction pollution involves limiting the production of dust and debris in the first place. Less volatile demolition practices (disassembling components rather than using a wrecking-ball) and use of benign building materials are two examples of this. The second tier of strategies for construction pollution control involves methodologies to curtail the spread of the pollution generated. Natural forces such as wind and stormwater flow can be controlled to limit their ability to pick up and carry off dust and debris. Securing piles of excavated earth, wetting or compacting loose soil, and bounding the site with natural filtration barriers such as hay bales are just three examples of control techniques.

Relevant Issues

Ecological

In the absence of protective strategies, stormwater runoff from a construction site will inevitably flush contaminants and sediment into local water bodies. As sediment settles to the bottom of these water bodies, they begin to fill in. If this occurs in large amounts, especially in still water bodies such as lakes, dredging may ultimately be required to maintain the lake or pond. The dredging process causes devastating damage to aquatic ecosystems. Sediment also fills up the deepest pools which occur in the lower reaches of the water, eliminating what typically serves as breeding areas for fish and aquatic insects. Heavy metals, chemicals and other inorganic pollutants carried in site runoff are biohazards to both people and aquatic life that swim in, or drink, the polluted water. Organic pollutants carried by construction site runoff are an additional concern. Nutrients such as nitrogen and phosphorus contribute to the accelerated eutrophication of water bodies, stimulating unnatural algal and vegetative growth, disrupting the biological processes of aquatic life. In addition to all this, the loss of earth from a site through erosion also has negative impacts, disrupting natural processes that occur in the ground such as the burrowing of insects and the formation of root structures by plants.

Air pollution is created by construction dust and soil that becomes windborne when a site is not properly protected. This has negative health effects for people as well as the area's flora and fauna.

Economic

Damage created by contaminated site runoff can have serious financial implications. Deposits of sediment on roadways and in drainage infrastructure must be removed. Build-up of sediment and pollutants in water bodies may require dredging, which is an expensive and disruptive process, in order to maintain their original shape and character. The purchase and transportation of fill and topsoil, as well as the labor to repair erosion-damaged sites, causes an unnecessary and often avoidable financial burden.

Airborne particulate matter on a construction site has negative economic impacts. Debris blowing around a site can cause costly property damage, degraded working conditions for staff, increased cleaning costs and attendant liability.

Neighborhood

Community members are greatly affected by damage to local bodies of water resulting from contaminated construction site runoff. Sediment build-up in these waterways also has negative affects for recreational activities such as fishing and boating. Dust and air-borne pollution from a construction site pollute local air quality and have negative health and comfort impacts for those living and working nearby.

Methodology

Design Strategies

Create and implement a Construction Storm Water Pollution Prevention Plan to limit contaminated construction site runoff, sedimentation, and erosion. This plan must also provide measures to prevent air pollution from dust and particulate matter during

the course of construction. The United States Department of Environmental Protection has authored a document entitled Storm Water Management for Construction Activities (US EPA document NO. 832/R-92-005), which is a useful reference guide for preparing a Construction Storm Water Pollution Prevention Plan.

Part of storm water runoff reduction may include the capture, treatment and storage of this water for use in site construction activities such as dust suppression.

Means and Methods
The Pollution Prevention Plan specified may use the following measures to control air pollution from dust and particulate matter:

- Design a strategic plan for construction staging that limits the area of the site that will be impacted during construction.

- When necessary, employ physical barriers to prevent wind from creating airborne dust and debris. These barriers can be vertical, such as fencing, or horizontal screening material that is 50% or less porous.

- Manage earth moving activities. Coordinate excavation with the weather to avoid such activities during periods of heavy wind or rain. Schedule earthmoving to be conducted close in time to when it is needed in order to reduce the amount of time earth is left exposed.

- Another method of preventing dust from becoming airborne is through spraying with either water or a non-hazardous, biodegradable suppressing agent. When wetting soil to prevent dust, it is important to dampen it slightly, but not enough to create runoff.

- Any mounds of soil that must be left on site shall be secured to prevent them from eroding or creating windborne dust.

- When conducting construction tasks that produce high levels of airborne dust, use dust collectors to clean the air. Cyclone collectors or bag collectors with fabric filters can be used to accomplish this task.

- To prevent soil, dust, and particulate matter from being carried off-site onto neighboring streets, equipment should be cleaned before leaving the site. Tires can be sprayed down so as not to lead tracks of dirt into the streets. In the event that soil and debris are deposited in the roadways surrounding a site, use street sweepers to clean the area before traffic propels the material into the air. Graywater, collected from site runoff or recycled from building water use, would be well suited to this purpose.

Case Studies

Construction Management Plan for the Columbia Street Pump Station Replacement Project submitted by the Greater Vancouver Regional District

Section 4.6 of this plan on Air Quality and Dust Mitigation outlines requirements to control construction dust on the site of an expansion project for a critical pump station in Vancouver's wastewater infrastructure. Contractors are required to follow specific guidelines to reduce the negative impacts of construction dust. They must use environmentally acceptable dust suppressants or water, as needed, to control particulate matter on all roads, storage zones, the work site itself, and disposal areas. All dry materials must be secured to prevent dust and debris from becoming airborne. All roads sullied by the construction process must be cleaned as required, at a minimum of at least once per day, at the end of the work day. All dump trucks used for the project must comply with emission standards of 1998 or later. The contractor is responsible for cleaning or repairing any damage done to neighboring buildings. A community liaison officer must be appointed to verify this is accomplished. (Greater Vancouver 2004)

The Donald Bren School of Environmental Management Science & Management in Santa Barbara, California

This LEED Version 1.0 Platinum project employed various protective measures on the construction site to prevent stormwater pollution. The original site was a parking lot and much effort was made to keep the footprint of the construction zone small, preserving surrounding habitats and vegetation. Existing site trees were protected throughout the construction process. All asphalt and concrete removed from the site was recycled and used as base for new paving. Desilting facilities were used at each drainage outlet. Hay bales and fencing were employed to aid soil erosion and sediment control. Following rainfall, silt and debris were cleared and hay bales replaced. All native soil from the site was retained and reincorporated into the project's landscape plan. (US Regents 2004.) (BIPER 2002)

Reference

Definitions

Erosion is a process during which parts of the Earth's surface are worn away and transported to another location.

Eutrophication is the process by which lakes slowly age. Accelerated eutrophication occurs when an excessive amount of organic nutrients are added to a lake due to human activity. This is a form of pollution because it creates unnatural algal and vegetative growth and damages the balance of the ecosystem.

Sedimentation is the deposition of soils in bodies of water and can occur naturally or due to human activities.

Standards

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Construction Storm Water Runoff Plan SEQ-6-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Construction Stormwater Runoff and Pollution Prevention Plan provides a tool to reduce adverse construction impacts to stormwater systems and reduce pollution due to dust and particulate matter. It should be designed to prevent runoff from offsite areas from entering disturbed site areas, slow runoff across site, remove sediment from onsite runoff, meet or exceed local requirements for sediment and erosion control and utilize stormwater onsite if possible. Potential uses for captured stormwater include washing construction vehicle tires and wetting dust for suppression purposes. This plan shall comply with the strategies and goals described in US EPA document NO. 832/R-92-005: Storm Water Management for Construction Activities.

Plan Components

I. Site Evaluation and Initial Plan Development

A. Collect Site Information
   1. Measure the Site Area.
   2. Determine the Drainage Areas.
   3. Existing Runoff Water Quality – Include this information only if it has already been analyzed, if information is available from an adjacent site or if information is available from the state or local government.
   4. Location of Surface Waters – Include location of rivers and bays adjacent to the site.
   5. Name of Receiving Water – Name the body (or bodies) of water that is receiving the runoff water and indicate whether it goes through the municipal water system or discharges directly.

B. Develop Site Plan Design

C. Calculate the Runoff Coefficient – the total rainfall that will appear as runoff expressed as a fraction. Calculate for each material covering the site.

D. Prepare Pollution Prevention Site Map – Indicate the location of surface waters, slopes after grading, disturbed areas and drainage patterns/discharge points.

II. Control Selection and Plan Design

A. Review and Incorporate State or Local Requirements

B. Identify Dust Mitigation measures
   Include areas where the following measures are implemented
   1. Temporary and or permanent seeding and planting (including sod stabilization)
   2. Mulching
   3. Soil retention through structural measures as identified in C below or Geotextiles
   4. Creation of protected buffer zones

5. Regular sweeping and wetting of dust and dry soils

C. Identify Structural Erosion and Sediment Control measures
Include the following measures as appropriate
1. Intercepting dikes and/or swales
2. Temporary Storm Drain protection or diversions
3. Silt Fences or gravel/stone filter berms
4. Sediment Traps and basins

D. Identify opportunities to collect and utilize stormwater for construction activities such as wetting dust for suppression and washing vehicle tires.

E. Include the following additional measures
1. Proper Disposal of Construction Site Waste
2. Compliance with Applicable State or local waste disposal
3. Compliance with Applicable State or local sanitary sewer or septic system regulations
4. Control Offsite Vehicle Tracking
5. Control of Allowable Non-Storm Water Discharges

F. Indicate the Location of Controls on the Site Map
G. Prepare an Inspection and Maintenance Plan
H. Coordinate Controls with Construction Activity
I. Prepare Sequence of Major Activities

III. Implementation and Verification

A. Implement Controls and maintain records of stormwater retained
B. Inspect and Maintain Controls - Inspect every 7 days or within 24 hours of a rainfall of more than ½"
C. Maintain Records of Construction Activity
D. Report Releases of Reportable Quantities
E. Plan Location and Public Access

Construction Storm Water Runoff and Pollution Prevention

SEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:** *(This will satisfy LEED™ 2.1 Sustainable Sites Perquisite 1: Erosion and Sedimentation Control requirements)*
A Construction Storm Water Runoff and Pollution Prevention Plan is attached. This plan conforms to US EPA document 832/R-92-005 and addresses measures to prevent air pollution from dust and particulate matter during construction.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Existing Site Structures

SEQ-7

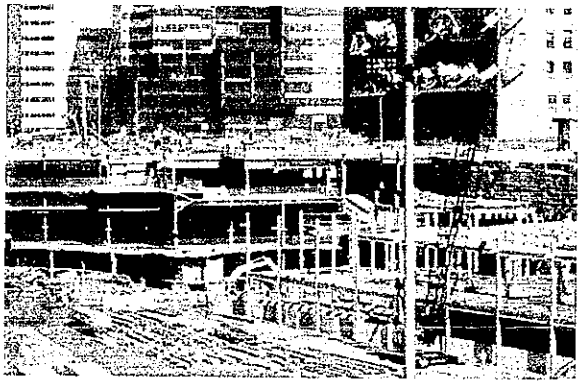
Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Encourage the re-use of existing site structures to conserve resources.

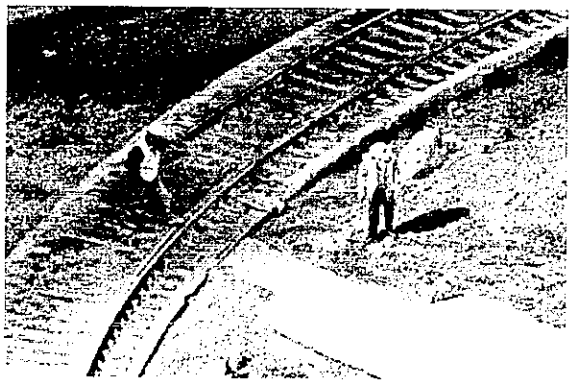
Action: Incorporate existing slurry wall, bathtub excavation, elements of Temporary PATH Station and utilities (such as the River Water Pump Station) for re-use in new site development to the extent possible.

Related Guidelines: SEQ-1, MEQ-1, MEQ-2, MEQ-3

Potential LEED™ 2.1 Credits: 3 possible with MR cr. 1.1, MR cr. 1.2, and MR cr. 1.3. (See Submittal Template)



Existing structure and new PATH Temporary Station on WTC Site, Croxton Collaborative Architects, P.C., 2002



PATH tracks on the WTC Site, Croxton Collaborative Architects, P.C., 2002

Introduction/Context

The reuse of existing site structures and portions of infrastructure is a major precept of sustainable design. This strategy preserves resources, reduces site disturbance, conserves energy and prevents additional air pollution through captured (embodied) energy and by avoiding demolition. Adaptive reuse of site elements is also a sound economic policy. By incorporating existing structures into new structures, money may be saved on the purchase of materials and labor. This technique is also positive for a community since it preserves its historic fabric and curtails the disruption that often occurs during demolition. The complex infrastructure at the site of the former World Trade Center presents many opportunities for adaptive reuse in the redevelopment plan. Many of these elements were carefully engineered and represent a significant investment of energy and material resources.

Relevant Issues

Ecological

The incorporation of existing site structures and infrastructure reduces the amount of construction waste produced on a site. The demolition of existing built-form can create large volumes of debris that must be carted away to a land fill. The demolition process can also release contaminants or particulate matter and effect air and water quality. The reuse of existing site elements also has positive implications for resource conservation: it reduces the raw material extraction needed to produce new building materials; it has a positive effect on air pollution as fewer emissions from the production and transport of new building products are released; it conserves the fossil fuel base. Reusing the maximum amount of site elements – in this specific locale, the foundation walls, the bathtub, and transportation infrastructure – allows for a scaling down of potential site disturbance, which benefits natural habitats and the ecosystem of a site.

Economic

In this case, the economic benefits march side by side with the ecological benefits of reusing site elements. Existing site structures are a resource. They reduce the initial project costs for the purchase and transportation of new materials. Labor costs may be less as a result of the reuse of these structures, depending upon the degree of modification necessary to render them suitable for reuse. Significant savings in time to excavate and rebuild major, customized elements such as the huge and costly 'bathtub' will also be realized at the World Trade Center site.

Neighborhood

Certain structures on a site may have historic or sentimental significance for a community. The preservation of these forms or even the act of giving them new life through renovation and reprogramming can be a positive action for the neighborhood. The reuse of site elements or infrastructure will speed up construction and limit disturbance to the neighborhood. Avoiding the potential for air pollution as a result of demolition has positive health effects for community members.

Methodology

Design Strategies

Incorporate existing site structures into new projects wherever possible. Design new structures so that significant elements can be easily disassembled, to facilitate future adaptation or reuse during the evolution of the site. There are a number of existing structures on the WTC site which have already been identified for reuse. Examples should include, but are not limited to, the "Bathtub"/Slurry walls, the existing PATH tracks and the PATH temporary station, the H&M tunnels and the supply and return river water pipes. This initiative should be continued and documented for ongoing best practice.

Case Studies

Temporary PATH station at WTC Site

The creation of the WTC PATH station as a temporary facility includes many of the precepts of good environmental/sustainable design. The key sustainable attribute of temporary facilities is their ability to be disassembled, reused and recycled. The minimization of composite systems will facilitate reuse of building materials. The facility includes many components, which have been designed and specified to support reuse. The most significant of these is the steel structure. Steel columns, beams and decking are all easily recycled. These structural steel components often contain a recycled component of 50-100%. The disassembly is facilitated by ease of access to fittings, bolts, convectors, etc. This strategy dramatically reduces airborne particulates and related air quality impacts associated with a traditional demolition sequence. The reduced use of finishes and the avoidance of composite systems (like the assembly of sheetrock, tape, spackle and paint) in many areas contributes to material reusability. From the exposed structural framework and decks to abundant use of simple sealed concrete floors, the reduction in finishes also simplifies maintenance requirements. Once again, the air quality impacts normally associated with the demolition of such a facility are greatly reduced. (Croxton Collaborative 2003)

NYC Highline Project

State and Federal funding is supporting the development of a master plan to turn a former train trestle by the meat packing industry on Manhattan' s West Side into a public green-space. Friends of The High Line was formed as a non-profit group to promote the conversion of this 22 block long, abandoned elevated railroad running from 34th Street to Gansevoort Street into a public green corridor. They feel it offers an opportunity to create a unique recreational amenity for New York City. As a result of their efforts, New York City has pledged capital support to help push this venture forward. If the vision of this project is realized, it will create a tranquil elevated public green space that offers views of the Manhattan skyline, the Hudson River, and gardens that are currently "hidden" inside various city blocks. This public promenade will also offer various recreation programs. Some potential ideas proposed have been a public urban beach, music venues, and botanical gardens. (Friends of The High Line 2004)

KSBA Architects Office Building in Pittsburgh, PA.

In a classic example of "adaptive reuse," the design team transformed a historic building from 1888 in downtown Pittsburgh into a functional office for their architecture practice. They performed a 100% rehabilitation of the existing building and kept the entire shell intact. The team also reused 90% of the building's architectural millwork and furniture. These design strategies helped them earn credits toward a LEED™ Version 1.0 Certification. (Green Building 2004) (USGBC 2004)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Use Existing Site Structures

SEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
This certifies and documents that existing site structures have been incorporated in new site development. A list of retained elements is attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 1.1: Building Reuse – Maintain 75% of Existing Walls, Floor and Roof)*
This certifies that at least 75% of existing building structure and shell (exterior skin and framing, excluding window assemblies and non-structural roofing material) has been maintained. A list of the retained elements is attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 1.2: Building Reuse – Maintain 100% of Existing Walls, Floor & Roof)*
This certifies that at least 100% of existing building structure and shell (exterior skin and framing, excluding window assemblies and non-structural roofing material) has been maintained. A list of the retained elements is attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 1.3: Building Reuse – Maintain 100% of Shell/Structure and 50% of Non-Shell/non-Structure)*
This certifies that at least 100% of existing building structure and shell (exterior skin and framing, excluding window assemblies and non-structural roofing material) has been maintained AND at least 50% on non-shell areas (interior walls, doors, floor coverings and ceiling systems) have been maintained. A list of the retained elements is attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

Plant / Vegetation Selection SEQ-8

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Use indigenous or acclimatized plants to reduce irrigation and maintenance requirements.

Action: Specify naturalized or indigenous plant materials, which will promote biodiversity and support site ecological systems, as well as reduce maintenance requirements. Use plantings that can be sustained by natural rainfall levels to reduce irrigation requirements.

Related Guidelines: UEQ-5, WEQ-4

Introduction/Context

The plant community of New York City has changed a great deal in the last 400 years. It has responded to urbanization and an evolving environment and as a result of the introduction of new species, either by intent or inadvertently. In some cases new species have become invasive, colonizing large areas and competing with local plants for limited resources. What's worse is that many of these foreign plants require large amounts of water and fertilizer to survive. This guideline strives to improve the ecological health of local plant communities, reduce plant maintenance requirements, restore the natural biodiversity of the area and minimize the negative ecological and health impacts associated with high-maintenance landscapes.

Native vegetation, which has evolved with the New York climactic conditions, has lower irrigation requirements and will reduce the need to waste potable and other water sources for landscape maintenance. Acclimatized plants typically need little or no fertilizer and pesticides to thrive, thus lessening the potential for environmental pollution from these sources. The specification of indigenous or acclimatized plants will contribute to the reinforcement of ecological systems, including fauna, which have evolved over time as appropriate to this locale and climate.

Relevant Issues

Ecological

The specification of native or adapted vegetation reduces the need for fertilizers or pesticides. Avoiding these chemicals reduces pollution to both stormwater and air. Fertilizers and pesticides in stormwater runoff taint neighborhood bodies of water and cause damage to aquatic habitats. Pesticides also inadvertently kill organisms other than those targeted, reducing ecological health and affecting biodiversity.

Acclimatized plants have evolved over time to thrive in the natural climatic conditions of a given location. Accordingly, they require less or no irrigation water.

Alternatives to indigenous plants, such as turf lawns, require mechanical maintenance in addition to chemical support. Activities such as mowing, typically

performed by equipment that burns fossil fuels, produce toxic emissions that affect air quality and contribute to both global warming and the destruction of the ozone layer. The need to fuel these machines depletes natural resources such as petroleum. In addition, the loud engines of maintenance equipment cause noise pollution on and around a site. While it is recognized that certain areas should be turf lawns, for the pleasure of people who will frequent the site, it is recommended that other types of local groundcover be used wherever lawns are not considered essential to the well-being of the population. This variety of ground cover will contribute to supporting local biodiversity, while meeting the needs of all residents and site occupants.

Hearty, acclimatized plants have a root structure that is much more robust than planted grasses that are alien to a region. The network of roots present when indigenous vegetation is planted helps bind the soil and reduce erosion. Stormwater runoff is also reduced because a healthy mix of natural plants absorbs much more rainwater than a field of manicured grass.

The use of indigenous vegetation is also important to the support of natural habitats. Native plants enhance the populations of insects and birds that comprise a healthy and balanced ecosystem.

Economic
The reduced maintenance needs of acclimatized vegetation yield lower operational costs. Money can be saved by not having to purchase potable water for irrigation, fertilizers, pesticides, herbicides and the constant, cyclical round of labor associated with their application, as well as the labor that would be required for grooming.

Because deep-rooted native vegetation contributes significantly to stabilizing the land and stormwater management, its use can create financial savings by reducing or eliminating the need to build stormwater control infrastructure. If some measure of stormwater is, in fact needed, natural conveyance and detention systems (such as bioswales and bioretention ponds) are less expensive to build and maintain than engineered alternatives.

Neighborhood
The use of indigenous plants for landscaping has many benefits for a community. The resulting reduced maintenance requirements helps curtail air, water, and noise pollution, making the environment of a neighborhood healthier and more pleasant. The added aesthetic value is also significant. The specification of native vegetation that varies seasonally ensures that there will always be an interesting and diverse landscape for community members to enjoy.
There are also educational benefits to using indigenous vegetation. The habitats created by these plants are ideal "laboratories" for scientific study, as well as conservation education.

Methodology

Design Strategies

Specify vegetation that is indigenous to the North East United States. Select specific plants that are well adapted to site conditions and are known to thrive in an urban locale, with little maintenance. For example, use plants that can be sustained by the natural rainfall levels in the area. Consider such factors as a plant's size and shape

while locating it in a landscape design. Avoid any plants that are considered invasive, as they frequently dominate and destroy the balance of an ecosystem as they mature. Employ a selection of plant types that thrive during different seasons to ensure continuing interest, color and variety in the landscape plan. This will also provide textural interest during the course of the year. Select perennial plants with long life spans to reduce maintenance requirements. Plant the site densely and in layers to promote water retention and air pollutant absorption. This strategy is also important in combating heat-island effect. Design a rainwater catchment and delivery system to accommodate irrigation needs at times of low-rainfall, without the use of potable water.

Means and Methods

There is a wealth of information available to aid in the selection of vegetation that will thrive in New York City. The Brooklyn Botanical Garden has created a highly useful source for this data as part of its New York Metropolitan Flora Project. As part of this effort, the Garden has documented the flora in all counties within a 50-mile radius of New York City. Their website (http://www.bbg.org/sci/nymf/) provides a list of local, natural vegetation by county. Another group called 'Trees New York' maintains a website with information including which trees are best suited for street-side applications in this climate. The United States Environmental Protection Agency provides useful guidelines for landscaping with native plants.

An opportunity exists here to consider the work of Alan Sonfist's Greenwich Village 'Time Landscape' Park, which uses only native species present before mankind's arrival in Manhattan, to demonstrate the original ecology, flora, fauna and soils of the area. The case study data is included below and in the Natural History section SEQ-13.

Case Studies

IBM Tivoli Systems, Inc. Headquarters, Austin, TX

The campus of this project consists of 6 buildings and 2 parking garages. The development of the site preserved much of its hilly terrain and existing oak and elm trees. The design includes natural stormwater processing infrastructure consisting of a four-acre pond and a series of smaller retaining ponds that are planted with native vegetation to naturally clean stormwater runoff before it leaves the site. The design team actually removed non-native cedars and replaced them with native trees, shrubs, wildflowers, and grasses to restore the site to a true natural condition. The use of these indigenous plants reduces the amount of water needed for irrigation. (BuildingGreen.com 2004)

National Wildlife Foundation Headquarters, Reston, VA`

As part of the design process for this building, a site inventory was performed, cataloging the natural features and wildlife on the wooded site and surrounding areas. When selecting plants for the site design, the inventory was used as a reference and more plants of the same species that already existed on the site as well as additional species that would compliment the existing site vegetation were selected. Because a portion of the site contained a thriving, mature ecosystem containing valuable vegetation, a plan was enacted to prevent disruption of that area. This resulted in the protection of one half-acre of the site on which 30 mature trees of over 30" caliper and related undergrowth was saved. The site uses a natural

stormwater management system which helps promote biodiversity. Native trees, shrubs, and ground covers that can handle the ebb and flow of water are used as natural filters. The site also provided a great opportunity to showcase diverse habitats. The development included design measures to accommodate various wildlife habitats including meadow, woodland, and aquatic. The landscape architects designed each ecosystem to provide shelter, food, and water for the creatures in each divergent habitat. The site-design also includes various deciduous, native vines that are popular with wildlife and which provide shading for the building during the warmer parts of the year. (BuildingGreen.com 2003)

Time Landscape, Greenwich Village, New York City
In the nineteen sixties, artist Alan Sonfist conceived of a plan to regress small portions of cities throughout the world to their pre-human ecosystem. He called these proposed park-like spaces Time Landscapes because they would celebrate the unspoiled land that existed before human intervention. In 1978, working with the Metropolitan Museum of Art and New York City Planners, Sonfist was able to realize his vision in Greenwich Village, between Houston and Bleeker Streets. This park uses species of trees that existed in the same location before man arrived. As these plants take hold, they transform the soil and animal life within it to their pre-human state as well. The result is a place where people can experience an almost pre-historic portion of the New York Ecosystem. (ArtsEdNet 1999)

Reference

Definitions

Acclimatized vegetation is that which can be sustained naturally and thrive in the conditions specific to a site's microclimate.

Indigenous or Native plants are those that occur naturally in a particular region.

Standards

Standards have not been included for this guideline.

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Plant / Vegetation Selection

SEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	●

☐ **Required Component:**
A planting plan and schedule is attached and demonstrates that the site vegetation selected is indigenous or adapted to New York City. This also certifies that an effort has been made to specify plantings that can be sustained by natural rainfall levels to reduce irrigation requirements.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Daylight Exterior Public Spaces SEQ-9

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Design buildings and site structures to consider available daylight for public open spaces and green areas (within the context of the established massing guidelines).

Action: Determine critical open spaces and green areas. Utilize shadow studies to determine available sunlight. Consider available sunlight in planning outdoor public spaces and site plantings.

Related Guidelines: UEQ-6, SEQ-3, SEQ-10

Introduction/Context

In the planning of a project such as the World Trade Center Redevelopment, there is a great opportunity to consider the positive and negative elements that will form the fabric of the completed complex in several, not necessarily conventional, ways. One of these, important in any sustainable project, is the quality of the negative, or outdoor spaces – those spaces that will fall between and around the built infrastructure. For this site to have a truly sustainable character, the outdoor spaces must offer community residents, building occupants and visitors a memorable experience. This will be accomplished, in part, by views to the series of innovative, contemporary buildings planned for the site and, in part, by providing a variety of landscaped outdoor spaces, including places to relax, eat al fresco, shop and stroll, as well as for contemplative and recreational activities. All of these spaces will be enhanced by the presence of abundant daylight, especially sunlight, in all its forms: bright beam light, diffuse light, sunlight filtered through trees or trellises, gilded early morning light, and slanted evening light, used and modulated as appropriate for each activity.

Providing sheltered, sunny 'outdoor' rooms, making the outdoors more available for longer periods of the year, enriches the site and guarantees its greater use. It adds an element of quality to the entire neighborhood that will be advantageous to businesses, especially retail shops. People are attracted to pleasant outdoor spaces and are more likely to linger, and purchase more, if they are thermally and psychologically comfortable. The strategy can be justified simply in terms of creating value, but it also contributes to human well-being, and potentially to job satisfaction.

It is appropriate to study opportunities to enhance the quality of outdoor spaces through extensive shadow analysis, looking at the impact of the different building profiles on the site throughout the day-lit hours. Wind studies (see UEQ04) must also be considered, as many of these spaces will benefit from more sheltered locales. Only with such research can a definitive plan evolve to will balance the needs of site density with human comfort issues. This accomplishment will make the World Trade Center an exceptional and exemplar model of human-centered design, as well as, a destination for people beyond those who live and work in the vicinity.

Relevant Issues

Ecological
Areas of an urban site that are covered by vegetation such as native grasses and/or ground covers including pachysandra, ivy, and periwinkle, provide environmental benefits including the reduction of urban heat islands and the promotion of biodiversity. Designing a site with daylight in mind will support the growth of these vegetated areas, support environmental comfort and human well-being goals of the project and contribute a measure of quality to the site that is invaluable in terms of visual and sensory pleasure.

Economic
Exterior areas around buildings feel much more pleasant and hospitable when they are designed to capitalize on available daylight. This goal is accomplished by spaces that reflect a clear understanding of the seasonal, traversing patterns of sunlight falling on these open areas. Site spaces appear more welcoming as a result of these strategies, and have the potential to attract businesses and consumers to an area. Day-light responsive urban plazas and open green spaces are well recognized amenities, known to enhance property values.

Neighborhood
More light-filled, open urban spaces adjoining a neighborhood and realized as part of the public domain, provide a great benefit to community members in terms of health and well-being, an expanded sense of community, as well as access to and enjoyment of the outdoors.

Methodology

Design Strategies
Daylighting offers one of the greatest opportunities to take advantage of natural assets such as the dramatic open south-to-west solar traverse that characterizes the site. The incorporation and optimization of daylight strategies requires a thorough understanding this major asset, the behavior of diffuse light and early integration of daylight apertures and diffusing elements into the design process.

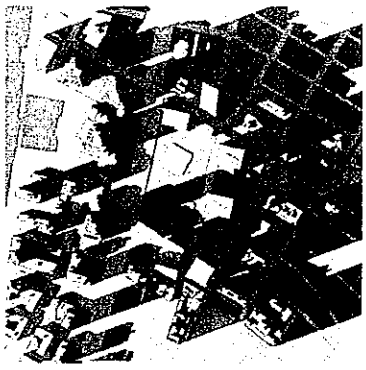
Means and Methods
Determine critical open spaces and green spaces. Utilize shadow studies to determine available sunlight (orientation and duration) and consider it in planning outdoor public space and locating public amenities, site plantings and areas for recreation.

Use diagrams to explore daylight opportunities on the site. These should include shadow studies to map the path of the sun across the site.

Early Conceptual Shadow Studies

Sept. 21 solar noon
(1249hrs)

Sept. 21 +2.0hrs
(1449hrs)



Sept. 21 +4.0hrs
(1649hrs)

Above: The WTC site as shown with an early, theoretical scheme. Building massing is kept to the north and east edges of the site, allowing for direct sunlight access during much of the afternoon and early

June 21 solar noon
(1258hrs)

June 21 +2.0hrs
(1458hrs)

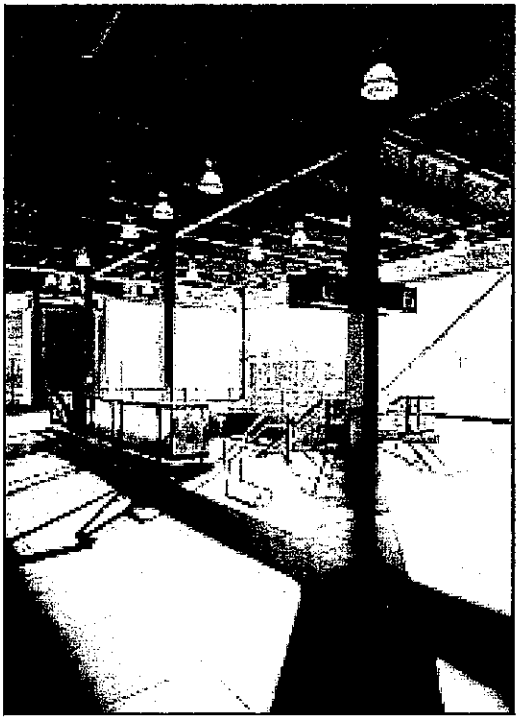
June 21 +4.0hrs
(1658hrs)

Above: The Summer Solstice (June 21), the longest solar day of the year, is chosen as the reference date . The original WTC footprints and most of the remaining plaza are exposed to direct sunlight from solar noon through the early evening.

Case Studies

Temporary PATH Station, World Trade Center Site, New York City

The design of this station created an open-air room flooded with daylight. As light filters through the translucent scrims that define the boundaries of the structure, it reflects off colored mosaic tiles creating an iridescent effect. (Dunlap 2004)



Lighting filtering down into the platform at the WTC Temporary Path Station
©Fred R. Conrad/The New York Times (Dunlap 2004)

Nine new Metro Stations, Copenhagen, Denmark
These stations locate the train platform 18 meters below ground level and yet the station receives daylight through skylights located in the stations' flat roofs. An urban square is formed around the portals that bring light down into the stations. The daylight that reaches the platform is supplemented by artificial light that is coordinated to increase as daylight levels decrease. (Metro 2004)

Reference

Definitions
Definitions have not been included for this Guideline.

Standards
Standards have not been included for this Guideline.

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Daylight Exterior Public Spaces

SEQ-9-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	●

☐ **Required Component:**
This certifies that site structures, plazas and amenities were designed to capture traversing daylight which has been quantified by duration, inclination, and seasonal variance. Attached daylight studies and designs of public spaces confirm an early examination of this guideline.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Solar Access SEQ-10

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To optimize solar access for utilization of solar energy.

Action: Determine maximum available photovoltaic potentials for all building surfaces. Develop a strategy for possible future transition to capture this potential. Quantify and document this strategy and any other "near threshold" renewable technologies in the Renewable Energy Transition Plan.

Related Guidelines: UEQ-5, UEQ-6 SEQ-9

Introduction/Context
The photovoltaic generation of electricity is on the cusp of becoming a cost-effective alternative to electricity purchased through a local utility and has many environmental advantages, which do not necessarily translate directly into dollars saved. The purpose of this guideline is to ensure that building forms and envelopes have been shaped to anticipate future integration of photovoltaic panels as the cost equations change and solar electricity becomes a clear choice based on economics alone. Based on current market trends this may be in the near future.

The use of renewable technologies for electricity production alleviates a number of environmental concerns including air pollution and fossil fuel depletion. A site that produces all or part of its own power reduces its dependence on the power grid. This self-reliance is significant in light of recent problems with portions of the U.S. power grid such as the major blackout that occurred across the Northeast in August of 2003 or the rolling blackouts that plagued California during January of 2001.

Photovoltaic cells directly convert sunlight into electricity. The PV industry has been experiencing expansive market growth over the last ten years. This is partly due to increased demand for clean energy sources and partly a result of the development of more economical and efficient PV cells. According to the March 2001 issue of PV News, a publication of PV Energy Systems, worldwide shipments of PV modules increased 43% between 1999 and 2000. Growth of this industry has averaged about 23% per year since 1993. According to Solarbuzz, a solar energy research and consultancy group, 37 Megawatts of grid-connected solar photovoltaics were installed in the United States in 2003. That figure is a 32% increase over installations in the previous year.

The development of building integrated photovoltaic (BIPV) systems has provided on-site renewable energy solutions that are more widely accepted since they also function as architectural elements. PV cells are now often integrated into the façade or roof of a building and become part of its design vocabulary. Many buildings erected in the past few years have been designed to include BIPV systems.

Relevant Issues

Ecological

The use of renewable energy has many environmental benefits. The generation of electricity via photovoltaic (PV) cells displaces more traditionally generated power from the energy grid. According to the U.S. Environmental Protection Agency's Power Profiler, the power being displaced in lower Manhattan is comprised of 2% non-hydroelectric renewables, 12% oil, 35% nuclear and 51% natural gas generated. These plants produce air pollution on the order of 1.2 lbs/mWh of Nitrogen Oxide, 0.6 lbs/mWh Sulfur Dioxide, and 1,090 lb/mWh of Carbon Dioxide. Power Profiler does not account for the nuclear waste created from this power generation although it is quite significant. The by-products of nuclear fission, as well as contaminated equipment used in the process, remain highly toxic for thousands of years and must be stored in highly protective assemblies away from people and other biological systems. Both of these non-renewable power plant types also deplete natural resources. The generation of renewable energy on- site also has the advantage of reducing or eliminating the resources needed to construct and maintain transmission equipment to move electricity from its distant point of generation to the project site.

Another benefit of PV electricity generation is the potential to capitalize on waste-heat for other uses such as the making of hot water. Typical PV cells are only 15% efficient with most of the surplus solar energy being converted into heat. Some industry manufacturers of PV systems (Innovative Design and Solar Design Associates) have designed and are currently testing PV/T or photovoltaic/thermal technologies that capture that waste heat for building use.

Some criticism of the PV industry's environmental record has been raised because of the potential for pollution during the manufacturing process of the Crystalline Silicon that comprises the majority of PV cells today. As manufacturing technology has become more sophisticated, the creators of PV cells now have production options that are environmentally benign. These processes include the use of water or glycol-based lubricants and deposition fluids, the replacement of carbon-tetrafluoride in the circuit production process, and the use of lead-free systems for electrical connections.

Economic

On-site renewable energy generation can produce cost savings across various scales. The operator of the site can save on utility costs especially peak-hour demand changes that are typically high. The utility company can also save money because of the reduced need for transmission infrastructure. In locations where net-metering is permitted, the owner of the site can potentially sell extra electricity generated on-site back to the utility company at market rate. This also aids the utility in ensuring that they can provide enough power to the grid during times of excessive demand like the occasional sweltering day that may occur during the summer.

There are a variety of government incentives that a site owner can receive for installing a photovoltaic system. One such incentive is available as part of the New York State Green Building Tax Credit instituted in 2000. Part II of Chapter 63 outlines 6 different program components that can qualify a project for credits. Component 5 covers incentives for photovoltaic systems. The credit is for 100% of

the cost of building integrated photovoltaic modules (20% per year x 5 years) or 25% of the incremental cost of non-BIPV modules (5% per year x 5 years) with a cap of $3/ watt. It is important to note, however, that this credit is only available to those projects that also meet all of the other criteria of the NYSGBTC.

In cases where building-integrated photovoltaic arrays are used, money can be saved on other building components since the elements containing the PV cells serve a dual function. (i.e. both a roof and a power generating array) Although the price of PV systems varies greatly depending on the type of PV technology used, they have been steadily gaining efficiency and becoming more cost effective. For instance amorphous silicon PV cells, which are more economical because their production avoids the step of the traditional process where silicon crystals must be grown, cost around $20 to $25 per square foot (not including installation costs) and generate between 4.5 – 6 Peak Watts per square foot.

An important "next generation" form of PV is anticipated to be a transparent unit that could replace the high performance windows currently in use on site. The shading coefficients, visible light transmission, and U.V. rejection characteristics are planned to closely match existing systems, while, the generation of electricity from both direct beam and diffuse light would be possible. Although operating at lower net efficiencies, these units would make "productive" the largest single area of the building envelope and create electricity directly at the point of use.

Neighborhood

The use of renewable energy technologies has major implications for air and water quality across every level from global to local. The displacement of the energy produced via fossil fuels and nuclear methods in a region by clean, renewable technologies will result in cleaner air and water for the entire community.

Methodology

Design Strategies

Determine the maximum available energy generation potential on site via photovoltaic technologies. The first step in this process is analyzing the incident radiation levels on all building surfaces. This activity should be coordinated with studies conducted in response to Guideline SEQ-9. Based on climate and radiation data, and the orientation of the building, one can determine how much solar potential exists for power generation. Next, by investigating various PV technologies that are feasible for the particular application at hand, one can estimate the amount of electricity generation that can be reasonably expected. At that point a cost-benefits analysis may be conducted to determine the most economical strategy for integrating PV technologies into the particular design. The potential for future PV generation based on projected advances in the industry should also be studied and integrated with the Renewable Energy Transition Plan as part of the Sustainable Guidelines requirements of EEQ-5.

Means and Methods

The photovoltaic effect describes the direct conversion of sunlight into electricity. A photovoltaic cell is a composite structure comprised of semiconductor materials

assembled in a specific way to control the generation and flow of the electricity. An enormous advantage of this technology is that it does not rely on any moving parts that may frequently require maintenance and repair. Historically, PV cells have been assembled into arrays and mounted on brackets that optimized their orientation to the sun. Building Integrated Photovoltaic systems (BIPV) use PV cells as part of a building element such as its façade or roof. The reduction of power generation that results from the cells not necessarily being placed at an optimized angle with respect to the sun (as with angled or moving PV arrays) is offset by the increased electricity production of the modern PV cells and the increased number of cells that can be purchased economically at decreased costs.

Case Studies

Brewery Block 4, Portland, OR

This office building in downtown Portland, Oregon boasts 23.5% electrical energy savings over ASHRAE 90.1 per year. It was designed to provide solar access for both occupant enjoyment and energy savings. The south side of the building was purposefully designed to allow the sun's rays to penetrate the building for daylighting and strike portions of the façade for renewable energy generation. The southern façade incorporates a BIPV system. It houses an amorphous silicon array of thin-film modules that are incorporated in spandrel panel extensions. A four square array is located at each spandrel to total 192 PV modules. A rooftop PV array is also present on the building. 77 Polycrystalline modules are expected to produce 13,400 kWh per year. The total energy output of the on-site renewable system is 21,600 kWh annually. This represents about 0.4% of the building's annual consumption of electricity. (US DOE 2003)

Greenpoint Manufacturing and Design Center, Greenpoint, Brooklyn.

This building, operated by a nonprofit organization and housing mostly artisans and craftsmen, has a PV system on its roof. The system uses multi-crystalline PV cells and produces 60.4 Peak Kilowatts of electricity which translates to 45,300 kWh per year, about 5% of the building's electrical load. (altPower, Inc. 2002)

AstroPower Headquarters, Newark, Delaware

As a solar cell manufacturer, AstroPower decided to implement as much PV technology as possible into their new headquarters. From the design's inception, the intention was to create a south-oriented BIPV façade for the front of the office complex. A standard aluminum façade system was used with custom sized glass-PV laminates replacing traditional façade panels. This BIPV system generates 30 Peak Kilowatts. A second PV array was installed on the flat roof of the manufacturing portion of the facility The system, which lies flat, generates 310 Peak kilowatts of electricity. The two systems combined produce 255,000 kWh annually and constitute 5% of the building's electricity needs. (Pereira 2003)

Reference

Definitions

Photovoltaic describes the process by which light is converted directly into electrical energy.

Peak Watts (or Peak Kilowatts) indicates the electrical output of a PV device during a period of optimal solar exposure.

Standards

Standards have not been included for this Guideline.

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Solar Access

SEQ-10-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	●

☐ **Required Component:**
This certifies that the potential for generating electricity through the use of photovoltaics has been studied and quantified. Documentation of this study is attached. A plan for the future expansion of on-site photovoltaic power generation as PV technologies evolve has been included in the Renewable Energy Transition Plan of Guideline EEQ-5.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Recovery of Resources SEQ-11

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To optimize utilization of site material resources and to facilitate the reduction of waste generated by building occupants that would otherwise be hauled to and disposed of in landfills and/or incinerators.

Action: Study large-scale and small-scale opportunities for on-site recovery of waste. Consider opportunities to recover food, paper, plastic, metal and construction waste. Consider composting, biomethanization and other viable "waste to reuse" strategies. Consider in conjunction with Renewable Energy Transition Plan and Co-generation study.

Impacts: SEQ-1, SEQ-2, WEQ-2, MEQ-1, MEQ-2, MEQ-3, EEQ-1, EEQ-5

Introduction/Context

Waste is something that most people don't want to think about. When the topic of garbage does in fact crop-up in people's minds, there tends to be a common misconception that waste has no intrinsic value. In truth there are many valuable components of what is traditionally considered waste. The recycling of some materials, metals, glass, and paper have become common, however many other materials are still not considered valuable and many materials that are recycled are not recycled to their highest best potential.

According to the Comprehensive Commercial Waste Management Study conducted by the New York City Department of Sanitation, the city produced 19,976,815 tons of waste in 2000. 13,207,160 tons (66%) of that total was from commercial sources and 2% of that waste was produced at the former World Trade Center Site. This gives dimension to the scale of resource recovery that could be accomplished on this site.

Throughout its history, New York City has handled 'garbage' in various ways. The city has in part been built upon refuse, discarded to fill in low areas and push riverbanks further outward. More recently, New York has been exporting its trash to landfills outside of the city on Long Island and in Westchester County. Today, the city is searching for landfills in other states for its waste disposal. This is expensive and discards potentially valuable resources. It is important to note that during the two World Wars when resources were scarce, New York City recycled everything possible. This type of thinking, considering the potential for intensively mining trash for useful materials (or energy), can drastically reduce the amount of land needed for disposal. It can also lessen the quantity of resources and energy needed to extract raw materials and manufacture new synthetic materials that might otherwise be recovered from the waste stream.

Knowing that the redevelopment of the world trade center site will largely create commercial office space and include a large retail component, predictions can be made regarding the basic composition of the waste that will be generated on-site. A majority of the waste created is likely to be paper, mostly high-grade and cardboard. Other significant types of

waste will be construction waste, organics, metals, plastics, and glass. Typically, these materials would be combined into one dumpster and trucked offsite for disposal at a cost of $156 per ton for the disposal service (2004 rate). There are, however, many buildings in Manhattan that practice robust recycling programs for at least their cardboard, along with some of their paper and metals. Ten million square feet of office space along with an additional 800,000 square feet of retail (including anticipated restaurants) will generate vast amounts of both wet and dry waste, much of which has reuse potential. A comprehensive strategy for resource recovery can institute various methodologies for extracting resources from this waste. An ideal situation would be to create a zero waste stream, one where as many resources as possible are culled from the waste stream to be reused on-site.

Relevant Issues

Ecological

There are many deleterious environmental impacts to traditional waste management. Just the process alone of transporting trash from its point of generation to its point of disposal has negative consequences. In New York City, idling garbage trucks emit 40.2 grams of VOC's, 710 grams of carbon monoxide and 11.0 grams of nitrous oxide per hour. It is well known that these compounds negatively impact air quality and contribute to global warming and acid rain. A typical garbage truck with a 20 cubic yard capacity transports between 3 to 8 tons of material per load. If a site can reduce its waste output by 100 tons/day by using on-site recovery and processing techniques, the number of trucks leaving the site each day could be reduced by 24.

Once waste reaches its final resting place, there are additional negative environmental impacts. Large tracts of open land are set aside for trash disposal. These lands are often removed from healthy local ecosystems. The release of methane into the atmosphere as garbage naturally breaks-down contributes to the greenhouse effect. There are some landfills sites where this methane is collected and used as an energy source, however this is not a usual practice. Harmful substances can leach into groundwater reservoirs. When a majority of a building's trash is combined in one container and not sorted by type nor scrutinized for resources, it is more likely that potentially toxic substances are inadvertently dumped at landfills that are not designed to contain them. These may include disposable batteries or fluorescent light bulbs. This effects both local water and air quality.

Economic

There are two levels of potential economic impact related to on-site resource recovery. The first benefit of reducing a site's waste stream is saving money on trash disposal service. In 2005, tipping fees in New York City are $90/ton plus an additional $66/ton for curbside collection and are projected to rise steeply.

The second layer of financial benefit associated with resource recovery is represented by the value of the resources themselves. These resources possess both material value and embodied energy.

Neighborhood

Efficient use of all available resources, including those found in waste has positive implications for the community surrounding a site. The reduction of environmental pollution associated with the reusing and recycling of materials is of benefit to people across the region. Fewer garbage trucks translates to better air quality, less noise, less wear and tear on local roads and, consequently, a significant improvement in quality of life to communities.

Methodology

Design Strategies

Develop a comprehensive site strategy for on-site resource recovery This can be coordinated with waste treatment methods used on-site as well. Recover paper, plastic, metal and construction waste. Separate this waste into categories based on reuse potential. Some of these items may be directly reusable on-site while some of these items may have value on a salvaged materials market exchange. Other materials can be sent to recycling plants where they will be reintroduced into the manufacturing stream as base materials.

Explore opportunities for waste-to-energy strategies. Organic waste, low-quality paper, and wastewater can be combined in an anaerobic digester to produce biogas for energy generation and compost for landscaping. The potential for energy generation from this type of system should be coordinated with the Renewable Energy Transition Plan outlined in Guideline EEQ-5.

Means and Methods

An opportunity exists to create a system on-site that reuses as much traditional "waste" material as possible to supplement resource recovery and reduce the transport of resources to and from the site. The first stage of such a process is the sorting and separation of various components of solid waste. An emphasis should be placed on finding the highest best use for each type of material. Construction materials such as gypsum wallboard, wood, and metals can be salvaged and either used directly or as ingredients to manufacture new building materials. Mixed and high quality paper can be sent to a local paper recycling mill where it will be added to the raw materials used to make new paper. Lower level mixed recyclables such as plastics, glass, and assorted metals can also be sent to a recycling plant to be reincorporated into various consumer products.

The potential for extracting valuable resources from organic wastes is also quite high. An anaerobic digestion process (similar to one currently on the drawing boards for 1 Bryant Park, a midtown commercial office tower) can be used to generate bio-gas to power electricity-generating apparatus. A bio-fuel plant is a system by which organic waste is broken down in an anaerobic process to release the embodied energy in the material into a form that can be harnessed. In one type of system, a bio-gas rich in methane is produced and used to create electricity from organic waste. Four main types of waste can be treated: food waste, low-quality paper, bio-degradable plastics and waste water/sewage. It is important to source-separate the waste stream as much as possible by installing special containers in appropriate locations. Any non organic or non-biodegradable items must be removed before the

remaining organic solids are ground and inserted into anaerobic digesters. The digesters are large, low-pressure, sealed steel tanks in which the organic waste stays for three to ten days at temperatures of either 95°F or 135°F. In this oxygen-deprived environment, bacteria breakdown the organic waste into a biogas mixture of 65% methane and 35% carbon dioxide which is then pressurized and can be used the same way as natural gas would, for example in a gas-absorption chiller or to create electricity from a generator. Fuel cells would be the best generation option because of their high efficiencies and the heat they produce as a byproduct. This residual heat can be used to supplement the heating of the digester tanks to their operating temperature. Additional byproducts of the digester tanks are water and compost. The compost must go through a finishing aeration process before it can be used for landscaping. The water is very high in mineral content and is excellent for use in irrigation, but it can also be used anywhere that grey water is appropriate.

Case Studies

Canada Composting Incorporated's Newmarket Plant, Newmarket, Ontario, Canada

Newmarket is a bio-fuel facility located 25 miles north of Toronto in Canada. It opened in July of 2000, and has a capacity of 165,000 tons of organic waste. Operating at full capacity, the plant will produce over 66,000 tons of compost and produce up to 5 MWh of electricity. The plant accepts all types of organic waste, including food waste, fiber waste such as paper products like napkins and paper towels, cardboard milk and juice cartons and disposable diapers, agriculture waste and industrial/commercial/institutional waste. The plant uses a German process called BTA developed in the early 1980's. It is a fully enclosed, highly-automated, anaerobic digesting process that uses two sophisticated processes to separate contaminants from the organic waste. The two byproducts of this process are compost and a biogas that is 65% methane and 35% carbon dioxide.

Compost Facility, Riker's Island, New York, NY

Riker's Island, the municipal prison in New York City, has built a composting facility sized to handle 80% of the 20 tons of food waste that is created each day by the 24,000 inmates and officers. The jail has special yellow bins in the kitchens to collect the organic waste so that all of the waste is pre-sorted before arriving at the facility. This waste is mixed with wood chips to add carbon and to provide better airflow through the mixture. The mix is mechanically agitated and ventilated to control the temperature while undergoing an aerobic decomposition. This part of the process takes 14 days. The plant is under negative pressure all of the time to keep odor in, and all exhaust air passes through a biofilter. The biofilter is a mixture of finished compost and wood chips, which contain microorganisms. The organisms reduce odors by removing volatile organic compounds from the air. The final part of the process is a two-step curing process and a final screening for contaminants. The compost produces is used for greening projects on the island.

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

Standards have not been provided for this Guideline.

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Recovery of Resources

SEQ-11-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
A study of potentials for on-site recovery of waste, both small and large-scale, has been performed and is attached. Feasible opportunities for the recovery of food, paper, plastic, metal, and construction waste have been implemented.

☐ **Required Component:**
Additional waste-to-use strategies such as biomethanization have been considered and coordinated with the Renewable Energy Plan developed as part of the requirements of Guideline EEQ-5.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Use of Undeveloped Parcels SEQ-12

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Utilize inactive and undeveloped site parcels to provide a positive contribution to site environmental qualities.

Action: Address both the "active" portions of the site under development, as well as, the "inactive" areas of the site, which have a supporting role. At a minimum, apply guidelines Storm Water Use (SEQ-2) and Heat Island Effect Mitigation (SEQ-3) to "inactive" site areas.

Related Guidelines: SEQ-2, SEQ-3, SEQ-5, SEQ-6

Introduction/Context
In large projects which are phased over time, there are often building parcels which serve as staging areas for structures currently under construction or are inactive for significant periods of time. In Manhattan these sites are seldom left completely alone. They may be paved for temporary parking or even receive temporary structures for a variety of uses. Whatever the temporary use may be, the site must still be understood as having an impact on ecological systems. While economics often preclude installing sustainable design measures which would be included in the final build-out, there are a number of important measures which can be instituted at small cost with large environmental benefits.

(Note: In no case should inactive sites fail to address storm water and heat island effect mitigation.)

Relevant Issues

Ecological

Open sites around New York City have experienced a renaissance in recent years. Gone are the weed-filled, abandoned spaces which were catch-alls for the dumping of both construction waste such as concrete blocks, corrugated sheeting, etc. and endless amounts of trash, to be replaced with pocket parks or in-fill gardens. Examples include Paley Park on 53rd Street and a locally, well-known in-fill garden near Greenwich Street. Recycling centers, green markets and other active uses which contribute to the management of the site and to its ecological well-being are also common uses for such spaces around the city, and could be considered as temporary uses for these open areas at the World Trade Center site.

Economic

Both water and solar energy resources offer economic potential. Stormwater might be harvested for use on adjacent construction sites, or to maintain temporary site plantings, reducing the amount and cost of municipal water supplied to the site. Moveable photovoltaic panels could easily be mounted on temporary structures and then re-used later, on building roofs or in another open building lot. The energy harvested could be fed into the grid, or used on-site for temporary energy requirements, or to meet some of the construction functions at nearby sites, with concomitant savings.

Neighborhood

The open sites at the World Trade Center, which are, in all likelihood scheduled for later development, need to be integrated into the overall planning, so that they contribute to the attractive qualities of the neighborhood, and do not detract from security arrangements that are in place. Temporary gardens, in the design of which community members can have an active role, are always popular and offer a satisfactory option, which can be organized at minor expense -- some topsoil and exterior lighting.

These spaces can also be used by the landscape designers as staging for the temporary planting of trees and shrubs, allowing them to acclimatize over time, so that only healthy, established vegetation is eventually installed at the final site location. Maintaining such spaces with porous surfaces and some type of organized activity will contribute to both overall site ecology and the safety of the whole area. Although the porous surfaces may be lost eventually, when scheduled uses for these open spaces are developed, their function as collectors of stormwater might be reallocated to green roofs and the stormwater can at least be harvested to benefit other site activities.

Methodology

Design Strategies
In the planning of each project, consider the options available for temporary use of associated space or spaces scheduled to be developed in later phases. Design temporary exterior lighting layouts to render these open areas safe and useable for any number of activities. If a specific function can be determined for any of the spaces, provide appropriate infrastructure and/or materials to facilitate these activities, so that each such space contributes to the overall World Trade Center site, rather than being an eyesore, and an embarrassment to the developer.

Means and Methods
There are many possibilities for the temporary use of open parcels of land at the site. Depending on the length of time a site will remain unused (not fully built out or lacking its final designated use), each interim plan demands slightly different solutions to make the temporary conditions acceptable.

Among the possible uses of open parcels of land in a busy urban center are stormwater collection and/or in-fill gardens. If the surfaces are paved, provide a stormwater catchment system so that the site becomes an asset, contributing to the overall efficiency of the site. If plantings are considered an option – perhaps to stabilize the soil and prevent erosion -- engage the public in the idea of community gardens, which provide a visually attractive option. Even on a temporary basis, such gardens have been found to be successful, citywide.

Provide appropriate pads for the temporary installation of solar panels, and conduit for the transfer of power generated. If the spaces are to be used for weekend fairs, or for green markets, provide appropriate, general exterior lighting, and porous pathways for public use. In all cases provide recycling bins and garbage disposal facilities, and make sure that these spaces are included in the regular pick-up schedules.

Case Studies
New York City: Parks and Recreation: Operation Releaf
A new initiative called Operation Releaf allowed for the restoration of 117 degraded landscapes in parks and playgrounds with trees, shrubs, and flowers, often using plants grown in the Parks and Recreation's two nurseries and three greenhouses. In 2003, this program was expanded to include "Greeting Gardens," small, decorative planting beds at park entrances, with historical and directional signage that welcome and orient visitors. In the first season, 30 greeting gardens were planted across the city. Through the successful Greenstreets program, 51 barren traffic triangles and roadway medians were converted into pocket parks and tree-lined malls. Local citizens and corporations, including MetLife and Wendy's, adopted many Greenstreets, which now number more than 2,050 in the city. (Project 2005)

Paley Park, 53rd Street, New York
This small, vest pocket park in midtown was created in 1967 and serves as a prime example of a successful privately owned public space. The park was funded by William Paley, former chairman of CBS, who was also involved in planning its

specific details. This park illustrates that even a small space can serve as a meeting place and place for a respite from the sometimes chaotic character of the urban environment. (NYC 2003)

Paley Park ©2003 Tom Spencer (Spencer 2005)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Use of Undeveloped Parcels

SEQ-12-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●		

☐ **Required Component:**
This certifies that the requirements of Guidelines SEQ-2 (Storm Water Use) and SEQ-3 (Heat Island Effect Mitigation) have been applied to the "inactive" site areas under my authority. It is understood that these provide minimum standards and that techniques that push the possibilities of stormwater use and heat island effect mitigation further are encouraged.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Natural History SEQ-13

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Make tangible the elements of site natural history to educate and inform site users.

Action: Integrate and exhibit site natural features and history to educate site users in interrelationships between built and natural environments and history of the site. A unique opportunity exists through the Memorial to connect visitors with this underlying bedrock, Manhattan Schist, formed 500 million years ago and the adjoining Hudson River which originally overflowed much of the site, forming the original shoreline along the line of the current Greenwich Street. The Hudson River with its four times daily reversal of tidal flows and contribution to cooling effect (river water system) is also a key element of the natural history.

Related Guidelines: UEQ-5, UEQ-7, SEQ-8

Introduction/Context

While the landscape which existed before the Europeans arrived has long since disappeared, the bedrock and underlying site geology remains unchanged. This ancient bedrock, accessible through the deep bathtub excavation, provides an opportunity to connect visitors, not only to the historical underpinnings of past and future buildings, but also to New York's unique geological history. It is our planet's geology, after all, that underpins the very thin layer of surficial life we are working to sustain. These rocks not only determine the soil which supports all plant life, they constitute the interface of the natural and artificial surface of this island.

The Natural History of the World Trade Center site also tells an interesting story about the shoreline of the Hudson River. When this shoreline was first mapped in the early 1600's, its line of demarcation ran almost through the center of the World Trade Center site. This serves to demonstrate just how much mankind has encroached on the river and the harbor since that time. It also highlights how much we have depended on the bedrock as a foundation for the 'fill' that has allowed the expansion of Manhattan's natural contours.

Relevant Issues

Ecological

A ridge of Manhattan Schist starting at more than 100 feet below the World Trade Center site constitutes bedrock and runs undivided, in an undulating manner, for the entire length of Manhattan. As it proceeds north. the ridge rises to within 35 feet of the surface, drops again north of Chambers Street, rises in midtown and emerges on the Upper West Side to create much of the hilly, rough topography north of 100th Street. The schist, formed 500 million years ago in the Cambrian Period, contains quartz, feldspar, hornblende, biotite and muscovite.

The Hudson River, reversing its massive flows four times a day in response to the lunar/tidal rhythm, is the destination for all water moving off the site and is under consideration for a cooling source that may be connected to and performing in concert with the Memorial Fountain.

Economic

The bedrock ridge rises at Lower Manhattan, and again in Midtown. It is for this singular geological reason that the city's famous skyscrapers were able to be built in on this site the first place. This bedrock once again establishes the foundations for the rebuilding of the World Trade Center at this location.

There is an opportunity to increase the number of people who visit the site for cultural and educational reasons by embracing its natural history in a marketable manner. By providing museum-type exhibits and allowing access to the exposed bedrock – a singular opportunity in Manhattan – for those interested in the geology and history of the site..

Neighborhood

Driven by the families of those who lost relatives and friends in the 9/11 disaster, who did not want the footprints of the Twin Towers to be 'covered up' or built over, Master Planning includes some access to the lower levels of the site at the Memorial. Here, the bedrock will remain exposed, as a reminder of the tragedy. However, visual access to this natural element, some depth below grade, also offers educational opportunities, and allows those who are interested in the natural geology of the island a rare opportunity to see a slice of the bedrock face, in situ.

Travelers arriving aboard ship and steaming up the Hudson River to the piers were, and to some extent still are, treated to a spectacular view, unique to New York, perhaps the hallmark of the city. Where the ridge sinks, in areas such as Soho, the Village and Murray Hill, and again North of Midtown, the land is filled with soft alluvial material, upon which skyscrapers could not be built. Lower, squatter structures became the order of the day, and remain so into the 21st Century.

Thus, the unique character of the underlying bedrock accounts for much of the quality and character of Manhattan's neighborhoods. The World Trade Center site and the surrounding neighborhoods originally supported large-scale buildings intended for financial and business endeavors, but leaving little room between these enormously high and rather inhospitable buildings for residential buildings or retail and cultural activities. All that has changed with the new neighborhoods built on the

island's extended fill areas, most notably, Battery Park City which is itself extended into and bordering along the last stretch of the Hudson River as it enters New York Harbor.

Methodology

Design Strategies

A powerful statement or interpretation of the two natural systems, the river and the geology or "rock" of Manhattan present themselves in this unique location. This is presented by the possible integration of the flow of water from the river with the fountain design – using the water as a heat rejection medium prior to returning to the Hudson.

A clear opportunity for interpretation/education on the subject of built and natural systems seems to naturally arise out of the striking Memorial Design and its fundamental connection to river and bedrock. (This is an excellent candidate in seeking a potential innovation point for LEED™ and should be explored.)

Case Studies

Time Landscape, Greenwich Village, New York City

In the nineteen sixties, artist Alan Sonfist conceived of a plan to regress small portions of cities throughout the world to their pre-human ecosystem. He called these proposed park-like spaces Time Landscapes because they would celebrate the unspoiled land that existed before human intervention. In 1978, working with the Metropolitan Museum of Art and New York City Planners, Sonfist was able to realize his vision in Greenwich Village, between Houston and Bleeker Streets. This park uses species of trees that existed in the same location before man arrived. As these plants take hold, they transform the soil and animal life within it to their pre-human state as well. The result is a place where people can experience an almost pre-historic portion of the New York Ecosystem. (ArtsEdNet 1999)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

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Natural History

SEQ-13-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐ ○	☐ ○	☐ ○	☐ ○	☐ ○	☐ ○

☐ **Required Component:**
This certifies that the natural history and features of the site (such as the underlying Manhattan Schist bedrock and the Hudson River) have been integrated into site development in a manner that exhibits them to site users and works to illustrate the interrelationships between built and natural environments and history.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Water Management WEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To optimize utilization of site water resources.

Action: Implement a Water Management Plan to evaluate use of stormwater, wastewater and potable water resources, study potentials for onsite reclamation of wastewater and provide a coordinated management plan for full site water resources.

Use Federal Energy Management Program (FEMP) Best Management Practices and EPA recommendations per EO 13123 (Sect 207) (June 1999) to develop the Plan. The Plan must include, at a minimum, information on operation & maintenance, utility information, facility information, emergency response information and planning considerations.

Related Guidelines: SEQ-1, SEQ-2, SEQ-6, WEQ-2, WEQ-3, WEQ-4

Introduction/Context

Water is vital to all life, and is the earth's most precious natural resource. It is also the most at risk. Of all the water in the world, salt and fresh, less than .02% is potable, and much of that is under poor management and/or threatened by global desertification and increasing amounts of pollution. In the United States, water is under enormous pressure in many locations, as the demand to provide increasing amounts of water for industrial purposes, agriculture, commercial and human use often exceeds the ability of the source to replenish itself. Although the annual New York City rainfall exceeds 47 inches, with some 25,000,000 gallons of precipitation in the form of rain and snow falling on the World Trade Center site each year, a rigorous water management plan is increasingly, an essential, sustainable strategy for all new building developments.

The source of New York City's water supply is a vast infrastructure of interconnected reservoirs and lakes in the Catskill/Delaware watershed, which supplies some 90% of the city's needs, along with the original Croton Reservoir System, which supplies 10% or less. A small amount of water – less than 1% of the annual usage -- is generated by a series of groundwater wells in Queens.

Various departments of the New York City Department of Environmental Protection (DEP) are responsible for the management of water in the city, as follows:

- The Bureau of Water Supply is responsible for the collection, treatment and delivery of clean drinking water to the city.
- The Bureau of Water Supply and Sewer Operation operates and maintains the water distribution system, including fire protection and sewage systems for the conveyance of waste water and stormwater to the treatment plants.

- The Bureau of Wastewater Treatment is responsible for the operation of wastewater plants, and has the critical responsibility of making sure that treated water is safe and of an acceptably high standard prior to its release to other bodies of water.

To deal with increasingly frequent hot, dry summers, the New York City DEP has established certain year-round water use restrictions to conserve water and to help ensure that there is an adequate supply for the essential needs of all residents at all times. These include:

- A prohibition on the use of city water for watering sidewalks and lawns from 1 November to 31 March. (This strategy also minimizes the presence of freezing water on sidewalks).
- A prohibition on the use of city water for watering sidewalks and lawns during the hours of 11 AM to 7 PM from 1 April to 31 October.
- It is illegal to open fire-hydrants at anytime.

Water conservation in buildings begins with the development of a Comprehensive Water Management Plan. A principle objective of such a Plan is to match water to its end use in terms of its quality. In this manner, water of varying qualities has a place in commercial building operations where water use is very high, but not a great deal needs to be of potable quality. In this process called 'cascade planning', potable water, or 'first use' water from the municipal utility is ideally reserved solely for human and animal consumption and use. First use water must be available in all buildings at drinking fountains, toilet room and kitchen faucets or taps, and in showers and dish washers. However, water for the conveyance of waste material in urinals and water closets, and water used for irrigation, does not have to meet such a standard of such purity. In these locations, treated and recycled (previously used) water, or rainwater captured from non-porous building and site surfaces may be an option. Such water, known collectively as 'gray water', can also be used as make-up water in cooling towers, and for other maintenance purposes.

Relevant Issues

Ecological

Concerns about the quality of drinking water are rising in New York City. The DEP maintains that the potable water supply is of a high standard and meets all health-related state and federal drinking water standards, except for one suspected contaminant in 2003 – the latest year for which data is available. This substance, haloacetic acids (HAAS), is actually a group of acids that forms in surface water as a reaction between natural organic matter, such as leaves and vegetation, and the chlorine disinfectant used to kill bacteria and viruses. The amount of haloacetic acids in the water can fluctuate from day to day, depending on temperature, amount and type of organic matter, etc. According to the DEP, there is some concern that ".....long-term exposure to disinfection by-products (possibly including haloacetic acids) is associated with an increased risk for certain types of cancer." Research into this issue is continuing.

City water is treated with a number of chemicals including the following:

- Chlorine – as a disinfectant
- Fluoride – as a tooth decay preventative (required by NYC Health Code since 1966)
- Orthophosphate – to coat pipes, reducing the potential for metals such as lead to be released.
- Sodium hydroxide – to minimize corrosivity in water with low-pH.

All surface water is vulnerable to pollution and waste from industrial processes, agricultural chemicals (fertilizers, herbicides, etc.), stormwater/sewer overflows, hydrocarbon contamination washing off impervious road and parking surfaces, and biological impacts from animal and bird coliform. To help protect the city's water from waterborne diseases such as Cryptosporidium and Giardia, two serious, potentially harmful, waterborne pathogens, a new ultraviolet plant will be built on the Catskill/Croton system in 2005. In addition, a new filtration system is being designed for the Croton System to further minimize human exposure to microbial organisms and inorganic matter, and to reduce disinfection by-product levels, in an effort to ensure that the city's water supply is in compliance the new, stricter water quality standards.

New York City does not have separate stormwater and wastewater sewer systems. Existing combined systems can quickly become overtaxed during a heavy rain, leading to the discharge of untreated contaminants from sanitary waste and street runoff directly into surrounding water bodies. There are nearly 450 combined sewer outflows annually in all of New York City, each one a threat to the health and quality of the waters surrounding Manhattan. It is therefore of critical importance that the entire, vast World Trade Center site, including buildings, hardscape and landscape, be designed to minimize run-off, capture and retain stormwater at the site to reduce outflow impact, and to conserve this vital resource for essential site requirements.

Economic

The New York Water System is both economical and flexible. Some 95% of the total water supply is delivered to the city by gravity. Only about 5% of the water is regularly pumped to maintain desired pressure, although during periods of drought, additional pumping may be required. The cost of water, at $1.52 per 100,000 cubic feet (748 gallons), based on 2003 statistics, is reasonable by national standards. The minimal need for pumping ensures that operating costs are relatively insensitive to fluctuations in the cost of power, and reduced demand in recent years has helped to maintain stability across the pricing structure. (According to the 2003 New York City Water Supply & Quality Report, the New York City per capita use of water was 136.6 gallons per day for all uses, a significant reduction from 154.5 gallons in 2001.) However, a Comprehensive Water Management Plan addresses more than cost for the resource and its operation. It also considers all potential costs associated with quality maintenance, delivery, use and disposal, or treatment, at municipal facilities. It looks at the impact of new construction and new infrastructure, as well as conveyance and pumping costs (before and after use) and the operation of water-management facilities. Such a plan includes options for water conservation, reuse, more specific metering and potentials for limiting the availability of potable water to

those purposes which require water in its purest form. Studies have indicated that end-use metering of water utilities can reduce usage by up to 20%.

The collection and reuse of stormwater for non-potable building requirements and landscape irrigation reduces the amount of water that must be purchased from the local utility. Treating and re-using 'used' or gray, and possibly even black water, to flush toilets and for irrigation purposes provides obvious long-term savings, although there may be significant first-costs associated with the design and construction of the necessary on-site treatment facilities and piping systems. Conversely, first-cost financial benefits are realized by reducing the need to build large-scale infrastructure to convey and discharge storm and sewer water that can be usefully retained at the site, as well as avoidance of the typical, on-going utility charges associated with this process, including the costs of energy and chemicals used in municipal water treatment processes. Along with these direct benefits, the construction impacts on greenfields and natural habitat along the rivers and reservoir system are also avoided, as a result of conservation and the recycling or employment of a cascade management system to water reuse.

Neighborhood

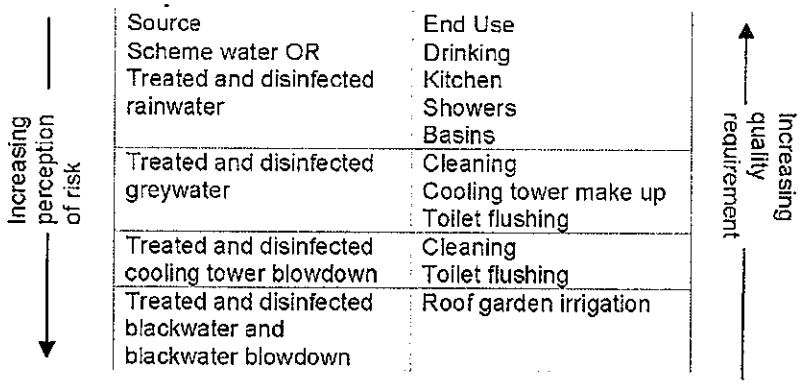
Because water is vital to all life, and is today so seriously threatened by overuse and pollution, every step towards conservation may be seen as a protective measure, with the broad intent to share and preserve this critically important resource for the benefit of all users. In New York, water is, by and large, plentiful; however, this fact should not deter every citizen from using it wisely so that it may continue to serve the entire community. In times of drought, the New York State Governor, through the State Emergency Management Office (SEMA), may declare a state of emergency, and restrictive measures will be enforced as an essential part of the DEP's strategy to conserve water. However, conserving water on a voluntary basis not only minimizes this impact on city residents, it may reduce the frequency of occurrence of such restrictions, and it saves building owners money, as well as avoiding the additional costs associated with enforcement.

Unlike most urban areas, the 600 hundred miles of waterways around New York City belong to the population, not the state. The population therefore has a vested interest in maintaining water quality around Manhattan, and especially New York Harbor, which are subject to impacts from combined sewer and stormwater overflows. These water bodies will remain cleaner, with less toxic substances in the water and bottom sediments, and less bioaccumulation of toxins in animal tissue (fish, shrimp, shellfish, etc), when site stormwater flows are retained on-site. PCB's have been found in varying quantities throughout parts of the Hudson River. It only takes only one gram of PCBs to render up to one billion liters of water unsuitable for freshwater aquatic life!.

Methodology

Design Strategies

Water conservation strategies are most efficient when based on the principle of water quality cascade, meaning that the least intervention or treatment required to meet the water quality necessary for the planned end use is by far the most efficient approach...



Cascade Chart (Chanan 2003)

This reason encourages design strategies which consider an integrated approach to water conservation, incorporating a series of options from the World Trade Center Guidelines. At a minimum, incorporation of low-flow fixtures that exceed the requirements of EPAct to reduce the demand for potable (municipal) water, and strategies for the capture, storage and recycling of storm water from roofs and paved areas can be used to enhance the design approach. After minimal treatment this water is acceptable for both flushing toilets and irrigation. Further reaching efforts would allow for the inclusion of an on-site water treatment plant and building dual piping systems for grey water – all water from sinks and showers – which may be used, after treatment and disinfection, for flushing toilets and cooling tower make-up water. As an even more comprehensive strategy, black water capture, treatment to tertiary standards, and subsequent reuse should be considered.

Green roofs and other planted and pervious areas of the site will contribute to retaining stormwater, lowering the amount of run-off, and acting as an effective water conservation strategy. In addition, vegetation and soil materials help to mitigate heat island effect, and contribute to reducing the impact of the summer sun through evapotranspiration.

Means and Methods
Develop and implement a Comprehensive Water Management Plan to capitalize on the most effective methods for conserving all water resources on the immediate project site and within the building(s). Extend the area for storm water harvesting as far out beyond the project environs as reasonable to capture maximum contributions. Include potable water, stormwater and wastewater strategies in the Plan (WEQ-1), which should be designed according to the recommendations of EPA EO 13123 (June 1999) and FEMP Best Management Practices.

In establishing the water management plan, according to the authors of *Sustainable Water Management in Commercial Office Buildings*, "Support from water utilities is crucial, with a change in mindset from being water suppliers and wastewater managers to complete water service providers". In developing a Comprehensive Water Management Plan, consult with the DEP. If the plan is for a large scale building or complex, and involves multiple initiatives, it will be important to work with these authorities in order to achieve coordination of strategies and maximum benefits. It is also important to work with city health officials to establish the

parameters for waste water systems that may be considered, such as gray and/or black water reuse, and the level of treatment required to render such water useable for irrigation and other building purposes.

Case Studies

United States Environmental Projection Agency – Sample Plans

The US EPA provides various sample water management plans covering different building program types for people to reference. These plans help individual facilities set long- and short-term water conservation goals. The EPA set a goal of incorporating water management plans at 5 percent of its facilities in its Executive Order 13123 and accomplished this by the end of 2002. In conjunction with these plans, the EPA is tracking water use at its facilities than have undergone water management assessments. This will provide feedback regarding the success of different management plans and the strategies they contain. Currently the EPA has water management plans for 11 facilities with additional ones in development. These can be downloaded from the EPA's website at http://www.epa.gov/oaintrnt/water/plans.htm. (EPA 2004)

Reference

Definitions

Potable Water is water that is of sufficient quality that it has been approved for drinking by the authority having jurisdiction.

Water Pollution: The impairment of water quality by agricultural, domestic or industrial wastes to a degree that the natural water quality is changed to hinder any beneficial use of the water or render it offensive to the senses of sight, taste, or smell or when sufficient amounts of wastes create or pose a potential threat to human health or the environment.

Water Contamination: Contamination of the water supply constitutes an actual health hazard, exposing the consumer to potentially lethal water borne disease or illness.

Waterborne diseases: These are diseases or illnesses caused by drinking contaminated water. The contamination can be bacteria (*Salmonella, Campylobacter, Shigella, Myobacterium, Vibrio, Leptospira, Escherichia coli*), viruses, or small parasites (*Cryptosporidium, Giardia, Toxoplasma*). Most outbreaks of waterborne disease are caused by fecal contamination of water by infected animals or people.

Water Treatment:

- Primary treatment involves separation of suspended solids from wastewater by screening and sedimentation.

- Secondary treatment involves additional treatment, usually by biological processes, to remove organic matter and residual suspended material followed by disinfection
- Tertiary treatment produces higher quality effluent through the further removal of contaminants such as nitrogen, phosphorus, heavy metals, residual suspended and dissolved solids, and synthetic organic chemicals. Tertiary treatment can involve processes such as carbon adsorption, reverse osmosis, micro-filtration, and biological nitrogen and phosphorus removal.

Water Quality Cascade: Use of water that requires the least intervention or treatment in order to meet the water quality necessary for the planned end use.

Standards

Standards have not been included for this Guideline.

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Water Management Plan WEQ-1-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Water Management Plan is intended to evaluate storm water, waste water and potable water resources, study potentials for onsite reclamation of wastewater and provide a coordinated management plan for full site water resources

Plan Components

I. Project Description (Plan Summary)

A. Provide a physical description of project. Include description of how water enters the site, is stored on the site and moves off the site.
B. Provide description of site water uses and their corresponding water quality requirements, how the use changes water quality and disposition of water at end of use.
C. Describe site water treatment systems: include onsite and offsite or municipal systems.
D. Outline local codes and city water programs/initiatives.

II. Water Resources Inventory

Provide a detailed list of site water resources. Include stormwater, municipal water, greywater and black water resources.

III. Water Uses Inventory

Provide a detailed list of site water uses. Include landscape requirements, building cleaning and maintenance, HVAC systems, toilets, food processing, showers, lavatories and pantries.

IV. Management Strategies

A. Document increasing Water Collection Potential
   1. Collect rain water from impervious ground-level surfaces and the roofs of buildings, treat water to tertiary standards and redistribute to all those services not requiring potable water.
   2. Consider creating a grey water system to collect, treat water to tertiary standards and redistribute to all those services not requiring potable water.
   3. In association with overall water management planning for the site, and cost considerations, review the potential to treat black water on-site as well.

B. Document means to decrease Water Use
   1. Use low-flow and dry plumbing fixtures.

2. Use automatic controls, such as motion sensors, on plumbing fixtures.
3. Specify no potable water to be used for landscaping, following the first year in which plants, trees and vegetation becomes established.
4. Provide monitoring controls and metering for 100% of the water systems. (*Studies indicate that metering utilities reduces usage by an average of 20%.)*
5. Reduce building cleaning requirements by designing particulate collection systems at entry ways and increasing ventilation air filtration.

V. Targets

Establish and describe project targets for the following

A. Amount of water diverted from the city sewers
B. Decreased demand for potable water due to measures implemented by this plan.
C. 5 year and 10 year plan for project water management.

VI. Evaluation

Upon project completion, compare established targets for IV.A and IV.B with results. If targets have not been met provide explanation and if necessary, revise 5 year and 10 year plans to accommodate revised results.

Water Management

WEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
A Water Management Plan is attached and includes comprehensive strategies for optimizing storm water, waste water, and potable water resources. This plan reflects the goals of both the Federal Energy Management Program's (FEMP) Best Management Practices and EPA EO 13123 (Sect 207). It also includes details regarding operation and maintenance, utility information, facility information, emergency response information, and planning considerations.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Wastewater Reuse WEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To minimize site wastewater outflows.

Action: Implement wastewater strategies as required by Water Management Plan. Use reclaimed storm water and/or site water for toilet flushing, cooling tower makeup, vehicle maintenance and irrigation needs. Study additional opportunities to reduce the amount of potable water used in the building for conveying sewage.

Related Guidelines: SEQ-1, SEQ-2, SEQ-6, WEQ-1, WEQ-3, WEQ-4

Potential LEED™ 2.1 Credit: 1 possible with WE cr. 2. (see Submittal Template)

Introduction/Context

With concern about water shortages around the world at an all-time high, it makes sense to engage in strategies to conserve this natural, severely threatened resource to the extent possible. To achieve maximum utility from water that has already been drawn from its sources via natural means – the evaporation/rainfall cycle -- and/or by human intervention, it must be recycled and reused in all appropriate situations. In buildings, the process where potable water delivered directly from the utility is reserved only for human consumption and personal use, and all other water applications depend on captured or gray water (recycled water that has been treated to tertiary standards), is known as water 'cascading'. Cascade planning is at the center of sustainable water management planning.

Among heavy water-consuming fixtures in all types of buildings, water closets are consistently the greatest (except for specific water-based industrial uses). Traditional urinals, because of frequency of use, also consume significant amounts of water. These fixtures do not require potable water for the conveyance of waste materials. Additional fixtures and applications that can perform as intended without the need for potable water include make-up water at cooling towers, on-site laundries, water used for irrigation and landscape purposes, and vehicle maintenance. These applications, along with toilets and urinals, may be supplied by non-potable, secondary use water from sources as described below.

At every building and building site, there are several sources of non-potable water that may be used to contribute to an overall Water Management Plan. First among these is storm water, precipitation that falls as rain or snow on the site. All water that falls on impervious surfaces may be harvested, cleaned and stored for application in any of the secondary uses described. Water from the roofs of buildings is significantly cleaner than water which has fallen on the streets, which tends to be compromised by hydrocarbons, dirt and particulate matter from fuel emissions and

salts, and in plaza areas, from fertilizers and herbicides that wash out from planting beds. Gray water is the name given to this water, and to water that is recaptured from sinks and showers --'light-soil' uses. Both sources provide water that can be used, after treatment and disinfection, for all applications described. Black water is water that has been used for the conveyance of sewage, and while it may be recycled back into the system for cleaning and further application, often in the form of sewage conveyance again, must be treated to tertiary standards and disinfected in order to eliminate pathogens.

Relevant Issues

Ecological

There are many ecological benefits associated with recycled water captured from sources other than the water utility, and used for non-potable purposes. The most important of these is the protection of the watershed region and the water supply by minimizing draw-down of freshwater resources.

The harvesting of precipitation involves the simple capture of a free, natural resource at the site, followed by the retention of that asset at the site for future use. Treatment and filtering of these volumes of water is essential prior to reuse, but stormwater has a wide application and may be used at all non-potable fixtures and equipment. Harvested rainwater is an effective measure in stormwater control, limiting the amount of run-off from the site, which is particularly important in New York City, where the stormwater and sewer lines are combined. Restricting run-off from the World Trade Center site will help to avoid some of the mearly 450 outflows which occur each year in the city, dumping raw sewage into surrounding water bodies, as a result of storm surge overtaxing capacity and flooding of the combined storm/sewer systems.

Gray water systems are designed to draw off and reuse water from lavatories, showers, kitchen sinks, dish and clothes washing machines and laundries. The water, which is lightly soiled, is filtered, treated and disinfected before its reuse. Because of the large volumes generated, utilizing gray water is an important conservation strategy for a sustainable building or complex. In planning, the design of a treatment facility that is able to service several buildings might be considered, to off-set first costs. In addition to the on-site treatment plant, a secondary set of piping is required at each building, to ensure separation of gray water from potable water supply lines.

Currently, wastewater from Lower Manhattan and the World Trade Center site is piped to the Newtown Creek waste facility in Queens, New York. Cutting down on volumes of contaminated waste water that are delivered to the treatment facility will reduce the amount of energy expended and chemicals needed in the treatment process prior to its release to the East River. The amount of chlorination currently in use at the plant is in excess of limits set by the Federal Clean Water Act, so any diminishment of waste and waste water helps to reduce the water pollution resulting from this process at its point of greatest impact.

Economic

The actual need for '*potable*' water use in commercial buildings is measured at 15% to 20% maximum of all water supplied to the building. This is the only direct fresh water supply from municipal sources that is actually *needed* for commercial building use. Assuming there is a sufficient supply, all other water could come from gray water sources. However, because black water systems are still fairly rare, not all water used even in sustainably designed buildings is able to be recaptured. An efficient water system can still be expected, reasonably, to use municipal water for as much as 50% of total consumption. Clearly, even at a 50% reduction in municipal water use, there is an enormous economic benefit in avoided water utility fees, which can accrue to any building designed to take advantage of these economies. However, to participate in the benefits, non-traditional strategies, which contribute recycled water for some 50% to 80% of the building's supply must first be designed and put in place.

There is a significant 'first cost' (initial capital investment) associated with the design and construction of an on-site waste water recovery, filtration, treatment and disinfection system, and the more extensive piping necessary for gray water will increase the cost of regular plumbing. There are also costs associated with the purchase or construction of large-scale cisterns and their associated piping to hold and distribute harvested rainwater, and additional costs associated with maintaining these storage facilities. Water efficient cooling towers can use gray water and are typically designed to minimize evaporation through the use of delimiters; however, it is important to consider any energy penalty that may result from the application of this technology. All of these strategies must be reviewed in terms of a life-cycle analysis (LCA) including an assessment of the relevant systems and their impacts and benefits. Once the capital expenditure has been amortized, water conservation through maximum utility can 'pay back' handsomely, in terms of reduced fees and operating costs. (This will be dramatically more significant in the years to come, as New York's water costs are projected to rise sharply in the near future). Even more importantly, it is a far-reaching conservation strategy with long term advantages for the entire community being served by New York's huge, complex water system.

With an efficient Water Management Plan in place, addressing fresh water supply and conservation, as well as waste water reuse strategies, both the supply lines and the sewer mains are asked to handle significantly lower volumes of water. As a result, there is less wear on existing systems and fewer repairs required, reducing regional infrastructure costs. The strategy may also defer or even eliminate the need for new processing, filtration and treatment plants. Eliminating the necessity to continually expand by building new water management infrastructure not only reduces the economic burden on the city, it preserves open land and habitat. This is a win win situation – a prime example of sustainability, where thoughtful planning maximizes the use of a free resource (stormwater) and optimizes a resource that is already drawn down (gray water). In this manner a critical need is supplied, while deferring, and perhaps permanently avoiding, significant infrastructure costs as well as reducing the day-to-day costs of an increasingly vulnerable and scarce commodity.

Neighborhood

Conservation of water resources is a goal of universal significance. It is an approach to sustainability intended to enhance protection of the water supply for the greater benefit of all who share its life-giving force. Beneficiaries include those who consume it and depend upon it, from the people in the watershed region to those downstream in the city. It is essential for agriculture, fishing and recreational activities. Wildlife too, must have a plentiful supply of fresh water to remain strong and vital. With careful management and less draw-down through conservation strategies, the many lakes, rivers and reservoirs that constitute the great watershed areas of the Catskill/Delaware Reservoir and Croton Reservoir systems, will remain capable of supplying the entire community they serve with essential fresh water every day, including times of emergency, during the inevitable and seemingly increasingly common, summer droughts.

Rainfall harvesting at the site addresses two critically important issues that enhance community quality of life, as well as contributing to conservation: it provides a large portion of the 'raw material' for gray water systems, so that potable water does not have to be used for non-essential functions, and it reduces the potential for stormwater surge, where the sewers are overwhelmed by run-off, resulting in raw sewage and bio-hazardous outflows. For the health and well-being of the community, it is important to minimize these outflows, which contaminate the waters around Manhattan, contributing to hazardous (unsafe) or poor water quality for fishing, recreation and sport.

A reduction in the amount of water required to convey sewage through the municipal system actually increases the net efficiency of the plants, thereby avoiding the need for new and larger treatment facilities. These facilities are costly and typically have a negative impact on their neighborhoods, producing odors and air pollution. In addition they need energy to operate and a heavy use of chemicals to neutralize contaminants. Use of less potable water on the supply side, may also have the effect of stabilizing utility rates and reducing taxes.

Methodology

Design Strategies

The simplest approach to waste water reuse is through rainwater harvesting. A system which captures water from the building roof may use conventional methods such as slight slopes to direct flow, gutters and downspouts or pipes to capture and deliver the water to storage tanks, or cisterns, located either at the side of the building or in the basement. The cisterns require an overflow valve to handle excess water beyond their capacity. With limited treatment, in accordance with the city requirements, this water can be filtered and reused in toilets, urinals and for irrigation purposes. Stormwater collection from impervious surfaces at street level is strongly encouraged; however this water typically requires additional treatment before reuse.

The selection and specification of low-flow, or ultra-low-flow fixtures at rest rooms, laundries and kitchens, will not only reduce the demand for potable water; it will reduce the amount of waste water generated by the building. This is a second methodology which can be used to contribute to meeting the goals of this credit.

Many fixtures are available today, which are more efficient than the baseline established more than twelve years ago by the Energy Policy Act (1992), and are further described in WEQ-3 Water Use Efficiency.

Because most of the buildings will be new, gray water systems are an important consideration for the World Trade Center site. These systems are essential to the conservation of water in the long run, and can be used here as practical and effective exemplars for all future construction where water recovery is central to the sustainable goals of the project. It is simpler and more cost effective to design and construct gray and/or black water systems for new structures, rather than retrofitting existing buildings, because space for the additional plumbing required can be designed-in intentionally and provided for in planning and in the construction documents. The selection of the type of treatment system is important, with a choice of several available, such as aerobic biological reactors or mechanical sand filtering systems.

Means and Methods

Architectural/engineering teams engaged in sustainable projects need to undertake a water audit early in the design process, in order to determine the amount of waste water that will be generated in the building and available from all sources in the project. Consider all possibilities where the replacement of potable water with recycled or gray water would be appropriate, safe and contribute to water conservation and a reduction in sewage conveyance needs. Among the possibilities, include water closets and urinals, as well as maintenance areas, outside hose bibs used for irrigation and vehicle maintenance. Sub-surface and drip irrigation systems can also take advantage of gray water. Cooling tower make-up water can use gray water as well.

Based on the scale of the project, the anticipated water use, municipal rates and operational expenses, determine if a gray water system is an economically viable alternative to the use of municipal water at all appropriate locations. Although water rates in New York City are extraordinarily low at the time, they cannot be expected to remain so, as the water supply is increasingly under pressure, with greater demand across the globe than the available supply. Design teams are encouraged to consider several pricing structures to determine a reasonable break-even point between first costs and future water costs, in their examination of the viability of waste water recovery systems.

The generation of waste water can be greatly reduced by the specification and installation of low-flow toilets and appliances, and dry fixtures. A review of strategies designed to reduce the use of all water resources needs to be undertaken in the waste water analysis, and must be coordinated with WEQ-1 and WEQ-3 to correctly develop the water inventory. Less waste water means that there will be a smaller resource for a gray water system. The system should be designed to permit 'topping up' as necessary with harvested rainwater or municipal water - by running all piping from this single source, the duplication of piping is minimized.

Because gray water systems can be costly to install, a good methodology for reducing this capital expense is to consider a single gray water treatment plant to service several buildings. Diversity of water sources will reduce the potential need

for added municipal water and help to reduce costs. Maintaining as much water at the site for reuse as described, will not only conserve potable water, it will greatly reduce the costs associated with sewage conveyance.

Case Studies

Audubon Center at Debs Park, Los Angeles, CA

The Audubon Society commissioned this project to provide a regional center with environmental education programs for 50,000 schoolchildren in the city of Los Angeles. Built on land leased from the City, the Center occupies 17 acres of a 282-acre urban wilderness park in downtown L.A. As part of its environmental agenda, this LEED 2.1 Platinum building was designed with a heavy focus on water conservation.. The building uses only 30% of the water consumed by a typical building of the same size and program. Even more significant, however is the degree to which this project reduces wastewater outflows. In fact the building is not even connected to the municipal sewer system, as 100% of its wastewater is treated on-site. The Audubon Center uses an anaerobic/aerobic hybrid treatment and filtration process. Wastewater is further cleansed by a peracetic acid and ultraviolet light advanced oxidation disinfection method. After being treated, a portion of this recycled water is used to flush toilets. 30% of the water is returned to the soil in an anaerobic sub-surface dispersion field. The architect specified dual-flush, low-flow toilets to lessen the initial amount of wastewater generated and reduce the required capacity and resource consumption of the treatment systems. (USGBC 2003)

20 River Terrace – The Solaire, Manhattan, New York

This LEED Gold residential tower operates an on-site blackwater system that processes 100% of the building's wastewater for reuse. The water recycled by this system supplies the HVAC system's cooling tower and toilets. Enough surplus is available to send 5,000 gallons a day to an adjacent public park. This building uses 50% less potable water than a conventional structure of this type. The structure recycles sufficient wastewater so that there is no potable water needed for exterior irrigation on the site. Waterless urinals and low-flow toilets further reduce the volume of wastewater generated by the tower. (USGBC 2003 [2])

CK Choi Building, University of British Columbia, Vancouver, B.C.

The CK Choi Building is home to the Institute of Asian Research at the University of British Columbia. The Building is a 29,000 ft², $4.5 million graduate research center comprised of offices, student workstations and seminar rooms. It's design incorporates many strategies to reduce wastewater generation and therefore does not require connection to a sanitary sewer system. In fact CK Choi uses 50% less water use than a typical new building of the same. (The building's water consumption is roughly 53 gallons per day.) Water efficient fixtures were used throughout the building. Bathrooms on all three levels of the building house composting toilets that, combined, save nearly 100,000 gallons of water per year. The composting "tea" that these toilets produce is automatically extracted from the compost tanks in the basement and combined with graywater from sinks and then filtered through a subsurface constructed wetland. The vegetation and microbial life in this wetland filter and clean the graywater through natural processes. In order to verify the safety and effectiveness of this system, the Vancouver Health Department has tested levels of fecal coliform in post-treated water and found that they are as low as 10 parts per

100 milliliters (mL). This is quite low considering that water with levels up to 200 parts per 100 mL is considered safe for people to swim in.

Reference

Definitions

Potable Water is water that is of a sufficiently high quality that it has been approved for drinking by the authority having jurisdiction.

Water Quality Cascade: Use of water that requires the least intervention or treatment in order to meet the water quality necessary for the planned end use.

Water Treatment:

- Primary treatment involves separation of suspended solids from wastewater by screening and sedimentation.
- Secondary treatment involves additional treatment, usually by biological processes, to remove organic matter and residual suspended material followed by disinfection
- Tertiary treatment produces higher quality effluent through the further removal of contaminants such as nitrogen, phosphorus, heavy metals, residual suspended and dissolved solids, and synthetic organic chemicals. Tertiary treatment can involve processes such as carbon adsorption, reverse osmosis, micro-filtration, and biological nitrogen and phosphorus removal.
  Source: Thomas et al. (1997).

Health Hazard or Non-Health Hazard: in water is a determination of whether the substance in the water is toxic (health hazard) or non-toxic (non-health hazard).

Standards

Standards have not been included for this Guideline.

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Wastewater Reuse

WEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	○	○	○	○	○

☐ **Required Component:**
An outline is attached, describing strategies used to reduce wastewater production as part of the Water Management Plan.

☐ **Required Component:**
An outline is attached, explaining strategies used to capture and use stormwater as part of the Water Management Plan.

☐ **Required Component:**
Calculations are attached, as part of the Water Management Plan: Part V. – Targets. These serve to demonstrate the target reduction of building potable water use that is expected to result from the strategies outlined above. Further, a calculation matrix is attached to show the difference between 'best practice' and adopted sustainable strategies.

☐ **Optional Component:** (To satisfy the requirements of LEED™ 2.1 Water Efficiency Credit 2: Innovative Wastewater Technologies)
This certifies that the use of potable water for sewage conveyance will be reduced by at least 50% from baseline conditions. Supporting calculations and a narrative description of the measures used to achieve this reduction are attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Water Use Efficiency

WEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To maximize water efficiency within buildings and reduce the burden on municipal water systems.

Action: Reduce consumption of potable water as required by Water Management Plan. Use 30% less potable water than a baseline building (utilize 1992 Energy Policy Act fixture requirements to determine baseline) would by utilizing efficient water fixtures, automatic controls and/or waterless urinals.

Related Guidelines: SEQ-1, WEQ-1, WEQ-2

Potential LEED™ 2.1 Credits: 2 possible with WE cr. 3.1, and WE cr. 3.2 (see Submittal Template)

Introduction/Context

Until the early 1990's, traditional toilet room fixtures and kitchen faucets were designed solely on the basis of aesthetics and functionality, indicating an alarming lack of awareness of the shrinking fresh water supply and worldwide water crisis. Until recently, these types of fixtures, which consume enormous quantities of water (a typical old-style water closet will use 5 gallons per flush), were the only choices available. However, today while they are still in wide use, they cannot be specified for new design projects. In 1992, new water efficiency standards were introduced through the Energy Policy Act (EPAct), and were designed to reduce significantly the amount of water consumed by typical fixtures – water closets, lavatory faucets, kitchen faucets, shower heads and others. Shortly thereafter, a series of incentive programs were made available in a number of cities across the country to replace heavy-usage fixtures with more efficient fixtures compliant with EPAct. These programs were universally successful: in 1994, the New York City residential rebate program, for instance, replaced 1,635,400 old-style water closets with units using 1.6 gallons of water per flush.

The sustainable water conservation strategies of this Guideline strive to exceed the EPAct requirements. The ability to surpass these minimum standards is increasingly possible with the continuing introduction of new technologies. These include low-flow fixtures, the design of which has improved greatly in recent years. In addition many fixtures may also incorporate flow-controls and sensors to further conserve water. The use of dry fixtures for non-potable functions is also being encouraged by the green movement. Dry fixtures include such technologies as composting toilets and waterless urinals. The use of recycled, or treated 'gray' water, in fixtures and equipment, where appropriate is another conservation strategy gaining popularity.

Relevant Issues

Ecological

Water is the common denominator for all life as we know it. Preserving supplies provides for a long-lasting and more equitable distribution of this vital resource, which in turn supports both human activities and greater biodiversity. Minimizing draw-down of the huge watershed system of lakes, rivers and reservoirs to the North and West of the city, helps to maintain a healthy supply for all dependents – agriculture, recreation, wildlife – as well as the city's needs, especially in times of drought.

Reduced demand for potable water directly from the utility preserves the integrity of the infrastructure, saves on energy used to pump supplies, and avoids the release of pollution associated with the burning of fossil fuels to generate electricity. It also lessens use of chemical treatments, such as chlorine, fluoride and sodium hydroxide, required to ensure that the water is safe to drink and meets the standards established by the New York City Health Code.

Economic

Much of the water delivered to commercial and industrial buildings does not need to be of potable quality (see WEQ-1, Comprehensive Water Management Plan and WEQ-2 Waste Water Reuse). However, of the portion that must be potable – drinking water, water at fountains and faucets, showers and dish washers -- conservation strategies that depend on low-flow fixtures and enhancement devices such as automatic controls -- can save considerably on both municipal water fees and operational costs. These controls also subtly reduce the amount of water available for each function, reducing the energy demand for pumping and for water heating, while providing associated savings. A major benefit accrues to the city from the minimized burden on the utility infrastructure, which delivers potable water to the building, allowing major expansions to be deferred, and repairs minimized.

Based on the New York City census figures, the per capita use of water in 2003 was 136.6 gallons per day for all uses, down from 141.8 gallons in 2002 and154.5 gallons in 2001. This declining curve indicates a new awareness of the need to conserve water, reflected in a more careful selection of high-efficiency plumbing fixtures and other conservation strategies. The new, low-flow fixtures as mandated by EPAct do not have a cost premium, while those that conserve even more water may still be slightly more expensive due to their novelty. However, with greater demand, these costs are coming down, while the long-term benefits and reduced amounts of water needed increasingly off-set any initial up-charge.

Neighborhood

Drought, as experienced in recent years in the New York area – 1989 for instance, when the available supplies of water dropped to 55% of capacity (a Stage III emergency), as well as the shortages of 1991, 1995 and 2002 -- puts a strain on the whole watershed. All activities which depend on a plentiful supply of water suffer under such conditions, including upstate agriculture, fishing and recreation, as well as the quality of wildlife habitat and fisheries. Every individual in the city feels, at a minimum, discomfort. In April 2002, when reservoirs were at a Stage I level (57.5% full), there was a proposal to divert water from the Hudson River for municipal use.

Only the concern that the new, invasive species of zebra mussel would gain access to the city's water supply, multiply quickly and block sinks, toilets and drains prevented this initiative from going forward. The use of Hudson River water has been shelved temporarily, but may have to be reintroduced – with disastrous results according to the New York City DEP -- if extreme drought conditions recur and conservation strategies have not been sufficient to protect and sustain the water supply.

Methodology

Design Strategies

The design of a sustainable building's plumbing system must consider all issues of sanitation, flow and pressure, as well as environmental issues, which seek to reduce the use of all water, but especially potable water. The challenge presented by this credit is to achieve a water conservation goal in the aggregate of 30% over a 'best practice' base-case design, which relies on EPAct 1992 to determine its permissible water use. In the marketplace, there are many choices that will assist a design team in succeeding in this endeavor. Below are listed a number of options and strategies that can be considered and/or specified:

Fixture	Code/EPAct Fixture	Sustainable/Low-Flow Fixture
• Water Closet:	1.6 GPF	0.8 – 1.1 GPF
• Urinal	1.0 GPF	0.0 (Waterless)
• Lavatory (Bathroom Sink):	2.5 GPM	1.8 GPM
• Shower Head:	2.5 GPM*	1.8 GPM
• Kitchen Sink:	2.5 GPM	1.8 GPM
• Hand Wash Fountain:		0.5 GPM

*At flowing water of 80 psi

The performance of the water efficient fixtures noted above can be enhanced further by the specification and/or addition of a number of devices, among which are vacuum toilet systems, dual-flush toilet systems, electronic sensors that turn faucets on and off automatically when they 'sense' the presence of a person, and devices that are self-closing after releasing a pre-determined amount of water. These are particularly appropriate for use in public places. Aerators, which maintain water pressure but restrict the flow, may be inserted in shower heads and lavatory faucets. This strategy is mandated by the city during times of drought so that water is conserved while the impression of a plentiful supply remains. New technologies have made waterless urinals a real option for the 21st century – they are now sanitary, odorless, efficient and cost effective. These units depend on hydraulic action, and use a buoyant, often blue, gel in place of water. They require little more maintenance and represent an excellent water conservation strategy. Waterless urinals are one of the multiple water conservation strategies that are beginning to be specified widely throughout public and private sector buildings in New York City.

In applications other than drinking fountains, typical washroom fixtures, and kitchen sinks, potable water use can be restricted or eliminated in accordance with the

overall Water Management Plan. Options include use of recycled or gray water at non-essential potable water locations, including cooling towers, on-site laundry locations and for irrigation purposes. Laundries or any commercial washing machine operation (on-site restaurant use, for example) can limit demand through use of a water-efficient ozone laundry system. Dry fixtures, such as composting toilets are an option, but are still fairly expensive and require special construction and maintenance methodologies, as well as an educated public.

Means and Methods

Develop an inventory in which all fixtures, equipment and services in the building that consume potable water are listed, but not those fixtures indicated in WEQ-2, Waste Water Reuse, which may be scheduled to operate with treated recycled storm or gray water. The fixture water use maximum allowance listed should reference EPAct as a starting point. This will provide a means to establish a base-case water use scenario. Following this, provide an inventory of low-flow and alternative water conserving fixtures specified for the project. The delta between standard 'good practice' (EPAct) and the more sustainable level achievable by the selection of water-conserving fixtures and equipment, will serve to indicate the amount of water saved.

Case Studies

National Resources Defense Council Robert Redford Building, Santa Monica, CA

The downtown Santa Monica Offices of the NRDC espouse ecologically benign water management strategies befitting a group dedicated to protecting public health and the environment. The systems in the building only use potable water for applications where it is essential: drinking and bathing. Graywater collected from sinks and showers is treated and then used for toilet flushing and landscape irrigation. A rainwater catchment and filtering system also provides non-potable water for these uses. The building's bathrooms are equipped with dual flush toilets that provide the user a choice of either a 0.8 or 1.2 gallon flush depending on how much water is needed. Waterless urinals contribute to maintaining water-use efficiency. The building operates water-conserving appliances such as a high-efficiency dishwasher. These strategies ultimately produce 60% less use of potable water as compared to a standard building.

New York City Toilet Rebate Program (New York, NY)

The New York City Department of Environmental Protection (DEP) launched one of the nation's most ambitious low-flow (LFT) toilet rebate programs in March of 1994. The City's goal was to encourage the replacement of one-third of the toilets in New York City with water-saving, 1.6 gallons-per-flush ULFTs.

"The Toilet Rebate Program (TRP) is a consumer-orientated water conservation initiative designed to save landlords and tenants money while helping the City stretch its capital construction budget. Since the program began in 1994, the TRP has installed more than one million toilet fixtures, cutting water use in the City by about 60 million gallons a day (MGD). These savings allowed the City to avoid the high costs of building new water supply and wastewater treatment facility, which helps keeps all water bills low and provides particular support to the City's affordable housing sector." (BuildingGreen.com 2004)

"The residential conservation programs have, in conjunction with other programs, reduced the City's use by almost 150 million gallons a day, with total savings to be expected from the TRP approaching 90 MGD by program end (end of calendar year). City wide 1,135,400 old-style toilets have been replaced by water-saving models and applications for an additional 500,000 toilets have been approved. Conservation has helped to preserve the City's affordable housing stock, helped protect water quality and allowed the City to avoid potentially billions of dollars in costly system expansions and modifications." (Mega-Cities 2001)

Reference

Definitions

Potable Water: is water that is of sufficient quality that it has been approved for drinking by the authority having jurisdiction.

Dry Fixtures: This term refers specifically to waterless urinals and toilets, such as composting and vacuum toilets that do not require water for the conveyance of sewage. These fixtures may have a water supply for maintenance purposes only.

Standards

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The Mega-Cities Project. "The New York City Toilet Rebate Program". Mega-Cities :Innovations for Urban Life. 2001. The Mega-Cities Project. 14 January 2005. <http://www.megacitiesproject.org/publications/pdf/mcp019b.pdf>

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Water Use Efficiency

WEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

☐ **Required Component:** *(This will satisfy both LEED™ 2.1 Water Efficiency Credit 3.1: Water Use Reduction – 20% and Credit 3.2: Water Use Reduction – 30%)*
The attached documentation illustrates that the design achieves a minimum of 30% greater water efficiency than a baseline building defined according to The Energy Policy Act of 1992.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Landscape Hydrology WEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To maximize utilization of site water for landscape requirements.

Action: Use storm water for landscape irrigation requirements in conjunction with Water Management Plan. Specify plantings requiring low amounts of watering. Use indigenous or acclimatized plants suitable for the current nature of the site. Employ high-efficiency irrigation systems with slow-drip, sub-soil irrigation and computer operation with linkages to meteorological data to optimize water resources.

Related Guidelines: SEQ-1, SEQ-2, WEQ-1, WEQ-2

Potential LEED™ 2.1 Credits: 2 possible with WE cr. 1.1, and WE cr. 1.2 (see Submittal Template)

Introduction/Context

As part of the Comprehensive Water Management Plan, water must be used to maximum levels of efficiency in order to preserve resources and to ensure the availability of potable water at all times for human and animal consumption. One of the most successful ways of contributing to this goal is to eliminate the use of potable, or municipal, water for irrigation purposes and landscape maintenance. All water used for landscaping functions can appropriately be derived from two, non-potable sources: First, through the natural cycle of precipitation, and second, through the use of recycled or gray water, gathered via rainwater harvesting from impervious surfaces at the site, and/or the collection of lightly soiled water from the buildings' waste systems. All water in this latter category must be treated to appropriate standards in accordance with the New York City Department of Health prior to use for irrigation.

In the United States, a growing number of cities have instigated conservation programs with municipal landscaping ordinances, rate structures and requirements for the installation of wastewater reuse systems, indicating a growing awareness of the need to preserve water resources. In recent years, public acceptance, as well as technological advances, in the collection and treatment of gray water and stormwater harvesting and storage have made the maintenance of healthy, efficient landscaping more cost effective and straightforward. Other significant strategies include the use of efficient water distribution systems, the specification of an indigenous or acclimatized tree, plant and ground-cover program, and application of an appropriate support and maintenance program of fertilizers, pesticides and herbicides to sustain the quality and health of the landscape planting materials with minimal toxic chemical impacts.

Relevant Issues

Ecological

Planted areas and trees are essential elements in the planning of the site. These pervious areas absorb stormwater naturally through their surfaces, contributing to the overall plan objective to capture and retain this vital element at the site (See WEQ-2). Ground cover such as grass offers opportunities for recreation and relaxation. Trees provide contrasting light and shade (chiaroscuro), enlivening the visual quality of open areas, plazas and streetscapes. Site plantings mark the changing of the seasons, adding variety, color and interest to the cityscape, a factor known to enhance human well-being. However, green spaces are important for more than their visual quality and psychological impact: these spaces contribute a major cooling effect at street level, which is a key environmental and human-centered/well-being issue. They reduce heat island effect at both ground level and planted roof areas, and they help to clean the air, absorbing carbon dioxide from vehicle exhaust, while throwing off oxygen.

Potable water is not needed for the maintenance of this huge asset-base. Carefully selected trees and landscaping plants thrive on recycled water, and in fact, contribute to the natural bioremediation cycle of such water by absorbing any remaining nutrients. The selection of indigenous and/or acclimatized trees, plants and especially ground-cover materials reduces the need for watering, as plants which have evolved in any given habitat are generally capable of surviving in tandem with the weather and precipitation patterns that characterize it. Indigenous planting materials also offer natural resistance to the typical pests with which they have evolved, and therefore require less use of fertilizer and pesticides to remain healthy, which in turn diminishes the amount of toxic chemicals needed for their maintenance. They provide food and habitat for indigenous species, such as the local song birds and insects -- bees and butterflies, for instance, which are essential to the continuum of biodiversity.

Economic

The use of trees and plants that require less water, and the use of irrigation systems that deliver that water efficiently, reduces municipal water fees and operating costs. The use of captured or recycled water further mitigates these costs. Native, drought resistant plants require minimal physical maintenance as well as the use of less maintenance chemicals, which also benefits the bottom line.

Purchasing plants from regional nurseries and tree farms not only guarantees planting materials that are acclimatized to the New York weather patterns and are therefore suited to the site locale, it saves on the costs of trucking, and cuts down on the use of gasoline, with its associated pollution. A further advantage is that this strategy supports local nurseries and market gardens, and helps to maintain the economy of the region by supporting small businesses.

Fertilizers, pesticides and herbicides are among the most toxic chemicals handled regularly by the general population. Many have ingredients that are in the process of being phased out and/or totally banned in the United States because of their extreme levels of toxicity. Minimizing toxins such as these, which pollute the air, exposing site occupants both at times of spray applications and during windy conditions,

lessens the often severe health risks that are associated with exposure to pesticides and other such plant maintenance treatments. These spray and surface-applied chemicals also 'wash out' in stormwater, so any reduction in their use, together with decreased volumes of stormwater, minimize the amount and number of treatments needed to handle the waste from the site at the Newtown Creek Waste Facility, protecting the East River and New York Harbor ecology and reducing water conveyance fees.

Neighborhood

The original World Trade Center site was comprised of approximately 16 acres of land and the redevelopment zone now continues to grow. With an annual New York City rainfall of more than 47 inches, that means that some 25,000,000 gallons of precipitation in the form of rain and snow falls on the site each year. Capturing and retaining a large amount of this water will contribute to enhanced site hydrology and reduce the potential for stormwater/sewage outflows in times of heavy rain.

Using water wisely ensures that there will be sufficient available for community needs in times of scarcity. Potable water is best conserved for human use, and captured or recycled water, which has multiple applications, can be stretched by the sustainable strategies discussed in this chapter. Native or indigenous vegetation thrives on recycled waste water, which may deliver additional nutritional value (depending on the system), and will provide enriched green spaces and natural habitat for wildlife, enhancing community enjoyment of the site.

Minimized use of pesticides, fertilizers, herbicides and other chemical treatments contributes to a safer environment for human beings and wildlife, and to enhanced health of workers and community members. Fewer spray-type chemical applications reduce human exposure to airborne pollution. Fewer chemical toxins washing into the New York Harbor and nearby bodies of water enhance overall water quality and contribute to an increase in fish and marine animal populations, along with cleaner conditions for recreation, such as boating and fishing. Wildlife, including song birds, frequent locations with an abundance of native vegetation offering food and shelter that are not treated with excessive chemicals.

Methodology

Design Strategies

Specify trees, shrubs, flowering plants and ground cover that are indigenous, or that have become acclimatized to the conditions and weather patterns of the North East region of the United States. Once established, these plant materials will require minimal manual watering beyond regular rainfall. Ensure that planting beds are of a sufficient depth to support the tree or plants' root systems, with good drainage at the lower levels, and soil capable of retaining and storing rainfall water. Test and amend soil if necessary, so that the alkalinity and/or acidity is appropriate for intended plantings, and add organic matter such as compost, manure or mulch to help retain moisture in the planting beds. Avoid laying out planting beds under building overhangs, where possible, or where they will not receive the full effect of available rainfall.

Consider using Xeriscape landscaping to totally eliminate irrigation needs for part of, or the entire, site. After the first year in which they become established, Xeriscape systems can reduce total water demand by as much as 50%. Where irrigation is necessary, employ efficient irrigation technologies to disseminate irrigation water economically and effectively, so that there is little or no loss or waste, and water is widely distributed, reaching the maximum amount of site vegetation.

While strategically placed lawns are an important community asset, and need to be included in the overall planning for green spaces at the site, they also have a high water demand and require the heavy use of herbicides to manage weeds. Regular mowing throughout the growing season is necessary, which contributes significantly to air pollution at the site. In small areas which are not conducive to public recreation or relaxation, but which will contribute to the overall 'greenspace' and landscaping plan, plant alternative, indigenous ground covers, which require little water and maintenance.

Design a stormwater harvesting system with cistern storage tanks, and/or a gray water system, with a piped or flexible hose delivery system to provide a large percentage of water for irrigation.

Means and Methods

Stormwater collection systems provide the means to use rainfall from the impervious surfaces at the site for irrigation purposes. If cisterns or holding tanks associated with such a system are located at basement level or below ground, they can be protected from frost damage, which is a serious consideration in New York City. However, a pump system, which uses energy, will be necessary to deliver the stored water to plaza or street level. If the tanks are located at ground level, they will be more vulnerable to the freeze/thaw cycle, however a gravity feed may be used to deliver water on an 'as needs' basis to irrigation systems and for other purposes. In either case, the cisterns must be equipped with an overflow valve and a means to remove excess water in case of flooding at times of heavy precipitation. Treated gray water may be a part of an overall collection system, or handled and stored separately for use within the site's buildings or for landscaping purposes.

In addition to using 'salvaged' or recycled water, employment of permanent, high-efficiency irrigation systems for all watering functions will extend the spread and delivery of water more effectively. These may be sub-soil hoses or pipes, or they may be near the surface of the planting beds. The following strategies may be considered:

- Use of slow-drip emitters and other low-volume irrigation devices
- Include moisture/rain sensors, timers, and shut-off devices, or tensiometers, which may be used to automatically limit distribution of irrigation water after a heavy rainfall.
- Systems that coordinate water demand with real-time meteorological data.
- Use of electronic controllers with timing devices
- Plan for multiple irrigation zones, with multiple cycles in accordance with the anticipated needs of each plant type or green area
- Zone lawn or turf irrigation areas separately from planting beds and trees

By setting all mechanical watering devices, including slow-drip system timers, to operate before sunrise or in the evening, water absorption is maximized and the potential for evaporation is minimized. This simple strategy can save as much as 30% of irrigation demand. Another option is to establish a water use pattern through careful plant material selection that minimizes or eliminates the need for watering in early spring, late fall and winter. This requires the setting of timers to operate accurately with seasonal changes. Automatic timers must be adjustable to allow for appropriate modification of irrigation sequences in times of drought and city water emergency restrictions. Use high quality mulch to help retain moisture in the planting beds in summer, and as a cover to protect plants from frost damage in winter. In New York City, most irrigation systems need to be drained and shut down during the winter months to avoid the freeze/thaw cycle and damage to pipes and valves.

A centralized irrigation control system for large areas of the site will save costs and labor and will increase water efficiency. These systems are generally computerized. There are several programs available such as Hyper-SPACE™, and SPACE Irrigation Survey, both developed by the Center for Irrigation Technology at California State University. Since water use will be part of the commissioning plan for the building, install water meters dedicated to track landscape irrigation water use.

Case Studies

EPA Research Triangle Park Facility, Triangle Park, North Carolina

This building was erected on the heavily eroded land of an abandoned farm. The land was covered with second growth vegetation that was only about 50 years old. During site analysis, a grouping of 100-year-old trees was discovered and marked for preservation. In fact, the EPA and their design team preserved as many old-growth trees as they could find on the site. They enacted strict forest protection laws and limited clearing to those areas absolutely essential for the buildings' construction. To reduce the need for major landscape maintenance, site vegetation was selected for its low-maintenance characteristics. Native landscaping and wildflowers were employed to reduce the long-term needs for water, fertilizer, and fossil-fuel burning maintenance equipment. Volunteers spent four weekends salvaging existing native plants to be reincorporated into the site design. The EPA now manages this site as a wildlife habitat. (BuildingGreen.com 2003)

Reference

Definitions

Potable Water is water that is of sufficient quality that it has been approved for drinking by the authority having jurisdiction.

Xeriscape: A landscaping approach designed to respond to natural climactic conditions. It is primarily concerned with water conservation. A xeriscape landscape is considered 'dry' because it uses plant species that survive on typical rainfall that is available via the normal climatological cycle at the site.

Water Treatment:

- Primary treatment involves separation of suspended solids from wastewater by screening and sedimentation.

- Secondary treatment involves additional treatment, usually by biological processes, to remove organic matter and residual suspended material followed by disinfection
- Tertiary treatment produces higher quality effluent through the further removal of contaminants such as nitrogen, phosphorus, heavy metals, residual suspended and dissolved solids, and synthetic organic chemicals. Tertiary treatment can involve processes such as carbon adsorption, reverse osmosis, micro-filtration, and biological nitrogen and phosphorus removal.
  Source: Thomas et al. (1997).

Standards

Standards have not been included for this Guideline.

Bibliography

BuildingGreen.com. "EPA Research Triangle Park Campus." BuildingGreen.com – HPB Case Study: Site/Water . July 2003. BuildingGreen, Inc. 23 September 2004. <http://www.buildinggreen.com/hpb/site.cfm?ProjectID=30>

Solley, W.B., R.R. Pierce, and A.H. Perlman. "Estimated use of Water in the United States in 1995".

US Environmental Protection Agency. "What is Water-efficient Landscaping".

Landscape Hydrology

WEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ⊛ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	⊛	⊛ Ⓔ	⊛ Ⓔ	⊛	⊛

☐ **Required Component:**
A site planting plan, schedule, and anticipated water requirements are attached. Calculations estimating the percentage of irrigation requirements to be achieved through water harvesting are indicated. A narrative description is attached outlining the high-efficiency irrigation technologies that have been specified.

☐ **Optional Component** *(To satisfy the requirements of LEED™ 2.1 Water Efficiency Credit 1.1: Water Efficient Landscaping – 50% Reduction.)*
This certifies that potable water consumption for site irrigation has been reduced by at least 50% over conventional means. A brief narrative of the methods used to achieve this is attached.

☐ **Optional Component** *(To satisfy the requirements of LEED™ 2.1 Water Efficiency Credit 1.2: Water Efficient Landscaping – No Potable Use.)*
This certifies that the project site will not use any potable water for irrigation. A complete description of systems used to capture and recycle rain/site water is attached. A list of all plant species used and calculations demonstrating how their irrigation needs can be met by the water capture systems described above is also attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Energy Management EEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To conserve and optimize building energy use and minimize air emissions, including greenhouse gases, associated with energy consumption at the site.

Action: Prepare an Energy Management Plan to conserve and optimize building energy use, minimize air emissions and coordinate and maximize the utilization of any site generated energy resources. The Plan shall include an energy use budget for the project for the first year of operation (building shall be a minimum of 50% occupied with unoccupied areas and building systems normalized for full occupancy) and broken down by major energy consumption category (i.e., heating, cooling, lighting, fan energy, pump energy, etc.). Consider base building systems apart from occupancy with allowances for interconnections. After each year of operation, the actual utilization of energy shall be recorded and compared to this baseline energy use budget with appropriate adjustments for deviations in occupancy, base building conditions and climate norms. Significant deviations shall be evaluated and a detailed explanation for the probable cause of the deviation recorded in the updated plan. Strategies for reducing energy consumption below the first year of operation, as defined above, shall be identified and described.

The Energy Management Plan shall include a similar itemization of any site generated energy resources, including a budget for each component, and annual updates of actual performance. The Plan shall identify measures and strategies for increasing utilization of clean on-site energy above the first year of operation, as defined above.

Review opportunities for coordinated site strategies to conserve energy. Provide a matrix outlining additional costs and savings, available incentives, benefits and impacts from, for instance, a co-generation plant, river water cooling, building integrated PV, fuel cells and other strategies.

Related Guidelines: EEQ-2, EEQ-3, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8

Introduction/Context

The world-wide demand for energy continues to increase at a rapid pace. The majority of this electricity is still produced by methods that rely on the consumption of non-renewable carbon-based fuel sources such as coal, oil, and natural gas. As these resources are continually depleted, their value and purchase cost is quickly rising. Observation of the steady increase in the price of gasoline over the past few years clearly indicates the magnitude of this problem to everyone including the average consumer. The environmental costs of increased energy usage and increased burning of fossil fuels to generate power are also of great importance. Conservation is the first major step needed to curtail this expanding dilemma. Beyond reducing energy usage, the use of more efficient and less ecologically detrimental sources for energy will further reduce both its financial and environmental costs. Effective incorporation of on-site energy sources reduces the need for utility

capacity growth in dense urban areas during peak periods, while providing standby generation assets for emergency operation. Coordination of on-site generation assets with a commodity energy purchasing plan can further reduce site energy costs. The Energy Management Plan provides a tool to accomplish these goals and manage these costs, through both design and continued evaluation.

Relevant Issues

Ecological

The benefits of energy savings for the eco-system are widely acknowledged. Energy efficiency of human activities reduces the need for the energy conversion processes that add pollution to the environment. Beyond conservation, society can further promote the transition to less environmentally damaging methods of electricity generation that avoid the by-products of traditional production. The burning of fossil fuels releases mercury compounds and particulate matter which cause health problems, particularly of the respiratory system. When consumed, fossil fuels also release carbon dioxide, methane and various nitrogen oxides all of which contribute to the greenhouse effect causing global warming. Sulfur dioxide, also produced by the combustion of fossil fuels, is a major contributing factor to acid rain. While generation of electricity with nuclear fission avoids the immediate discharge of pollutants into the atmosphere, it creates the danger of catastrophic accidents and generates nuclear waste products whose thousand year toxicity results in intractable waste disposal systems. The reduction of energy society's energy needs is critical to the preservation of a clean and healthy planet. Moreover, the use of more efficient and benign energy sources, ideally renewable ones, to meet the balance of our energy needs will further help this cause.

Economic

Good energy management improves project economics both for the project bottom line and for the community. Energy efficiency has long been recognized as a viable method of reducing project operating costs. Coordination of energy efficiency measures with on-site generation assets through a design optimization process utilizing computerized energy simulation, can reduce not only project operating costs, but also the generation and transmission infrastructure upgrade costs, entailed by the project, that would otherwise be borne by the community.

Neighborhood

The improvement of water and air quality as conventional electricity generation decreases is a major benefit for the health and well being of society as a whole. Lessened pollutants from power plants will also result in cleaner buildings due to reduced airborne particulate matter which sullies facades, and acid rain, which corrodes building materials as well as affecting water quality. A reduction in energy demand, especially during peak hours, also increases electrical security, lessening the likelihood of major power failures. On-site utilization of waste heat from the generation process can further reduce operating costs, along with reducing the environmental burden of fossil fuel use for generation of low-grade heat.

Methodology

Design Strategies

From a general perspective, the strategies incorporated into the management plan fall into four areas. These areas include energy use conservation, site generation, renewable energy and ongoing management strategies.

The USGBC has identified several products and protocols which offer useful energy management strategies. The Commissioned Systems Manual required by LEED Credit EA3 is an indexed systems manual that provides a resource for sequence of operations for all equipment, operating instructions for all energy and water saving features and systems, functional performance test results, seasonal guidelines, sensor calibration recommendations, line diagrams of commissioned systems, troubleshooting tables and ongoing maintenance guidelines. The measurement and verification protocols identified as part of LEED Credit EA5 offer several paths to verification of equipment operation. These should aid in energy use conservation and ongoing management strategies.

On-site generation is a powerful tool for reducing project energy costs, societal infrastructure costs and environmental damage. On-site generation, especially when coupled with heat recovery for combined heat and power (CHP) applications, offers excellent economic return for many project types. The energy efficiency creating these costs, further reduces fuel consumption required to meet the project electricity demands. On-site generation further reduced the need of central generation and transmission upgrades necessary to support the electric requirements of the project.

On-site energy generation using a renewable source is even more advantageous from both a financial and ecological standpoint. Since renewable energy sources by definition are inexhaustible, their cost is largely associated with initial infrastructure and ongoing maintenance. As technology progresses these costs will be comparable if not less to those of more traditional, e.g. fossil fuel based, electricity production.

Means and Methods

Develop and execute the energy management plan (EEQ-1-P) This plan should include such strategies as energy use conservation, peak load reduction, on-site (and renewable) power generation, and continuing energy management.

Working with a building's energy profile in a holistic fashion is a crtical part of the design and decision making process. Potential interrelationships between different conservation strategies can make the individual techniques much more productive. Improvements in the building façade that lessen a buildings thermal load can permit the design of smaller HVAC systems which, in turn, use less energy to operate.

Explore the potential for on-site electricity generation with both renewable and non-renewable energy sources. While most didtributed generation applications utilize conventional fossil fuels, some operations have utilized renewable fuels, such as

land-fill ort sewer treatment generated gas, or bio-fuels. For a more thorough discussion of renewable energy please see EEQ-5.

Fuel Cells are another potential method for on-site electricity production. However, in their current state of development, they are not as viable as some of the other systems described above. Ongoing research is trying to find the most effective and clean method for supplying the hydrogen fuel that these cells need to operate. Current technologies use fuel reformers that take hydrocarbon-based fuels like natural gas and liberate their hydrogen. This has the negative side effect of releasing as much global-warming causing carbon dioxide as if the natural gas was simply burned to generate heat in a more conventional power plant. The fuel cell does have a benefit though, because it converts the fuel more efficiently and produces more electricity per unit of carbon dioxide released than combustion does.

Avoid using high-grade energy sources, such as electricity or chemical fuels to create low temperature heat for space heating or domestic hot water. Meet heating requirements from the recovered heat of energy conversion from chemical fuels to electricity or by utilizing heat pump technologies to extract heat from local environmental sources, such as the earth or surface water. Examples of small scale cogeneration include the use of micro-turbines as the heat source for domestic hot water. Electricity is generated as a by-product of the water heating process. Examples of heating with heat pump technology include ground source heat pumps, river or lake water source heat pumps, and domestic water heaters that provide domestic hot water while providing the useful by-product of space-cooling.

Photovoltaics convert only a portion of solar radiation to electricity with the balance of the energy being emitted as heat. Some systems have been configured to capture this heat for domestic hot water or space-heating end-uses. The waste heat from electricity generation with biomass fuels can also be captured and. Geothermal power systems present a similar opportunity. After the steam they create is used to produce electricity, it can be used for building conditioning or hot water production

Case Studies
Please note that, although the case studies discussed below involved existing buildings, they are still quite relevant to this topic. Because the concept of comparing a well-designed building's energy performance to a base-case scenario may seem abstract to many, taking a look at a "before and after" study showing the effect of specific energy management strategies on an existing building may be quite useful.

U.S. Department of Defense Naval Facilities Engineering Command Washington, DC
In its model energy program, the Naval Facilities Engineering Command (NAVFAC) demonstrated outstanding overall performance in energy management and conserved over 900 billion British Thermal Units (Btu) in the last year. The NAVFAC Energy Program used alternative financing mechanisms to fund energy efficiency improvements that produce significant guaranteed energy cost savings; installed renewable energy technologies and highly energy-efficient cogeneration plants, reducing dependence on power from the electric grid; and developed internet-based energy reporting tools to better track (and ultimately reduce) energy use and costs.

United States Postal Service Pacific Area Energy Management Program California, Nevada, Arizona, Hawaii and the Pacific Islands
The USPS Pacific Area Strategic Energy Management Plan enabled the USPS to save millions of dollars in energy costs, significantly reduce electricity consumption and improve the environment. The plan created a framework that includes an effective administrative structure, energy management tools for data collection and reporting to management and staff, performance goals, contractual vehicles, and implementation tools to evaluate and complete numerous energy efficiency projects.

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

Standards have not been provided for this Guideline.

Bibliography

ASHRAE/IESNA. ASHRAE/IESNA 90.1-1999: Energy Standard for Buildings Except Low-Rise Residential. Atlanta: ASHRAE/IESNA, 1999.

ASHRAE. Guideline 4-1993: Preparation of Operations and maintenance documentation for Building Systems. Atlanta: ASHRAE, 1993

Energy Star Partnership, Guide for Instituting a Strategic Energy Management Plan, Draft 2002.

Turner, Wayne C. Energy Management Handbook. Fifth Edition, The Fairmont Press, Lilburn, GA, 2004

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Energy Management Plan EEQ-1-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Energy Management Plan is designed to conserve and optimize building energy use, minimize air emissions and coordinate and maximize the utilization of any site generated energy resources. The plan provides for an integrated consideration of site energy generation and requirements, renewable alternatives and transition plans to full renewables, proximity of off-site energy generators, emissions, secondary energy sources (waste heat) and energy potentials within site waste products. The plan also outlines energy monitoring and reporting requirements of the PANYNJ and New York State (Executive Order 111).

Plan Components

I. Project Description (Plan Summary)

A. Provide a physical description of project with emphasis on energy systems. Include energy conservation opportunities, potential site energy sources, regional renewable and non renewable energy sources and site energy requirements.

II. Energy Resources/Requirements Inventory

A. Provide a detailed inventory of available on-site and off-site Renewable Energy Resources. These include Solar-Electric (Photovoltaic), low-impact hydroelectric, wind, tidal, geothermal, and bio-mass/bio-gas.

B. Provide a detailed inventory of available on-site and off-site non-Renewable Energy Resources.

C. Provide detailed accounting of site energy requirements with demand timetable. Accounting should be coordinated with the Measurement and Verification protocol instituted at the site. If the Measurement and Verification protocol is designed to facilitate recording of energy end-use components, such as lighting, heating, cooling, air movement, heat rejection, pumping, receptacles, etc, individual budgets can be established for these components and then verified over time. Breakdown of energy use into end-use components will greatly facilitate identification of system and component malfunctions in the energy systems.

III. Energy Management Strategies

A. The Plan shall include an energy use budget for the project for the first year of operation (building shall be a minimum of 50% occupied with unoccupied areas and building systems normalized for full occupancy) and broken down by major energy consumption category (i.e., heating, cooling, lighting, fan energy, pump energy, etc.). Consider base building systems apart from occupancy with allowances for interconnections. After each year of operation, the actual utilization of energy shall be recorded and compared to this baseline energy use

budget with appropriate adjustments for deviations in occupancy, base building conditions and climate norms. Significant deviations shall be evaluated and a detailed explanation for the probable cause of the deviation recorded in the updated plan.

B. Utilize full DOE-2 building energy model to optimize building energy use and investigate energy reducing alternatives.
C. Provide full and continuous monitoring of building energy systems.
D. Strategies for reducing energy consumption beyond the first year of operation, as defined above, shall be identified and described.
E. The Energy Management Plan shall include a similar itemization of any site generated energy resources, including a budget for each component, and annual updates of actual performance. The Plan shall identify measures and strategies for increasing utilization of clean on-site energy above the first year of operation, as defined above.
F. Review opportunities for coordinated site strategies to conserve energy. Provide matrix outlining additional costs and savings, available incentives, benefits and impacts from, for instance, a co-generation plant, river water cooling, building integrated PV, fuel cells and other strategies.

IV. Targets

Establish and describe project targets for the following

A. First year of operation.
B. 5 year and 10 year plans.
C. Year 2010 per the requirements of EO-111

V. Evaluation

See III.A. (*Note: The following Annual Energy Report is completed by PANYNJ, not the leaseholders of the site. It is provided here as a verification of the standard of energy management in effect under EO-111, and, by extension, the WTC Site.*

A. Annual Energy Report requirements as required by New York State under Executive Order 111
   1. Filing on December 1st of each year for the previous fiscal year (April 1st-March 30th) with NYSERDA.
   2. The target is a 30% reduction in energy consumption based on the Energy Use Index (EUI), which is calculated by dividing the total BTU's consumed by the total square footage and comparing it to a baseline year of 1989-90.
   3. There is a one-page form for this report that must be completed. It includes information on:
      a) The types of energy used and how much of each
      b) The reported energy use last year, the percent change and the use in the base year
      c) The total peak electrical demand in megawatts
      d) The amount of renewable power used in kilowatt/hours
      e) Compliance with EPA Energy Star criteria.

VI. References

<http://www.tcet.state.tx.us/PDF/052102Tech_Conf/Building%20Technologies/David%20Claridge.PDF>

<http://www.hvac.okstate.edu/pdfs/bs01/BS01_0335_342.pdf>

<http://www.eere.energy.gov/femp/operations_maintenance/commissioning_guidebook.cfm >

(Note: this is an excellent commissioning reference. The following link brings up the introductory chapter; the bookmarks then bring up succeeding chapters. This document blends commissioning into energy management, showing that they are just different phases of the same thing, and that the most successful strategy for energy management is continuous commissioning, where you continuously monitor whether systems and equipment are operating as intended.)

<http://www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm>

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Energy Management

EEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
An Energy Management Plan is attached and follows the requirements outlined by Guideline Document EEQ-1-P: Energy Management Plan.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Building Commissioning EEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To implement a Building Commissioning Plan.

Action: Engage an independent commissioning authority to prepare and execute a commissioning plan. Implement fundamental, best practice building commissioning procedures. Include design phase reviews, contractor submittal reviews, pre-functional and functional testing (including seasonal testing), training, Operations & Maintenance manuals and post occupancy review. Provide Building Commissioning Plan consistent with the requirements of NY State Green Building Tax Credit (NYSGBTC) 638.8.

Related Guidelines: EEQ-1, EEQ-3, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8, IEQ-4, IEQ-7, IEQ-8

LEED™ 2.1 Requirement: EQ Prerequisite 1 (see Submittal Template)

Introduction/Context
The goal of Building Commissioning is to ensure that the building, its systems and its equipment are delivered to the building owner fully functional and in accordance with the design intent. The Commissioning Authority is responsible for the Commissioning process and must be independent from both the Design team and the Contractor. Fundamental building commissioning is required by New York State EO-111 and is a prerequisite under the LEED™ Green Building Rating System. Additional commissioning, as defined in LEED Green Building Rating System Energy and Atmosphere, Credit 3, is not required by this guideline. The requirements of the Green Building Tax Credit, for commercial buildings, which require only commissioning of the base building systems, are extender under this guideline to include all energy using equipment and systems, even those installed during tenant improvement of the property.

Relevant Issues

Ecological

The direct result of commissioning is that the building systems provide exactly the required operating environment with the least expenditure of energy and water. By insuring that each piece of equipment is exactly as specified and that the equipment is being controlled according to the specified sequences of operation, commissioning assures that building operation minimizes waste and maximizes efficiency.

Economic

The economic benefits of building commissioning have consistently exceeded the actual cost of commissioning within the first year or first couple of years of operation. These economic benefits fall into a number of categories which incorporate both immediate first cost savings, or value capture, and future operating costs and capital replacement costs. The first category of cost savings involves verification of contractor delivery and correct installation of required products and systems. Often, the commissioning process identifies deficiencies in the construction delivered by the contractor and provides a reliable verification that the contractor has delivered all that was required by his contract.

The second category of economic benefits results from accelerated delivery of a fully functioning building. In conventional non-commissioning building hand-over from contractor to owner, the owner is typically involved in a protracted problem identification process. Because functionality of the individual building systems and components has not been rigorously explored, only through operation and use over time is the full range of operating sequences explored. Often this process can go on for years, with the contractor on call to correct deficiencies as they appear. This call-back process is inefficient and rarely results in timely corrections. For many owners and tenants this loss of functionality is also an economic loss.

The third category of economic benefit has to do with operating cost reductions, both in terms of energy use and maintenance. Correct initial set-up of equipment and systems results no only in more efficient alteration, it also results in more reliable operation. Detailed and complete conveyance of operations information to the owner's operating staff decreases required outside intervention necessary to achieve acceptable operation.

A final category of economic benefit from commissioning is the longer equipment life usually achieved by systems that benefit from complete and correct initial set-up and from complete education of operating personnel. The initial set-up and education process sets the course for a long and relatively trouble-free system life. The commissioning documents, furthermore, provide a vehicle for transferring facilities information across the generation of operators, insuring that personnel changeover does not result in deterioration of systems operating knowledge. Maintenance, adjustment, calibration and operations information are memorialized for use throughout the life off the facility.

Neighborhood

The commissioning process is a proven way for a building owner to confirm that the building, as delivered, is fully functional and calibrated to meet the stated systems performance requirements. The entire community benefits from a building that is fully-functional from the day it opens. Reduced energy use by such a building has positive effects for a neighborhood, including the availability of a greater electrical supply during peak demand periods and reduced health impacts, as well as reduced costs and fewer emissions associated with power plant operations. Greater satisfaction experienced by building occupants in a building with well-coordinated systems, and their ability to enjoy a healthier and more productive workplace, also benefits the population as a whole.

Methodology

Design Strategies

Follow one of the national standards for commissioning, such as Portland Energy Conservation, Inc. (PECI) or ASHRAE.

Means and Methods

Engage the Commissioning Authority at the beginning of Design Development

Make the commissioning Authority an active member off the design team.

Utilize the directed third party peer reviews described in LEED Credit EA3 to insure that the design documents match the design intent. Utilize the expertise of the Commissioning Authority as a resource for the detailed design of the project.

Utilize the Commissioning Authority in the preconstruction meeting to insure that General Contractor and subcontractors are aware of expectations for the project.

Plan for a Continuous Commissioning program utilizing a calibrated building energy simulation model coordination with the building measurement and verification protocol.

Case Studies

Marion County Courthouse Square, Salem, Oregon

The city of Salem wanted to be sure that their new transit mall facility would be a good example of sustainability. They decided to use the LEED certification process as a tool to evaluate the success of this goal and were required to have the new building commissioned as part of that endeavor. Putting this new facility through the commissioning process yielded benefits that were above and beyond simply qualifying for LEED certification. During this process, an independent commissioning

agent recommended 101 improvements, of varying importance, to make the building perform up to the standards of its designers' original intent. 13 of these recommendations were considered to be critical action items that required correction in order for the building to perform as desired by its client and design team. Some of these issues included inaccurate flow and temperature sensors, excessive operation of cooling units, improper control of supply air temperatures, malfunctioning economizer cycle, and outside air volume control difficulties. The commissioning process also revealed incorrect operation of the heating system, leading to an inability of the system to warm the lobby on cold days. Through the commissioning process all of these issues were both discovered and corrected before the building was permanently inhabited. Occupant comfort and efficient operation were achieved from the moment of building occupancy, avoiding the traditional break-in period of occupant complaints, expensive operation, and equipment failures.

North Clackamas High School, Clackamass, Oregon
This LEED Silver certified building underwent a valuable commission process in preparation for hosting its 1,850-member student body. The process began early in the construction phase and was completed shortly after the building's opening. The commissioning review exposed 75 concerns, 15 of which were serious. These major issues included improperly calibrated static pressure controllers, faulty carbon dioxide sensors, excessive running of pumps and exhaust fans, the need for damper adjustment and repair, and incorrect lighting control sequences. The resolution of these deficiencies resulted in a reduction of electricity usage of roughly 35,800 kWh/year and a reduction of natural gas usage of about 6,100 therms/year. This translates to an annual energy savings of $7,700. Besides economic benefits, the correction of these issues as a result of the commissioning process also helped create a school that is much more comfortable for students and teachers and has fewer maintenance issues (that would likely result in occupant complaints) for its staff to cope with.

Reference

Definitions

Commissioning Agent – the organization that performs the actual commissioning tests, including the operating performance test, calibration testing, and owner education

Commissioning Authority – the organization that manages the commissioning process, establishing the scopes of work for all participants, scheduling major activities, and providing documentation of all commissioning activities.

Operating Performance Test – Programmed run-throughs of all operating cycles of equipment within a system to demonstrate the functionality of the equipment, controls, and the system as a whole throughout the range of its operation. Operating performance tests are created for each system with written, repeatable test procedures, with expected system responses and acceptance criteria.

Standards

Standards have not been included for this Guideline.

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Building Commissioning Plan EEQ-2-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The USGBC defines Building Commissioning as, "A systematic process to ensure that all building systems perform interactively according to the Contract Documents, the Design Intent and the Owners Operational Needs." It is a process that ideally begins in the Pre-design phase, continues through Design and Construction and concludes with Acceptance by the Owner. The purpose of this Plan is to outline and provide a framework for the Building Commissioning Process.

Plan Components

The Building Commissioning Plan components identified below have been made consistent with the requirements of NY State Green Building Tax Credit (NYSGBTC) 638.8 and the intent of the LEED Prerequisite on Fundamental Building Commissioning.

I. **Selection of Commissioning Agent and Identification of Commissioning Team**

A. According to USGBC requirements the Commissioning Authority "can be from a design team firm, as long as that person is not responsible for project design, supervision or construction management."

B. The team will include the owner, users, occupants, operations and maintenance staff, design professionals and contractors.

C. The Commissioning Authority has the responsibility to insure that all of the required steps of the commissioning process are completed. He will direct the design team to furnish the information necessary for the commissioning process and will direct the commissioning agent to perform those tests, demonstrations, and other activities to document the conformance of the constructed project with the Design Intent document and the construction documents.

II. **Pre-Design**

A. Document owner's requirements and design intent.
B. Prepare outline of Commissioning Plan.
C. Define systems to be commissioned and roles of each stakeholder in the commissioning process.
D. Define Owner's goals and expectations to be included in the Design Intent document.
E. Prepare Basis of Design document outline including building program, design codes and standards, environmental conditions and assumptions

III. **Design Phase**

A. Review the Basis of Design narrative and add, zone occupancy, systems and processes, commissioning criteria and control logic or sequence of operation, as the design progresses.

B. Prepare and update the building Energy Model including the building envelope and mechanical system assumptions and verify anticipated building energy baseline.
C. Perform commissioning-focused design review.
D. Provide the Commissioning Specification that identifies the scope of commissioning, and the responsibilities of Owner, Engineers, Contractor(s), and Commissioning Authority.
E. Update Commissioning Plan.

IV. Construction Phase

A. Document that all tasks identified in the Commissioning Plan are carried out in a complete and timely manner including the following construction phase tasks:
   1. Verify and document procedures for cleaning and testing of HVAC piping and ductwork, and review and approval of Final Report.
   2. Verify and document functionality of HVAC system controls, interlocks, monitoring, and alarms.
   3. Verify and document calibration of valve and damper operators, limit switches, and sensors.
   4. Identify observed construction deficiencies and provide progress reports For corrective activities.
   5. Verify and document accuracy of Testing, Adjusting and Balancing contractor. This will be accomplished by testing 20% of control valves, and all pumps, air handling units, chillers, and auxiliary boiler.
B. Provide repeatability testing and performance verification procedures of all systems and equipment.
C. Review reference manuals for operation, maintenance, and monitoring of all systems and equipment and append as required to provide a complete and functional document.

V. Acceptance Phase

A. Prerequisites to Acceptance Phase
   Before the acceptance procedures can start, the following shall be observed and documented:
   1. HVAC systems and associated subsystems have been completed, calibrated, and started up and are believed to be operating in accordance with contract documents.
   2. Automatic control systems have been completed and calibrated and are believed to be operating in accordance with contract documents.
   3. Testing, adjusting, and balancing procedures have been completed, and all TAB reports have been submitted and reviewed and discrepancies corrected and accepted.
   4. A statement shall be issued certifying that all work has been completed and equipment and systems are operational in accordance with contract documents
B. Verification
   Verification comprises a full range of checks and tests to determine that all components, equipment, systems, and interfaces between systems operate in accordance with contract documents. This includes all operating modes, all interlocks, all control responses, and all specified responses to abnormal or

emergency conditions. Verification of the proper operation of the control system also includes verifying the interface of the control system with the TAB criteria and the response of monitoring and control system controllers and sensors. Verification of operating modes, etc., can be done concurrently with controllers and sensors. Verification will also validate the TAB report. Depending upon the scope of the project, previously agreed upon percentages of different devices will be subjected to the verification process. The Verification process shall be complete before Final Acceptance can occur.

1. The field verification of the final TAB report will be directed and witnessed and the results certified.
2. Verification of the water flows reported by the TAB Report for the chilled water supply to the air handling units and cooling coils. The Commissioning Agent shall verify that the actual water flows reported to these devices is correct to within 10% of the reported values. A failure of the Commissioning Agent's test shall require that the TAB rebalance all water flows to all air handling equipment.
3. Verification of the air flows to the occupied spaces. The Commissioning Agent shall verify that the actual air flows to the occupied spaces are correct to within 10% of the reported values.
4. Verification of the calibration of the controls and instrumentation for the automatic temperature control system. The Commissioning Agent shall verify the calibration of the specified percentage of the thermostats, regulators, temperature and pressure sensors, and flow metering devices installed. This representative sample shall be accurate to within +/- 10% to the setpoint. A failure of more than 5% of tested devices to meet the test criteria shall be cause for a determination of failure and a requirement for the Contractor to recalibrate all instruments.
5. Verification of sequence of control function. The Commissioning Agent shall randomly select one control sequence of operation for each system and verify that it functions in accordance with the specified sequence of operation and provides the appropriate control function. A failure of more than 5% of the randomly selected tested controls shall require that the automatic temperature control contractor re-verify all controls.
6. Verification of the proper installation insulation for ducting and piping. The Commissioning Agent should randomly check insulation thickness, existence of a continuous vapor barrier, and acceptable conditions at pipe and duct support points. Any observed deficiencies must be immediately repaired.
7. Verification of steam trap operation. AS specified percentage of the steam traps should be checked to insure their proper function and to verify that they are not leaking. Because of the limited number of traps for this system, 50% of the traps should be checked.
8. Verification of the controls for the lighting systems. The Commissioning Agent should check both the room occupancy sensors for proper action in controlling room lighting based on room occupancy, and the photo sensors designed to shut down artificial lighting when natural lighting is available. The

testing should cover the specified percentage of the installed occupancy and lighting sensors, and a failure of 10% of these tested devices to function per design will require all such devices to be recalibrated by the contractor.

9. Verification Report. The final tabulated checklist data sheets shall be assembled in a verification report and submitted to the commissioning team for review. The verification report shall document any unresolved deficiencies and may suggest a method of correction. The Commissioning Authority shall determine if verification is complete and whether the HVAC system is functioning in accordance with the contract documents.
10. Certificate of Readiness. A Certificate of Readiness shall be issued stating that all equipment, systems, and controls are now complete and ready for functional performance testing to begin. This certificate shall be supported by completed pre-start / start-up checklists, signed by the responsible parties, and the final verification report.

C. Functional Performance Testing

Functional performance testing should progress from tests of individual components of the central equipment and systems, including chillers, cooling towers, boilers, and pumping systems, to tests of the systems that distribute the HVAC services throughout the building. The extent of these tests, as well as details of the services to be tested, shall be in accordance with the contract documents. *(Please note that these are typically dynamic tests involving predicted performance, observation of system response, and independent verification.)*

D. Training

Training prepares the building operators to take possession of the building and to operate it in the fashion for which it was designed. The training process should convey both the information necessary for building operation and the rationale that governed the design. After training, the building operators should understand, not only building operation, but also why the design is the way it is. To achieve that end, training should include not only constructors and vendors, but also members of the design team. Documents transferred during the training process should include not only the operations and maintenance manuals from the vendors, but also the Basis of Design from the Design team, along with transcripts of the Functional Performance Testing.

E. Final Acceptance

To conclude the acceptance phase, as-built documentation must be compiled, the Commissioning Report and Systems Manual must be completed and submitted, and recommendation for acceptance of the facility determined. It is possible that some acceptance procedures (such as off-season tests) may not have yet been completed, but this should not impede final acceptance.

Building Commissioning

EEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 1: Fundamental Building Systems Commissioning)*
A Commissioning Plan is attached and incorporates the requirements of the Green Building Tax Credit 638.8 (f), LEED Fundamental Building Commissioning Prerequisite and the requirements of EEQ-2-P.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Optimize Energy Performance EEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To optimize the performance of building energy systems

Action: Optimize the performance of building energy systems through the utilization of a full DOE-2.1E, DOE-2.2, or Energy Plus building energy model to compare alternative strategies for energy efficiency (kwh) peak load reduction (kW) and reduced use of fossil fuels. Integrate with the Energy Management Plan. This is to include the full analysis of architectural and mechanical decisions in relationship to building energy expenditures. Achieve a minimum of 20% decrease in energy cost above ASHRAE 90.1-1999. This savings reflects both tower and office tenant build-out potentials. Tenant build-out potential (as demonstrated in a typical tenant build-out) will be modeled in the same integrated exercise and the economic results provided to potential tenants in support of the preferred build-out. Include full list of energy conserving opportunities available to tenants.

Provide daylight dimming and occupancy sensors on light fixtures where appropriate. All light fixtures to use high efficiency ballasts and low mercury/low lead, long life lamps. Specify recyclable lamps. Utilize energy efficient equipment, which meets or exceeds the following; NEMA premium efficiency motors, variable speed systems for all fans, pumps and motors and ENERGY STAR® products. Comply with FEMP levels for commercial products not rated by ENERGY STAR®. Provide a high performance building envelope, including minimized thermal bridging, superior insulation, air infiltration barrier and insulated wavelength selective glazing (to improve daylight transmission). Provide envelope construction details consistent with NYSGBTC 638.7(d)(2). Use air-side and water-side economizers, as appropriate.

Related Guidelines: EEQ-1, EEQ-2, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8

LEED™ 2.1 Requirement: EQ Prerequisite 2 (see Submittal Template)
Potential LEED™ 2.1 Credits: 2 possible with EA cr. 1.1, &1.2. (see Submittal Template)

Introduction/Context
Building Energy use accounts for approximately 40% of the annual energy use in the United States. Savings of up to 50%, as compared to buildings that just comply with energy code, have been demonstrated by individual high performance buildings. Many of these highly energy-efficient designs utilize off-the-shelf systems, components and design strategies, with no reduction in amenity or functionality. Achievement of these savings requires a knowledgeable design team with an integrated design approach, a flexible and sophisticated owner and a dedication to the energy efficiency goal.

Relevant Issues

Ecological
Building energy use contributes to all of the environmental problems of our energy intensive society. Generation of electrical energy and combustion of hydrocarbon fuels contributes to global warming and to air pollution from the by-products of combustion SO_2, NO_X, CO_2, heavy metals, mercury, and other particulate by-products..

Economic
Energy conservation in buildings often represents a very low-risk, high return investment for owners. Improvements in building energy efficiency of up to 20% can be obtained with very little additional first cost, merely by employing good design standards. Significant energy operating cost savings, over 30%, can be obtained by instituting measures that provide simple payback periods of less than 5 years. When taken together, the first-cost of heating, cooling and electrical load reduction measures is offset by reduced system size, complexity and cost, often resulting in significant operating cost savings at little additional first cost.

Neighborhood
Energy-efficiency resulting in more comfortable indoor environments can increase worker satisfaction and greatly enhance productivity. Some companies use this as a strategic recruiting tool. Energy-efficiency measures reduce demand, resulting in lower and more stable energy prices. Reduced energy use limits the consumption of finite natural resources and mitigates emissions that cause water and air pollution.

Methodology

Design Strategies
Optimized building energy performance requires an integrated design effort involving all disciplines of the design team. While individual energy conservation measures may be proprietary to a single discipline, their implementation and performance typically interacts with many other elements of the building which fall into the purview of multiple disciplines. In general, the strategy to optimize energy performance can be organized into the following sequence of activities:

1. Minimize heating, cooling, ventilation, lighting and electrical loads.
2. Select systems to meet the resulting loads in an optimally efficient fashion, especially during non-peak, or part-load operation.
3. Select system components for maximum energy efficiency.
4. Design control sequences to minimize system operations.

While these steps seem sequential, in fact, the process is interactive and iterative, and many of the solutions initially may seem counter-intuitive. The energy optimization design task is best informed by a comprehensive design assistance activity utilizing computerized building energy analysis and other forms of computer simulation and calculation appropriate for the particular design. The computer analyses provide numerical results for the individual design alternatives, and further examination of these results can provide insight into the optimal direction of the design efforts.

Means and Methods
Several strategies are known to be effective in office and commercial buildings for the cost-effective reduction of building energy costs. These include:

- Energy Star office equipment with automatic low-energy "sleep mode" when equipment is not in use.
- Maximum efficiency lamps, ballasts and light fixtures to exceed ASHRAE Standard 90.1-2004 lighting power density requirements. The maximum power density for lighting for open office applications in this standard is 1.1 Watts per square foot.
- Recyclable, low mercury/low-lead long-life lamps
- Daylight Responsive lighting control
- Demand controlled ventilation
- Optimized building envelope, including high performance windows with selective low-e coated glass and thermally broken frames..Window systems should be selected with an assembly U-value of no greater than 0.45 and a SHGC, Solar Heat Gain Coefficient, of no more than 0.36
- Variable speed pumps, fans, water chillers, and refrigeration compressors.
- All electric motors to be NEMA premium efficiency rated.
- Highest efficiency equipment including water chillers, and other refrigeration devices, pumps, fans and air-handling units. Water cooled water chillers should be selected with a maximum power draw of 0.55 kiloWatts per ton at ARI conditions. Other water cooled refrigeration devices should be selected at less than 0.7 kiloWatts per ton. Air cooled refrigeration devices should be selected at no more than 1.05 kiloWatts per ton. Packaged water cooled refrigeration devices should be selected with an EER of at least 13. Pumps should be selected with a minimum mechanical efficiency of 70%, while fans should be selected with a minimum mechanical efficiency of 65%.
- High temperature difference thermal transport systems, such as low temperature air delivery and large temperature difference chilled and hot water supply systems. Low temperature air delivery (supply air temperatures below 50°F) can significantly reduce fan energy for air conditioning at the expense of a minor increase in refrigeration energy. The resulting decrease in air handling unit and ductwork sizes can significantly reduce air conditioning system first costs and the required architectural accommodations for these systems.
- Optimized design of thermal transport systems to reduce pressure drop and thermal losses. Examples include use of large radius elbow, where possible in ductwork, attention to ductwork configuration immediately downstream of fans to minimize "System Effect", and selection of pipe sizes and accessories to minimize pressure drop.
- Separation of ventilation and dehumidification functions from sensible heating and cooling functions.
- More efficient thermal comfort delivery systems, such as radiant heating/cooling, and displacement ventilation. Such systems rely upon natural heat transfer forces such as convection and radiation, rather than upon forced air to transfer thermal energy to the occupied space.
- Occupancy sensor controlled lighting, and, in some cases, air conditioning.

- Combined Heat and Power (CHP)
- Electric peak demand control
- Building automation systems with optimal start-stop algorithms, equipment optimization algorithms, and malfunction detection algorithms.
- High-performance chillers
- High-performance glazing/windows

Several of these measures may seem may seem straightforward and unilateral, others are more complex, with off-setting and counter-intuitive interactions among multiple energy efficiency measures. For example, with respect to the building envelope, certain measures, such as minimized thermal bridging, superior insulation, air infiltration barriers and insulated, wavelength selective glazing should be optimized within the allowances of the building budget. Products should be selected at some point of diminishing returns, where further improvement would not be cost effective. Other envelope characteristics, such as the ratio of the building perimeter to the usable area of the floor plate and the percentage of glass in the envelope have a more complex impact on building energy cost. These variables do not demonstrate a simple linear relationship with building energy efficiency, having interactions among themselves that significantly alter their impact on building energy consumption. For example, while an optimally energy efficient building would have a relatively large percentage of its floor area daylit, this increase in daylit floor area is best achieved by elongating the building perimeter to bring more floor area close to the window wall, rather than by increasing the glass height to bring daylight more deeply into the floor plate. The optimal trade-off between glass and opaque wall, perimeter length and floor area will be particular to each project and must be determined through computer simulations.

A common design management technique for the design of energy efficient buildings is called energy budgeting. This technique sets aside a first cost budget allowance line-item for energy efficiency measures early in the design process, based upon the capitalized value of the maximum achievable energy cost savings for the project. When additional first cost energy efficiency items are validated and incorporated into the project as the design progresses, the additional first cost of the items are withdrawn from the energy efficiency allowance and installed into the appropriate place in the cost budget. Because each energy efficiency measure must at least meet the specific economic criteria upon which the capitalization of the budget was based, the total first cost addition of energy efficiency measures will always be less than the budget allowance and the combined economic performance of all of the approved measures will be better than the capitalization criteria.

Because of the innovative nature of some of the energy efficiency solutions that might arise from these design efforts, full commissioning is considered a must for these high performance buildings.

Case Studies

The Plaza at PPL Center, Allentown ,PA

The building has energy, and consequently, cost savings of 30% compared with a minimally code compliant building. Building envelope energy efficiency measures include brises-soleils and canopies to shade the south façade of the building, and high-performance glazing, walls, and roofs to reduce conductive gains and losses.

Lighting controls reduce lighting energy more than 30% during the day, while occupancy sensors further reduce lighting energy in support rooms without daylight. HVAC energy efficiency measures include: an enthalpy wheel to recover heat and humidity from exhaust air to precondition incoming ventilation air; carbon dioxide sensors to control the flow of outdoor air directly to spaces where it is needed; an ice-storage system to allow small chillers to run only at peak efficiency, and smart controls to carefully regulate building system operation.

The William Jefferson Clinton Presidential Center, Little Rock, AR
The building has energy cost savings of 33% compared with a minimally code compliant building. Building envelope energy efficiency measures include external shading devices on the west side of the building and high performance glass. Photocells control ambient lighting in response to daylight levels. HVAC energy efficiency measures include radiant heating and cooling floors, displacement ventilation, demand controlled ventilation and desiccant dehumidification. The building includes a 50 KW photovoltaic array. The percentage of total energy provided through the photovoltaic system is significantly increased by the rigorous energy efficiency program that dramatically reduced overall building energy costs.

Reference

Definitions

Assembly U-Value – the thermal transmission value of the window and framing system, acting together as a whole. The assembly U-value increase three dimensional thermal conductions effects between glazing and framing members.

Combined heat and power – Generation of electricity on site with collection and beneficial use of waste heat from the generation process.

Daylight responsive Lighting Control – control of electric lighting in the space to maintain specific lighting levels, taking into account the contribution of daylight to maintenance of those lighting levels.

Demand Controlled Ventilation – Control of ventilation rates to the space in response to occupancy levels. Typically this is accomplished by maintaining a constant concentration differential of carbon dioxide between the ventilation air and the interior air. Given that humans operating a fixed metabolic level generate carbon dioxide at a constant rate per unit of body weight, maintaining a constant concentration differential maintains a constant ventilation rate per pound of human body.

EER – Energy Efficiency Ratio – the ratio of BTU's of cooling output from a refrigeration device to Watts of electricity input.

Electric Peak Demand Control – control of electric devices or dispatch of distributed generation assets to maintain a fixed limit of maximum electric demand for a facility. Electric demand control often results in de-energizing discretionary electric loads during periods of high electric demand.

FEMP is shorthand for the Federal Energy Management Program, an endeavor of the U.S. Department of Energy. This program is intended to reduce the cost and environmental impact of the federal government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy and improving utility management decisions at federal sites.

NEMA is shorthand for the National Electrical Manufacture's Association.

Selective Low-e coated glass – Glass with applied coatings that selectively transmit visible light while absorbing or reflecting the non-visible portions of the solar spectrum. Non-visible components, including ultra-violet and near infra-red radiation account for about 55% of the energy of sunlight. Rejection of these non-visible components reduces solar heat gain, while maintaining daylight transmission through the glass.

Solar Heat Gain Coefficient – The fraction of incident solar heat gain that is transmitted through a glazing system

System Effect – Pressure drop in a ductwork system that is caused by the geometry of the ductwork system immediately downstream of the fan discharge. Air flow at the fan outlet is typically at a high velocity and is typically asymmetric across the discharge throat as a function of fan rotation. Incorrect configuration of ductwork at this outlet can result in very large pressure drops.

Thermal Transport System - the means for conveying heat energy around the building. Typical heat transfer fluids include air and water.

Standards

ASHRAE/IESNA. ASHRAE/IESNA 90.1-1999: Energy Standard for Buildings Except Low-Rise Residential. Atlanta: ASHRAE/IESNA, 1999.

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Optimize Energy Performance

EEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
Building energy systems have been optimized through the use of a full energy model (created with either DOE-2.1E or Energy Plus). During this process alternative strategies for energy efficiency, peak load reduction, and increased use of renewable energy were compared. A full analysis of architectural and mechanical decisions have also been studied in relationship to building energy expenditures. The results of the above studies have been integrated with the energy management plan and are attached.

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 2 and Credit 1: Optimize Energy Performance – 20%)*
This certifies that the project will achieve a minimum of a 20% decrease in energy cost above ASHRAE 90.1-1999. The attached energy model supports this statement.

☐ **Required Component:**
The optimization of lighting has been studied. Where effective, daylight dimming and occupancy sensors have been provided on light fixtures. All light fixtures use high efficiency ballasts and low mercury/low lead, long life lamps. Recyclable lamps have been specified.

☐ **Required Component:**
Energy efficient equipment has been specified that meets or exceeds the following: NEMA premium efficiency motors, variable speed systems for all fans, pumps, and motors, AND Energy Star® products where feasible. All commercial products not rated by Energy Star® comply with FEMP.

☐ **Required Component:**
A high performance building envelope has been provided that includes minimized thermal bridging, superior insulation, air infiltration barriers, and insulated, wavelength selective glazing. Typical envelope construction details are attached and consistent with NYSGBTC 638.7(d)(2).

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 1: Optimize Energy Performance – 25%-60% {potential for 8 additional points})*
This certifies that the project will achieve a minimum of a ___% decrease in energy cost above ASHRAE 90.1-1999 and is expected to qualify for ___ additional points (above and beyond the 3 awarded points for a 25% decrease) under *LEED™ 2.1 Energy and Atmosphere Credit 1: Optimize Energy Performance*. The attached energy model supports this statement.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

Ozone Layer Protection

EEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce emission of ozone depleting chemicals.

Action: Specify building HVAC systems with zero levels of CFC refrigerants, and provide plan for future elimination of HCFCs and Halon in HVAC and refrigeration equipment and fire suppression systems. Avoid insulation materials that utilize chlorine-based gases.

Related Guidelines: EEQ-1, EEQ-3, MEQ-1

LEED™ 2.1 Requirement: EQ Prerequisite 3 (see Submittal Template)

Introduction/Context

In 1930 a team at DuPont synthesized a new family of refrigerants to replace sulfur dioxide and ammonia, which had been in use since the advent of mechanical cooling. This creation of a family of synthetic gases called chlorofluorocarbons (CFCs) provided the standard refrigerants for HVAC and other refrigeration systems. The refrigeration industry and the production of CFCs increased rapidly following World War II and nobody realized that these gases might be environmentally problematic until 1974. At that time scientists began to hypothesize that if liberated chlorine atoms reach the stratosphere, they could attack the ozone molecules that protect the Earth from ultraviolet radiation. At this point in history CFCs were the only known mechanism by which chlorine could make it to the upper atmosphere due to their molecular stability. This theory did not create much concern among the members of the scientific community until the hole in the ozone layer above Antarctica was noticed in 1985. This discovery caused much alarm and ultimately led to an international treaty, The Montreal Protocol on Substances that Deplete the Ozone Layer, in 1987. This treaty was amended several times as different options for replacements for CFCs became viable. The treaty called for the cessation of both production and consumption of compounds that damage the ozone layer by the year 2000. This included CFCs, halons, carbon tetrachloride, and methyl chloroform. (The phase-out date for methyl chloroform is actually 2005) By the beginning of 1996, the production of CFCs and most other "Class I" ozone depleting substances was banned in the United States as well as a majority of the other industrialized nations around the world. In the building industry this mostly affects HVAC, refrigeration, and fire-suppression systems, as well as the manufacture of thermal insulation.

Modern refrigeration systems are designed to prevent the discharge of refrigerants into the atmosphere through the use of high efficiency purge systems, which purge water and air from the system while leaking very little refrigerant. Regulations require the recycling and recapture of refrigerants when refrigeration devices are serviced or retired. The LEED Technical and Scientific Advisory Committee (TSAC) has authored a document that will be incorporated into LEED 2.2 to modify LEED Credit EA-4. Under the new procedure, the point in Credit EA-4, which currently is awarded for complete avoidance of HCFCs, can now

be earned, even when using HCFCs, if procedures and equipment are utilized to prevent discharge of the refrigerant and if the more energy efficient characteristics of the HCFC refrigerants are fully utilized.

Hydrofluorocarbons (HFCS), which do not cause ozone destruction, have been proposed as more long-term replacements for CFCs and HCFCs

Relevant Issues

Ecological

The escape of CFCs from equipment into the atmosphere creates conditions that cause environmental harm. When CFCs reach the stratosphere, they react chemically with ozone molecules, destroying them. This has causes a thinning of the ozone layer, which serves as the ultraviolet radiation shield for Earth, and eventually a hole appears. Without this shield, increased ultraviolet radiation strikes the Earth's surface where it causes severe problems for people, such as skin cancer. UV radiation also damages other living systems, for example, disrupting the aquatic food chain, 'burning' the soft tissue of amphibians, altering plant-insect interactions, changing the growth patterns of fungi, and reducing the productivity of agricultural plants. CFCs are also greenhouse gases. They linger in the upper atmosphere and trap heat on Earth, rather than letting it escape to outer space. Over time CFCs contribute to global warming, which has deleterious effects on the planet's overall climate.

HCFCs, one of the interim replacements for CFCs, have a half-life of CFCs and less potential for destroying ozone and exacerbating the greenhouse effect. This can be quantified by comparing the global warming potential (GWP) and the ozone depletion potential (ODP) of specific chemical compounds. For example, CFC-502, one of the least environmentally destructive CFC refrigerants, has a GWP of 4,600 and an ODP of 0.221, while HCFC-123, a comparable refrigerant, has much lower values – a GWP of 1,700 and an ODP of 0.04. Hydrofluorocarbons (HFCs), another refrigerant replacement option have no chlorine molecules and most have an ODP of 0. However, many HFCs actually have a higher GWP than their HCFC counterparts. For example, HFC-404A has a GWP of 3,900 compared to the 1,700 GWP of HCFC-123. In addition, some HCFC refrigerants are inherently more energy efficient than their less environmentally damaging HFC replacements. This has the unfortunate effect of forcing a choice between the lesser of two evils, the destruction of the ozone layer or less energy efficiency..

Halons are extreme offenders in terms of ozone destruction. Some varieties of the gas destroy ten times as much ozone as CFCs. For example, one of the Halons with a low GWP, Halon 1211 has an ODP of 3.0! Some Halons also contribute significantly to global warming, while others have virtually no impact: e.g. Halon 1211 has a negligible GWP, while Halon 1301 has a GWP of 5,600.

The chlorine molecules present in certain gases used in the manufacture of specific types of building insulation also destroy stratospheric ozone.

Economic

As the ozone layer diminishes, greater levels of ultraviolet radiation are able to strike earth with damaging consequences. Effects such as the reduction of crop yields and damage to the ecosystem's natural food cycle have significant economic implications. Negative health effects for humans exposed to UV radiation lead to increased medical costs. Although there are financial implications associated with the removal of cheap, available ozone depleting chemicals from industry, these costs will be quickly off-set by avoiding UV radiation damage.

CFCs were once the cheapest gases to use for refrigerants. However, because CFC production in the United States was banned in 1995, most non-CFC HVAC and refrigeration systems available today (using HCFCs and HFCs) are not significantly higher in cost than their CFC predecessors. However the decreased efficiency of some of these replacement refrigerants may increase a building's electricity needs and operational costs. Since some HCFC refrigerants are inherently more energy efficient than their HFC replacements, this may result in a conflict between ecological and economic goals.

Currently, alternatives to Halon fire suppression systems are all more costly. Common replacement gases for Halon in a "total flooding" gaseous system includes HFCs. These systems cost anywhere from twice to three times as much as a Halon system, depending upon which specific HFC is specified. Systems that use non-chlorine-based gases, such as HFCs and other inert gases, cost even more than that. Alternatives to "total flooding" gaseous systems, such as fine water mist systems, also have a cost impact, equivalent to non-CFC-based systems.

Measures to reduce ozone depletion from the insulation industry include alternative manufacture practices and the use of alternative types of insulation. Many common types of solid foam insulation begin as liquids that are expanded and dried during the manufacturing process using CFC or HCFC gases. Other types of granular insulation that are "blown" into cavities use these damaging gases as delivery agents. However, most of the large chemical companies and insulation manufacturers are now developing air expansion and water blowing technologies that will eliminate the need for ODMs in their processes.

While these environmentally superior techniques are being developed, there are currently two economic disadvantages. A large capital investment is required to convert plants to use these alternative technologies. In some cases, more environmentally benign production techniques cannot produce insulation with as high of an R-value as those using ozone-destroying and greenhouse gases. This means that more insulation is required for an application, at added cost. Technology can be incorporated into the production line to capture and recycle ozone-depleting gases that are used to foam insulation materials. However, this too adds additional cost to the manufacturing process, which is passed on to the consumer. Use of alternative types of insulation may be a more cost-effective strategy. Effort must be spent to find a balance between environmental stewardship, economy and function when selecting building insulation.

Neighborhood

The stratospheric ozone layer protects Earth's inhabitants from ultraviolet radiation. When people are overexposed to UV rays, their risk of developing serious medical problems including skin cancer, cataracts, and weakened immune systems is greatly increased. Over-exposure to UV rays adversely affects wildlife, and is considered to be a major factor in the die-out of many amphibians and whole families of frog and newt species. This begins to create a biodiversity 'gap', which is a serious event in the natural world and ultimately for all life on earth. Many crop yields are significantly lower as a result of exposure to extreme levels of ultraviolet rays. Preventing the use of ozone-destroying substances can help avoid these problems.

Greenhouse gases cause global warming and drastic climate change worldwide. Increased summer temperatures present health risks for elderly people and those susceptible to heat stroke. Violent storms and extreme weather often result from these temperature changes, causing destruction to property, woodlands and crops, as well as causing storm-related deaths. By reducing the use of chemicals, especially chlorine, which contributes to the greenhouse effect, quality of life can be better protected.

Methodology

Design Strategies

Zero use of CFC-based refrigerants in the building will satisfy the requirements of LEED™ 2.1 EA Prerequisite 3. Design a plan to eliminate the use of other ozone-depleting substances such as HCFCs and Halons from building HVAC, refrigeration, and fire suppression systems in the near future (i.e. earlier than required by the Montreal Protocol) Specify insulation materials that are not manufactured using chlorine gas.

Means and Methods

The interim replacements for CFCs in building HVAC and refrigeration systems have been mostly HCFCs. These continue to cause damage to the ozone layer, although their lifespan in the stratosphere is only half that of CFCs (some 80 years). Hydrofluorocarbons (HFCS), which do not cause ozone destruction, have been proposed as long-term replacements for CFCs and HCFCs, in spite of losses in efficiency with their use. Although HCFCs typically operate as heat transfer mechanisms (similar to CFCs), some of the newer HFCs are designed to avoid this problem. The increased energy use caused by less efficient refrigerants exacerbates environmental problems rather than eliminating them. (For example the generation of extra electricity to counteract these inefficiencies, is associated with greenhouse gas emissions from power plants.) Industry is struggling to find refrigerants that are both environmentally safe and as energy efficient as their predecessors, and in the meantime, is working to improve the performance of available replacement refrigerants.

Halons have been used in fire suppression systems because they are very effective at suffocating most types of fires, do not conduct electricity, disperse rapidly without leaving residue, and are not toxic to humans in short exposure periods. However

because of their extremely high ozone-destroying properties, The Montreal Protocol calls for their phase-out. There are various parallel studies being conducted to produce viable options for the replacement of Halon in "total flooding" style fire suppression systems. One option is to replace the Halon with another gas. Current commercially viable replacement gases are either HFCs or inert gases. HFCs are known greenhouse gases and thus may not be ideal. Inert gas options such as Argotec and Inergen do not have this problem, but are not as efficient at extinguishing fires, and have large technical limitations and costs. Another option that may be viable in certain applications is the use of a water mist system. This type of system is environmentally benign, but not effective in all fire-extinguishing environments, especially those where electrical conductivity is a hazard. Water mist systems have much larger capital costs. Other promising alternatives are being studied by leading industrial companies, however none are currently on the market.

Chlorine-based chemicals used in the production of some types of insulation destroy ozone. These chemicals are used as foaming agents for insulation types that contain components that must be expanded or extruded such as extruded polystyrene, polyurethane, polyisocyanurate, and phenolic and urethane foams. Both CFCs (non-banned) and HCFCS have served as foaming agents. To avoid ozone-depletion, companies have tried to adjust their manufacturing methods in different ways. Some have shifted to alternative foaming agents like HFCs and hydrocarbons. Although not destructive to stratospheric ozone, these agents have the disadvantage of exacerbating the greenhouse effect. Icynene is an insulation product that uses carbon dioxide and water to foam the insulation. Unfortunately, this has the side effect of reducing its R-Value, thus extra insulation must be specified to achieve the same thermal insulation level. Air-Krete is an inorganic foam insulation made from magnesium oxide and foamed under pressure with compressed air. Although it is inert, emits low VOCs, and is non-combustible, Air-Krete must be foamed in place and is very brittle.

Case Studies

1. Green on the Grand Office Building, Kitchener, Ontario
   This office building has an air-conditioning system without CFCs or a cooling tower. The building's construction used no CFCs and minimal HCFCs. Waste heat from a central, gas-fired chiller is sent to a landscaping pond in lieu of a rooftop cooling tower. Heat is lost to the water through evaporation and the need for CFCs typically used in conjunction with a cooling tower is eliminated. This building's energy use is extremely low, 28% of that described by ASHRAE 90.1 as an average usage profile.

2. LCRA TESNCO Dalcahu Service Center, Austin TX
   This existing industrial site was converted to an office space and public conference center. The HVAC system was designed to use no CFCs or HCFCs in any of its cooling equipment.

Reference

Definitions

Chlorofluorocarbons (CFCs) are synthetic compounds (once used as refrigerants) that destroy ozone molecules in the stratosphere.

GWP (Global Warming Potential) is an index describing the relative warming potential of a greenhouse gas as compared to the same mass of carbon dioxide: The lower the number, the less environmentally damaging the gas.

Halons are ozone depleting compounds used in fire suppression systems.

Hydrochlorofluorocarbons (HCFCs) perform similarly to CFC's but cause far less damage to the ozone layer.

Hydrofluorocarbons (HFCs) are refrigerants that do not destroy ozone because they lack chlorine atoms. Many of these substances act as greenhouse gases and contribute to global warming

ODP (Ozone Depletion Potential) represents how actively a particular gas destroys ozone once in the stratosphere. The lower the number, the less environmentally damaging the gas.

Refrigerants are elements of the refrigeration cycle that transfer heat.

(*Refer to TSAC 2004 for a list of various refrigerants and their ODP and GWP values)

Standards

Standards have not been included for this guideline.

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Ozone Layer Protection

EEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 3: CFC Reduction in HVAC&R Equipment)*
This certifies that building HVAC systems specified for this project contain zero levels of CFC refrigerants.

☐ **Required Component:**
The attached plan provides for the future elimination of HCFC's and Halons in HVAC and refrigeration equipment AND fire suppression systems.

☐ **Required Component:**
The use of insulation materials that contain chlorine based gases has been avoided.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Renewable Energy

EEQ-5

Sustainable Design Guidelines Reference Manual
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Purpose: To meet a portion of site energy requirements with on site and/or purchased renewable energy sources and institute a plan for transition as renewables become more cost-effective.

Action: Utilize site generated and/or purchased renewable energy for a percentage of total building energy use. Provide transition plan for future conversion to renewables. Purchase or generate on-site a minimum of 20% of overall annual electric energy requirements with renewables by 2010 consistent with NY State EO-111's evolving requirements and capabilities. Provide infrastructure to integrate technology into building systems, when possible.

Related Guidelines: UEQ-8, SEQ-1, EEQ-1, EEQ-3

Potential LEED™ 2.1 Credits: 3 possible with EA cr. 2.1, 2.2, & 2.3. (see Submittal Template)

Introduction/Context

Renewable energy is a free-source of energy, produced through harnessing natural, renewable resources in a manner that does not pollute. It includes technologies based on the power of the sun, wind and Earth's internal heat. Small-scale, low-impact hydroelectric generation, using methods that do not adversely affect the body of water on which they operate, can also be considered a means of renewable energy. Systems that convert organic matter (biomass) into usable energy and hydrogen fuel cells are two other renewable energy potentials. All of these methods avoid the negative environmental impacts of more traditional power production such as burning fossil fuels or nuclear fission.

Renewable energy can either be purchased through power utilities or generated on-site. Some electric companies produce a percentage of their total output through renewable technologies. In fact many states have passed laws to require this. In September of 2004 The New York Public Service Commission (PSC) voted to require that at least 25% of the electricity sold to consumers in New York State be generated through renewable resources by 2013. In the meantime a building can support commercial renewable energy systems even if their local utility does not yet provide any direct renewable energy options. Building owners can purchase "Green-Tags" or Renewable Energy Certificates that represent an amount of renewable power generated elsewhere in the power grid. Although this will not have a direct effect on the local environment, it has positive ramifications for the field of renewable energy as a whole. Purchased renewable energy must comply with Green-E or other recognized standards for renewable energy providers. On-site renewable power has added economic and ecological advantages due to the elimination of transmission needs and potential independence of the regional power grid. Potentials for renewable energy generation vary by regional climate and site location. The technologies needed to produce this energy are becoming increasingly available and economically viable.

Relevant Issues

Ecological

Traditional means of electricity generation have serious negative environmental effects. Fossil fuel burning plants deplete coal, oil, and natural gas resources. The gases released from these plants contribute to health problems for people, smog, acid rain, and the greenhouse effect. Nuclear power plants generate toxic waste that must be stored in highly protected areas for thousands of years. Both of these types of power plants contribute to negative water quality, both through contamination and thermal pollution. Although somewhat cleaner, hydroelectric power plants cause damage to the aquatic ecosystems involved. The use of these plants affects both the food chain and the availability of water for people to use in their daily lives. For example a large dam can prevent fish from reproducing and dry out a river that was once used for irrigation of crops and drinking water. Low-impact hydroelectric plants, which don't involve night pumping, have far fewer negative consequences. Concerns have been expressed about the potential for wind turbines to harm birds. Careful study of this problem has resulted in new, safer forms for turbines. These operate at speeds that can efficiently generate power but also let birds pass through unharmed. Biomass energy systems have an added advantage as they can divert large amounts of wood-based construction and land-clearing debris from landfills. Hydrogen fuel cell technology, when perfected, will produce water and heat as its only by-products.

Economic

By generating power on-site through renewable means energy costs can be reduced. Although there are initial infrastructure costs the avoidance of utility charges and peak hour demand charges can quickly pay back those funds. Federal and state programs exist through which developers can obtain financial assistance such as tax credits and low-interest loans to support the installation of an on-site renewable energy system. Where programs exist, building owners can sell excess electricity generated by their systems back to the local utility company at competitive rates. This 'bonus' energy may help the utility company to meet their peak demand, especially during heavy usage periods which usually occur in mid-summer. The costs of renewable energy technologies are continually decreasing with advances in efficiencies and production methods. In 2003, 744.1 MegaWatts worth of PV Cells were produced worldwide with 13% of that in the United States. During the past five years the capacity of wind-power generation in the United States has bloomed from 1,800 MW to about 6,400 MW installed in 30 states nationwide. Geothermal systems are still relatively expensive and considered a niche market by some. However, certain site conditions, such as available space for the required boreholes, may make geothermal systems competitive.

Neighborhood

The improvement of water and air quality as conventional electricity generation decreases is a major benefit to all people. Self-sufficient power, along with reduced transmission losses created by local generation, helps avoid overloads on the national grid that have the potential to cause wide-reaching blackouts. Dependence on these types of local power sources may contribute to the avoidance of loss of

computer data, as well as revenue, due to down-time experienced during a power outage on the national electrical grid. If local renewable energy systems are designed carefully to avoid negative side effects (such as noise from wind turbines), they clearly provide for a more secure source of energy and less dependence on foreign oil, providing benefit for all members of the community -- those that share directly in the resource and beyond.

Methodology

Design Strategies

Meet a total percentage of building electricity needs by either purchasing or generating renewable energy on-site. 1, 2, or 3 LEED™ 2.1 credits can be obtained if the percentage of on-site renewable generation equals 5, 10, or 20 respectively. By the year 2010, 20% of the overall annual electric energy of the project must be met by renewable energy sources. This is consistent with NY State's EO-111's evolving requirements. A plan should be devised to facilitate future transition to larger amounts of renewable power. The infrastructure to integrate these future renewable technologies needs to be built into the project at its inception to avoid higher installation costs in the future. This will greatly reduce the capital investment needed to install a renewable energy system at a later time.

Green power can be purchased to help meet the building's energy needs. If the local power utility does not provide a significant portion of their generation portfolio through renewable means, Green Tags can be purchased from third party agencies to support the production of renewable energy elsewhere in the power grid. One LEED™ 2.1 credit can be achieved through the purchase of Green Power. In order to satisfy the requirements of LEED™ 2.1 EA credit 6 at least 50% of a building's electricity must be purchased from a provider using renewable sources for its generation and, at minimum, the building owner must commit to a two-year contract for the purchase of Green Power. For the purposes of this LEED™ 2.1 credit, renewable sources are defined by the Center for Resource Solutions Green-e standards.

Means and Methods

Photovoltaic cells convert sunlight directly into electricity. These cells can be placed in an array that tracks the sun's movements or integrated into the façade (building integrated PV) or other portions of a building. Since photovoltaic cells produce direct current, converters must be used to transform their output into the alternating current used by standard plug-in equipment. Because PV cells generate their peak power during the hottest parts of a sunny day, when many people are turning on air conditioners, they help offset demand loads from the power utility. Batteries must be used to store electricity generated by a PV system for nighttime use, although some buildings use a hybrid system relying on fuel cells or wind power during the dark evening hours. There are many different types of photovoltaic cells. Crystalline silicon is the leading commercial material, although thin film cells are becoming very popular since they use less material, cost less and are beginning to become as efficient. Photovoltaics are expensive to produce as the semi-conducting materials

from which they are made have high costs. As technologies advance and manufacturing costs are reduced, the price of PV systems continues to fall. The use of any on-site power source such as PV has the added advantage of reducing the need for transmission infrastructure. Building-Integrated PV systems save money since they replace traditional building assemblies with ones that serve a dual function. One example of this is glazing, ether spandrel or even vision, which incorporates integrated PV cells. There are also financial incentives to promote the incorporation of on-site PV systems. These include tax credits, low interest loans, grants, special utility rates, and the opportunity for net metering where the site sells power back to the power company. Because of their performance and ability for easy integration into a project, PV systems are the leading contender in the market for on-site renewable energy systems today.

Wind energy is very popular in Europe and is now coming of age in the United States. Wind power systems use turbines to convert wind into electricity. Innovations in wind turbines that make them more efficient are now boosting this already expanding industry. It provides clean, renewable energy and can be harnessed on scales varying from large power plant wind farms to smaller on-site power generation. In regions with reliable wind currents, wind power is the most economical of all the renewable energy systems. Wind turbines can be deployed on open land in a windy area adjacent to a site, in the sea, or they can be integrated into the building itself. Some architects are attempting to sculpt buildings so that aerodynamic flow directs wind into a power-generating turbine. The American Wind Energy Association estimates that, with government support, small on-site wind turbines could contribute 3% of the overall annual U.S. power consumption as early as 2020. Some states have financial incentive programs to aid building developers in obtaining the capital costs to build on-site wind installations. It is clear that the integration of building and wind power technology is an evolving frontier that will have large ramifications in the near future.

Small-scale, low-impact hydroelectric plants can be an ecologically responsible and renewable energy source. Large-scale hydroelectric power systems provide a substantial percentage of the U.S. power supply. Those that do not involve off-peak or night-time pumping are essentially emission-free, but have several negative environmental consequences. Hydroelectric plants often have adverse effects on water quality and quantity for areas downstream of their installation. Another detriment is that fish are frequently injured or killed when passing through a plant's turbines. Small-scale low-impact hydro systems, that do not use off-peak pumping, generally do not create these hazards. Any hydroelectric system that generates 30 MW or less is considered small-scale. Typically these plants do not require a dam to stop the entire body of water. This prevents them from having such a large effect on downstream water and provides areas for aquatic life to bypass the installation.

Electricity can be produced using plant material in a biomass system. Of the four technologies available, only the gasification type is truly non-polluting. In this system methane gas produced during the breakdown of biomass is used to supply hydrogen fuel cells. In 2002, roughly 9,700 megawatts of electricity was generated in the United States using biomass. Almost 6,000 MW of that came from forest products and agricultural waste, 3,000 MW from municipal solid waste and 500 MW from other sources such as landfill gas. Most of this electricity was generated by burning the

biomass to create steam and drive turbines in place of the coal used in coal-fired plants. (Coal fired plants still make up a large percentage of U.S. power production today). Although the incineration of biomass does not produce the sulfur dioxide and nitrous oxides that burning coal does, it still releases carbon dioxide, a major greenhouse gas. To the extent, however, that the biomass will be left to natural biodegradation processes, leading eventually to oxidation, that carbon dioxide would have been generated anyway.

Geothermal power generation uses heat from deep within the Earth to turn a turbine and produce electricity. The United States currently has geothermal power installations that produce about 2,800 MW annually. The high initial costs associated with building a geothermal power installation have limited their use. However current research into making geothermal plants more efficient and cost-effective should help promote this technology.

Case Studies

DEP Cambria Office Building, Ebensburg, PA

This building uses two types of on-site renewable energy systems. It employs ground-source heat pumps that are linked through a closed-loop geothermal well field to supply both heating and cooling for the HVAC system as well as hot water for building use. The building also has a 14.3 kW PV installation located on its south-facing sloped roof. This system provided 28% of the building's total energy costs. Some of the PV panels used are mounted on solar tracking devices.

Ford Motor Company Dagenheim Engine Plant, London, England

Two 85 meter high wind turbines will produce 100% of the power requirements for Ford's new Clean Room Assembly Hall and Diesel Engine Plant in Dagenheim England.

Genzyme Center, Cambridge MA

This building uses renewable energy production strategies. Two small photovoltaic arrays on the building's roof generate 20 kWp peak output (15,000 kWh per year) and help further reduce peak demand on-site. All of the building's purchased electricity has been provided through Green-e certified renewable sources. This ensures that the amount of power being bought for the building is being displaced somewhere in the power grid by the use of renewable generation methods. This building also uses a Combined Heat and Power (CHP) system. Although this type of electricity generation is not powered by a renewable source it does represent somewhat of a renewable heating strategy for the building. The central heating and cooling systems are powered with steam from an adjacent power plant. The steam is used in absorption chillers for summer cooling and in heat exchangers for winter heating. This steam is a byproduct of the power plant's normal operation and is being put to good use by the Genzyme Center. As long as this plant continues to make electricity, the symbiotic heating system of the Genzyme Center will have a "renewable" source of energy. An additional advantage is that, with this system, peak summer electrical demand is low and doesn't burden an aging electrical grid.

Reference

Definitions

Geothermal Energy Systems use heat from the earth to produce electricity.

Green Power refers to electricity that is produced by a system that does not contribute to environmental pollution.

Photovoltaic Systems convert light (typically from the sun) energy to electrical energy.

Renewable Energy is produced by a source that is infinite (will never run out)

Standards

Green-E Standard for Purchased Renewable Energy

This standard insures that purchases of renewable energy conform to the following characteristics:

- 50% or more of the electricity supply comes from one or more of these eligible renewable resources: solar electric, wind, geothermal, biomass, and small or certified low-impact hydro facilities,
- if a portion of the electricity is non-renewable, the average air emissions are equal to or lower than those produced by conventional electricity alone,
- there is no direct support of nuclear power, (because of the amorphous nature of the national power grid there is always a possibility that a miniscule portion of the electricity being used may have somehow come from a nuclear plant) and
- the product meets the Green-e new renewable requirement.

To comply with this standard, renewable energy providers are subjected to the following requirements:

- make full disclosure of the percentage and type of renewable resources in their electricity product;
- present product pricing and contract terms in a standardized format, for easy comparison;
- submit their marketing materials for review twice a year so Green-e can ensure they are not making false or misleading claims; and
- undergo an annual independent Process Audit to verify product content claims and ensure enough renewable power has been purchased to meet customer demand.

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Renewable Energy Transition Plan EEQ-5-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Renewable Energy Transition Plan is designed to ensure that a plan is in place for eventual transition of site energy requirements to full renewables and projects are designed to facilitate this transition. NY State EO-111 requires that 20% of overall annual electric energy requirements are satisfied with renewables by the year 2010.

Plan Components

I. **Project Description (Plan Summary)**
   A. Describe project energy requirements and use of renewable energy to satisfy these requirements.

II. **Management strategies**

   A. Provide a detailed inventory of available on-site and off-site Renewable Energy Resources (this should coincide with the inventory provided for PLAN EEQ-1). Including the potentials for purchasing Green-e Certified power.

   B. Provide calculations confirming that 20% of overall annual electric energy demand (of the buildings that exist at the time) will be met by renewable energy after 2010.

   C. Describe characteristics and features of the currently designed infrastructure that can accommodate or can be modified to accommodate integration of renewable energy technologies that may be available or cost effective in the future. Give preference to site generated renewables.

III. **Targets**
Establish and describe project targets for the following

   A. First year of operation.
   B. 2010
   C. 2025
   D. 2055

IV. **Evaluation**
Evaluate the cost implications (in current dollars) of converting conventional, high performance systems in place at the beginning of building operations to Renewable Energy systems, and quantify anticipated energy conservation and cost savings as a result of the switch to renewables.

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Renewable Energy

EEQ-5-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
A transition plan for future conversion to renewable energy is attached. It specifies that a minimum of 20% of overall annual electric energy requirements will be met through renewable means by the year 2010, consistent with NY State EO-111's evolving requirements and capabilities. The design includes infrastructure to integrate this technology into building systems, where possible.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.1: Renewable Energy – 5%)*
This certifies that renewable energy as defined by LEED will supply at least 5% of total building energy use at completion of construction.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.2: Renewable Energy – 10%)*
This certifies that renewable energy as defined by LEED will supply at least 10% of total building energy use at completion of construction.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.3: Renewable Energy – 20%)*
This certifies that renewable energy as defined by LEED will supply at least 20% of total building energy use on completion of construction.

**Please note, for the purposes of satisfying LEED™ credit requirements, "Renewable Energy" includes energy systems such as solar, wind, geothermal, low-impact hydroelectric, biomass and bio-gas (draft version of LEED™ V. 2.2)*

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 6: Green Power)*
This certifies that at least 50% of a building's electricity will be purchased from a provider using renewable sources for its generation and the building owner has committed to a minimum two-year contract for the purchase of Green Power.

**Please note, for the purposes of this LEED™ 2.1 credit, renewable sources are defined by the Center for Resource Solutions Green-e standards.*

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

Energy Systems Control and Maintenance EEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide for ongoing verification of initial operation and energy utilization of building energy systems.

Action: Provide a computerized, fully integrated Building Management System (BMS) with energy and fluid flow measurement capabilities for all major energy consuming systems. Institute a maintenance plan for ongoing measurement, verification and maintenance of equipment efficiencies and resource utilization. Provide programmable controls. Install permanent monitoring systems to track energy performance. Provide for maintenance and operational continuity through manuals and education. Install continuous metering equipment for a representative sample of lighting systems, motors, drives, chiller efficiencies, and trending of economizer and heat recovery equipment cycles, air distribution pressures and volumes and boiler efficiencies. Integrate the above systems into the Building Commissioning Plan.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, IEQ-1, IEQ-3, IEQ4, IEQ-7, IEQ-10, IEQ-12

Potential LEED™ 2.1 Credit: 1 possible with EA cr. 5. (see Submittal Template)

Introduction/Context
With the complexity of the site, incorporating rail stations, hotels, performing arts center, office towers, underground malls, street level shops, restaurants, and cafes, comes a diverse set of energy systems and requirements. Managing systems performance while achieving lower energy costs will be a complex task for the WTC Redevelopment, requiring the wise use of technology, well defined process, and a skilled staff.

The WTC Redevelopment Project will mark its position in Lower Manhattan, as well as the world, as a leader in energy performance for the built environment. On-going verification and continuous improvement of a building's energy performance is a visible means of taking responsibility for the consequences of its design of the development and the buildings therein, both initially and as facility usage changes over time.

EO-111 sets a target for energy savings (20% improvement over code), but does not provide specific guidance regarding on-going verification. It does however reference NYSGBTC, in particular, Section 638.8 Commissioning which provides requirements for a Systems and Energy Management Manual, and Training. International Performance Measurement and Verification Protocol Volume III and ASHRAE Guideline 14 (see References) provide the means to develop a program for on-going verification of operation and energy utilization of building energy systems. The measurement system installed within the building shall be sufficient to conform with the requirements of LEED version 2.1, Energy and Atmosphere Credit 5, for IPMVP, method D.

Relevant Issues

Ecological

Natural resources are limited. A sustainable future requires that we take responsibility for their use to support today's and tomorrow's needs. Energy, water, and materials use are all embedded in our building designs. With the longevity of buildings and their systems, we are committed to that level of use for decades. It is critical that building and building system design are optimized to deliver their intended services with minimal use of resources – minimal impact on the environment.

With optimum use of energy and water resources incorporated into the building design, verification is required to demonstrate actual performance delivery in the building as constructed. However, energy and water optimization in building operation is not a static issue. From the day the building is turned over to its occupants, it starts to change. Variations include change of use, occupants, staff, equipment (as it ages), utility structures, and technology. The results of these changes may offer new opportunities for optimization that were not available at the time of the initial design development.

The components of systems control and maintenance must be dynamic. On-going measurement, analysis and improvement over the building life cycle is required to achieve optimization of energy and water use.

Economic

Energy and water savings are clearly understood benefits of green building design and operation. One analysis places the 20-Year Net Present Value of Energy and Water Savings at $5.80 per square foot and $0.50 per square foot respectively. These savings derived from average extra costs of building green estimated to be from $3.00 to $5.00 per square foot (averaging 1.5% to 2% of the total construction cost). Energy and water savings may indeed be sufficient to cover the cost premium of building green without attempting hard measurement of Operations & Maintenance Savings or the Productivity and Health Value of building green.

For new construction, energy and water savings are projections. Actual delivery of financial gain requires the formulation of a baseline and an on-going process of measurement, analysis, and improvement as the building evolves. The process begun in design and construction continues through commissioning of the building and its operation to support continued financial benefits through process improvement, development of staff, and shared knowledge in the broader community of practice.

This is a continuous learning process with the knowledge developed contributing to Operations & Maintenance savings realized by green buildings. The analysis cited above estimates the net present value of those O&M Savings of Green Buildings at $8.50 per square foot. This savings is in addition to the energy and water savings and derived from the same investment premium.

The Net Present Value of the operating costs' savings for building green has, therefore, been estimated to be more than three times the first cost required to obtain

this level of performance. Because the return on investment of the green building features will equal or exceed the return on investment of the basic building project, green features represent an opportunity for further investment without the necessity of an additional building project. In other words, the green building features will increase a building's value.

Neighborhood

Intelligent energy systems control yields energy-efficiency cost benefits, as well as controllable comfort levels within the building, resulting in satisfaction and well-being among the building occupants. The energy-efficiency results in lower and more stable energy prices. Better management of energy use limits waste and the needless consumption of finite natural resources. It also reduced emissions from power plants that cause environmental pollution and lead to increased health problems for members of the wider community.

Methodology

Design Strategies

- Integrate the control, monitoring, and metering functions of a BMS in the M&V Plan for building energy and water systems
- Verify building and system energy performance and refine the energy baseline as a component of the commissioning process
- Embed energy system M&V in a facility management continuous improvement process

Means and Methods

Measurement & Verification (M&V)
The on-going measurement and verification of performance for energy and water utilization requires a sound framework on which to base the performance assessment. IPMVP Volume III provides an overall guide for application to new construction. The basic calculation is simply:

Energy Savings = Projected Baseline Energy Use – Post-construction Energy Use
For new construction, 'Energy Savings' provides a focus on those aspects of the new building that are intended to contribute to exceptional performance. The energy use baseline is hypothetical for new construction since no history is available. Post-construction energy use is the actual delivered performance, verified initially at commissioning, and the subject of on-going measurement over the life of the building. This calculation provides the framework for the development of the M&V Plan.

The value of on-going measurement and verification of energy and water use lies in its contribution to the decision-making process of facility staff. Three main issues in developing the detail of the M&V Plan are:

- Appropriateness – are the baseline and measured energy use meaningful in the context of the operation of this building e.g. energy codes, industry standards, issues of importance to this building
- Rigor – is the detail appropriate for the M&V methods and analytical tools that will be used; does the cost/benefit of the detail suit the objectives of the M&V program
- Repeatability – are the baseline and energy use measurements consistent and repeatable, allowing performance comparisons on a broader scale.

Addressing these issues provides guidance for the selection of information to be included in the M&V Plan. IPMVP further provides four M&V Options:

- Option A Partially Measured Retrofit Isolation: Projected baseline energy use is determined by calculating hypothetical energy performance of the baseline under post-construction operating conditions

- Option B Retrofit Isolation: Projected baseline energy use is determined by calculating hypothetical energy use of the baseline under measured post-construction operating conditions

- Option C Whole Facility: Projected baseline energy use determined by measuring the whole-building energy use of similar buildings without the energy conserving measures of interest in the new construction

- Option D Calibrated Simulation: Projected baseline energy use determined by energy simulation of the baseline under the operating conditions of the M&V period.

For the purpose of this guide, Option A has no value, since stipulation of savings offers no information to the staff decision-making process. Options B & C offer solutions of some value at the level of individual energy conserving measure, system level and whole building comparison.

However, Option D provides a whole building approach that can be directly linked to the design of the M&V Plan. Option D guided by appropriateness, rigor, and repeatability, provides an insight to the interrelated energy conserving measures of importance, to the systems level of performance, and, in aggregate, whole building performance. The M&V Plan, using the simulation models, provides the specification of information sources: utility bills, system sub-metering, and BMS information points. This coupled with technical guidance from ASHRAE Guideline 14 provides the basis for specification of BMS features and functions.

Commissioning

The commissioning process associated with measurement and verification of energy and water systems performance goes beyond verification of feature and function of the BMS. There is also the initial verification of performance following the M&V Option selected. Analysis of the energy use of the first year can be used to refine the understanding of building operation and thereby update the baseline for on-going verification of performance. (IPMVP Volume III 4.5.8 Option D: Savings Estimation)

Continuous Improvement
The design, installation and commissioning of BMS technology and Energy Control and Management process should reflect the continuous improvement process employed by facility management. This may be a form of Total Quality Management or a Six Sigma process. The key role of the BMS is providing those measurements that support the analysis from which improvements are developed and implemented.

For example, the GSA Workplace 20.20 program is developing the GSA facility process within the framework of a Balanced Scorecard. This brings a business context to facility decisions. That would appear to be a desirable position if high performance green buildings are to become known for their contributions to business.

Case Studies
State Office Buildings, Santa Fe, New Mexico
In the wake of a severe flood caused by leaking pipes that damaged components of the HVAC system at one of the State Office Buildings, the New Mexico Building Services Division decided to take advantage of the situation and have a new building automation system installed. Working with Trane, they not only replaced the equipment in the flood-damaged building, but extended the new building automation system to other state office buildings in the complex with new fiber-optic cabling run through existing underground utility tunnels. The new system, which consists of centrally controlled chillers and distributed variable air volume boxes with direct digital control, provides enhanced thermal comfort and vastly improves building control Instead of running around checking thermostats, building maintenance staff can not concentrate on responding to other occupant needs. A laptop workstation and remote communications software allow staff to check the buildings' status in real-time and even troubleshoot problems from off-site. Not only does this system greatly increase maintenance staff productivity and occupant comfort, it is also responsible for energy savings because it provides ongoing monitoring of the HVAC system's performance. The State Energy, Minerals, and Natural Resources Department credits the new system with an annual savings of $140,000 in gas and electricity. (Trane 2005)

Reference

Definitions

Baseline is a complete set of assumed conditions of design, use, operation, and occupancy of a building. It is typically based on an energy efficiency standard or guideline.

Building Management System (BMS) is a computer-based system that can be programmed to control and monitor the operations of energy consuming equipment in a facility.

Measurement and Verification (M&V) is the process of determining energy or water savings using one of the four IPMVP Options.

Metering is meant to indicate the collection of energy and water consumption data over time at a facility through the use of measurement devices.

Monitoring is the collection of data, both for consumption and for operating conditions and parameters, at a facility over time for the purpose of savings and performance analysis e.g. energy or water consumption, temperature, humidity, hours of operation.

Projected Baseline Energy Use is the baseline energy use or demand calculated using post-construction operating conditions.

Simulation Model is an assembly of computerized algorithms that calculate energy use for specified time intervals at the systems and the whole building level based on engineering equations and user-defined parameters.

Standards

"International Performance Measurement & Verification Protocol (IPMVP): Volume I Concepts and Options for Determining Energy Savings 2001", Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

International Performance Measurement & Verification Protocol(IPMVP): Volume III Concepts and Options for Determining Energy Savings in New Construction, April 2003, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

"Guideline 14 – 2002 Measurement of Energy and Demand Savings", ASHRAE, 2002

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NYSGBTC 638.8 Commissioning; identifies the contents of the Systems and Energy Management Manual, Training requirements.

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Energy Systems Control and Maintenance EEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
A Systems and Energy Management Manual is attached, which describes the integration of the BMS and energy systems, as installed for the applications listed under Guideline EEQ-6, with scope and content as described in Green Building Tax Credit 638.8 (k) (2). Incorporate the measurement and validation Options B, C, or D of IPMVP 2001 in the manual and BMS implementation strategy.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 5: Measurement and Verification.)*
Where appropriate, the scope of applications has been extended to include indoor water risers, outdoor irrigation systems.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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End User Metering EEQ-7

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Maximize tenant incentives to conserve energy.

Action: Include electrical distribution infrastructure required to allow end-user metering of tenants, including electricity use (kWh) and demand (kW) metering. Provide examples of existing incentive programs to tenants.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-5, EEQ-6

Introduction/Context
The benefits associated with End User Metering stem primarily from ensuring the end user is accountable for the energy they use. When tenants are required to pay for the energy they consume, the typical New York City "missing incentive" is restored in support of resourceful and efficient tenant design.

The New York State Energy Research and Development Authority (NYSERDA), is a strong advocate of end user metering "In master-metered building situations (without submetering), individual users are not charged separately for utilities in proportion to their consumption levels. Instead, the total utility costs are apportioned by square footage, number of rooms, or other pre-engineered formulas. As a result, the occupants do not receive the type of price signal associated with the individual commodity use whereby costs vary directly with consumption. Studies have indicated that users in these master-metered buildings tend to consume much more energy than occupants with individual energy meters."

A basic concept of economics is expressed by the term elasticity. This term refers to a user's variation in appetite for a product based upon its cost. Some users may be relatively inelastic and their rate of consumption will vary little as the price of the product varies. Other users will be highly elastic, and when prices rise, their consumption will be highly curtailed. Sub-metering or end user metering allows each tenant to exercise their individual energy consumption elasticity by charging them for their consumption.. End-use metering thereby ensures a more equitable distribution of utility costs and rewards energy-conserving users. End user metering also removes energy-cost volatility from the landlord's lease-expense budget. End-use metering allows each tenant to express the variations and flexibility in the timing of their individual energy consumption. For some relatively inelastic tenants, energy consumption may be little affected by individual metering, but for others, energy savings may be significant. Providing individual meters, furthermore, also anticipates new developments in electricity rate structures as the electricity supply market becomes more de-regulated. A number of utilities are developing real time electric rates under which the customer pays for the actual cost of delivering electricity at any point in time. These rates take into account both the cost of generation and the capital cost associated with meeting the overall system demand at the point (accounts for increased transmission infrastructure needed). Individual tenant-meters will allow each tenant to respond appropriately to these time-varying electric rates directly expressing their ability to shift operating schedules in order to benefit from lower utility costs.

Relevant Issues

Ecological
End-use metering results in lower energy consumption by many users. As such, it accrues major ecological benefits as it reduces the need for electricity generation. Today a high percentage of the generation of electrical energy is via the combustion of hydrocarbon fuels, which contribute to global warming and to air pollution from the by-products of combustion SO_2, NO_X, CO_2, heavy metals, mercury, and other particulate by-products.

Economic
End-use metering results in lower energy consumption by many users. As such, it often represents a very low-risk, high return investment for owners. Significant energy operating cost savings can be obtained by instituting measures that provide simple payback periods of less than 5 years. When taken together, the first-cost of end-use metering infrastructure is offset by reduced system size, complexity and cost, often resulting in significant operating cost savings at little additional first cost.

Neighborhood
End-use metering encourages accountability for energy use behavior. It prevents specific users from abusing the system through excessive consumption, where the costs are prorated among the entire tenant population. As a result of sub-metering, where the electrical costs may be the responsibility of each tenant's own consumption, conservative usage patterns become more apparent among all tenants. The resultant energy-efficiency reduces electricity demand, resulting in lower and more stable energy prices. Reduced energy use limits the consumption of finite natural resources and mitigates emissions that cause water and air pollution.

Methodology

Design Strategies
In certain occupancies, such as residential and some retail, each tenant has direct service from the utility with an individual meter and energy billing directly from the utility. In other occupancies, such as office, individual utility metering may not be feasible. For those applications, the landlord provides sub-meters by which energy costs may be allocated to tenants by use. Sub-meters may monitor both consumption and peak demand, so that these separate portions of the facility electricity cost may be allocated to each tenant.

Means and Methods
Landlords choosing to sub-meter tenants may elect to use incremental systems so that a greater portion of the tenants requirements' for building services are provided through sub-metered circuits. For example, packaged water cooled air conditioning units place the electrical consumption of the compressors that provide cooling for the tenant onto the sub-meter, as opposed to a central chilled water system, in which the

compressors of the water chiller are fed through the main building meter. In general, electricity is the only utility service that is sub-metered. Steam services typically have a central meter, and are not sub-metered, as is the case with water service. For some facilities with central chilled water systems, Btu meters are provided on the chilled water service to each tenant, allowing the energy and operating costs of providing the chilled water to be allocated by usage. Btu meters typically are expensive, and require periodic calibration, so that their usage is limited. One limitation for this strategy, however, is that under current Consolidated Edison rate structures, completely sub-metered buildings purchase electricity under a different and higher rate than do buildings that have only a master meter and no sub-meters. Consolidated Edison considers allocation of energy costs by sub-metering to be resale of electricity and mandates that such installations utilize their purchase for resale rate.

Case Studies

Central Building Utilities Metering System, Yale University, New Haven, Connecticut.
The various sectors of Yale's campus are connected to an array of utilities including electrical, steam/condensate, and chilled water. Some of these utilities are provided from the campus' central cogeneration plant, while a portion of the electricity is generated and purchased from a local power plant. A complex metering system was required to track the utility usage on this campus, not only because of the multiple sources of generation, but also because of Yale New Haven Hospital which is an independent organization that shares space and utilities with the Yale School of Medicine. The Central Building Utilities Metering System provides real-time monitoring, on line diagnostics, and report generation for billing, energy management, and utilities systems engineering. Engineers and managers have direct access to all information regarding the flow of utilities on the campus. This system is an invaluable analytical tool, providing essential data for operation, troubleshooting, engineering, billing, and energy conservation. Energy savings are supported by this metering system because it promotes end-user awareness of their energy usage, optimization of power plant operations, flattening of peak demand, and continuous monitoring of the systems performance. (Boed 1999)

Brewery Block 4, Portland, Oregon
This building is home to market-rate commercial office space and saves 23.5% in electricity over the goals laid out by ASHRAE Standard 90.1. In order to accomplish this, the structure was designed with various energy saving strategies in mind. One such feature was the ability for end-use metering. The chilled water used for cooling, electricity, and natural gas are all delivered through sub-meters that track the quantities used by each office and retail tenant. This gives the building's owner the ability to charge each tenant for the precise amount of utilities they actually use and consequently encourages these tenants to conserve and practice energy efficiency to save money. (US DOE 2004)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

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End User Metering

EEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	

☐ **Required Component:**
The electrical distribution infrastructure required to allow end-user metering of tenants, including electricity use and demand metering, has been provided.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Thermal Energy Storage EEQ-8

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce peak electrical demand and required equipment capacities through storage of heat or cooling potential.

Action: Utilize thermal storage media to meet peak heating and cooling loads while minimizing building peak demands on site energy infrastructure. Thermal storage media may be actively charged or discharged, such as with ice or chilled water storage, or passively charged and discharged as with ground sink or ground water storage

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-5, EEQ-6

Introduction/Context

Commercial buildings are notoriously poor customers of the energy distribution infrastructure. They tend to place large peak demands on the infrastructure simultaneously with one another, and then spend long periods of time, overnight, in particular, and for office buildings, weekends and holidays, drawing little from the utility grid. Hospitals, industrial buildings, or even multi-family housing operate with more continuous requirements for energy. This "peaky" behavior reduces the number of hours of use over which the capitalization required to serve these buildings may be amortized. The capitalization involved is not only monetary, it is also environmental. The rights of way and siting for the utility infrastructure, power plants, transmission lines, electrical substations, gas pipelines, etc., all have environmental consequences, as land is diverted from more sustainable or functional use.

By placing these high intermittent demands on the utility infrastructure, commercial buildings force utilities to operate in a much less efficient and more polluting fashion. Commercial buildings tend to have their highest power demands on the hottest days of the year, when electric generating and transmission equipment is most burdened. Utilities tend to utilize their least efficient and most polluting generating assets to help meet these demands so that this equipment can remain idle for the rest of the time. A survey of the major public utilities reveals that approximately 90% of the pollution from electric generation is emitted by only 50% of the plants. Gas turbines, which now supply a significant portion of the electricity in the United States, and a preponderance of the generation during peak periods, rapidly lose efficiency as exterior temperatures climb. A typical utility-class gas turbine will drop from 30% efficiency at 75°F to 26% efficiency at 95°F. In fact, many utilities employ refrigeration machines to chill the incoming combustion air to the turbines, because of the resulting large gains in efficiency. Because of lower temperatures for the inlet combustion air, gas turbines operate between 10% and 20% more efficiently at night.

Utilities recognize the impact of building peak electrical demands upon their infrastructure by charging buildings for their peak power draw. Electric rate structures charge for both the amount of energy used by the building and its peak electrical draw. Some rate structures, generally classified as "Time of Day Rates" charge buildings for peak demands that occur within the time frame that the utility is experiencing the peak demand upon its resources. Economic analysis of the feasibility of thermal storage systems should recognize all rate structures that may apply to the building.

The impact of peak demands on capitalized equipment applies within the building also. In New York City, refrigeration plants for commercial buildings typically demonstrate between 1200 and 1600 equivalent full load hours of operation per year. In effect, cooling capacity is lying idle between 80 and 85% of the hours of the year. Through use of thermal storage systems, equipment capacity can be cut in half by increasing the hours of utilization of this smaller equipment. The decreased peak electric demand of this smaller equipment lessens the pressure on utilities to construct more generation and distribution capacity.

Passive thermal storage is also effective in spreading the requirements for heating and cooling over time and reducing peak demands. Architecturally massive construction, ground coupling and groundwater heat sinks all can be used to reduce peak conditioning demands. The efficiency of conventional air conditioning systems can be increased by rejecting heat, not the outside air at peak summer temperatures, but to ground water, river water, or the earth itself, at temperatures moderated by the thermal capacitance of the heat sink.

Thermal storage can also be incorporated in to projects by actively controlling the temperature of the structural mass of the building. In this application, the building mass becomes the mechanism for thermal delivery to spaces through convection and radiation, and the mass of the building stores thermal conditioning potential for delivery to the space over time.

Relevant Issues

Ecological

Reducing the peak electrical and heating requirements of buildings reduces the need for the construction of energy infrastructure. Reducing peak electric demand on hot summer days decreases the utilization of more polluting less, efficient generation assets. Shifting demand from hot summer days to cooler summer nights decreases the amount of fuel consumed by the combustion turbines that meet this demand.

Thermal shifting or storage always has a negative effect on one or more of our shared natural systems (air, ground water, river water, etc.). The utilization of river water for cooling has been a strategy from day one at the World Trade Center. Hudson River marine environmental impacts are inherently of concern. The dynamic reversals of the river's flow associated with the tidal interface and the immediate transition to the broader boundaries of New York Harbor do create a more dynamic, diffuse and unique interface when compared to the similar sites at the river's edge.

The net ecological gains resulting from enhanced system efficiencies have, to date, been felt to outweigh these thermal impacts.

Economic

Because most commercial buildings buy electricity based not only upon the total amount of electrical energy consumed, but also upon the peak power demand in each month, reduction in peak demand can result in energy cost savings, even as total energy consumption may increase slightly. The monthly electric bills for a commercial building in New York are about equally divided between energy charges and demand charges. Most thermal storage systems provide significant electrical demand reduction with only a small increase in energy consumption due to increased storage. Thus, a 20% reduction in peak demand, easily achievable with an active thermal storage system, accompanied by a small 2 or 3% increase in energy consumption results in a significant cost savings for the owner. In most commercial buildings, significant energy cost savings are more readily achievable with a better return on investment through demand reduction than through improvements in equipment efficiency.

Neighborhood

Above and beyond the community benefits of reduced energy usage as established in previous Guidelines, the use of thermal storage strategies at the World Trade Center Redevelopment site also has the potential to enhance public spaces. One example of this would be the integration of thermal storage with site fountains. The heat rejected to the water in these fountains could keep them from freezing and let them run for longer periods of the year, adding aesthetic value to the site's public spaces.

Methodology

Design Strategies

High mass architectural construction has been an effective strategy for mitigating temperature extremes since humans lived in caves. Historical architecture, such as Indian Pueblos, Moroccan mud-houses, and massive stone houses, continued the development of that strategy. In recent times, passive solar houses have made use of massive construction to mitigate peak heating and cooling loads over time. The strategy is also effective for commercial buildings, and includes not only massive above-ground construction, but also sub-surface construction to take advantage of the thermal mass of the earth.

Ice thermal storage is a known technology that is currently experiencing a renaissance as electric peak demand charges rise. A refrigeration plant, operating during off-peak hours, recharges the ice bank storage, which is discharged during the day to help meet peak cooling loads. Some additional energy is consumed by ice making as opposed to conventional cooling and by conduction losses from the ice bank. The availability of very low temperature water to make very low temperature supply air also makes possible pumping and fanpower savings that more than offset the parasitic energy use from ice making. First cost savings from

fan, ductwork, and pipe size reductions enabled by the availability of low temperatures often more than offset the cost of the thermal storage.

Chilled water thermal storage operates similarly to ice storage, except that parasitic losses are much reduced. The size of the chilled water storage tank, however, is many times greater than the size of the ice tank. Because very low temperatures are not available, energy and first cost savings from fan and pump reductions are also not available.

High mass construction can be used to actively condition the spaces of a building. Piping imbedded in the internal finish surfaces of a space can be used to add or extract heat from the massive element over time keeping the surface temperature of the mass close to comfort requirements. To the extent that the surface area of the internal mass dominates the radiant environment of the space, this technique can provide the bulk of sensible conditioning to the space. While abrupt peak loads might overwhelm the thermal capacity of conventional building systems to maintain consistent space temperatures, the thermal mass of the structural conditioning system limits the rate of space temperature change. The structural conditioning system can then continue to act after peak loads have subsided to return the mass to its desired temperature. Because of the mass of the object, large amounts of heat gain or loss result in only small changes in temperature.

Rejection of refrigeration waste heat to low temperature sources always results in an increase in efficiency of the refrigeration plant. Low temperature heat sinks are often available in the earth and in surface water. Tidal surface water and running water, such as rivers or streams, create the best heat sinks because water warmed by the building's reject heat is carried away from the site and replaced by fresh, un-warmed water. Rejection of heat into the ground, or extraction of heat can be an effective strategy, especially for smaller buildings or conditioning plants. Plants that work in only one mode (heat rejection, or heat extraction), however, tend to thermally pollute the ground source/sink, creating a local area of altered temperature that, over the years, becomes a less effective resource. Plants that switch from heat rejection to heat addition over the annual cycle tend to be more successful in utilizing the ground thermal resource over time.

Means and Methods

- Use an ice storage system to meet building peak cooling load, with smaller chillers and reduced peak electric demand
- Use chilled water storage to reduce chiller size and peak electric demand to meet building peak cooling load
- Use high mass building construction such as heavy weight concrete to reduce and postpone building peak cooling load
- Utilize subsurface thermal tempering capability of underground walls and floors or even earth covered roofs to reduce building peak cooling loads
- Utilize actively heated and cooled massive slabs to store heating and cooling.
- Utilize ground source heat rejection (geothermal wells) to reduce condensing temperature and increase efficiency of chiller and decrease electric load during peak cooling demand

- Utilize surface water heat rejection (e.g. Memorial Fountain river water) to reduce condensing temperature, increase efficiency of chillers, and decrease electric load during peak cooling demand periods.

Case Studies

1155 Avenue of the Americas, New York, NY
This office building incorporates an ice storage system to reduce required peak cooling capacity and peak electrical demand

World Financial Center, New York, NY
This 5 building office complex incorporates a one million gallon chilled water storage system to reduce required peak cooling capacity and peak electrical demand. The central plant for these buildings also draws its cooling water from the East River. The water is taken from the river through an inlet that prevents fish and debris from entering the cooling system.

Foundation House, New York, NY
This office building in Manhattan utilizes two 1550 foot standing column wells for heat rejection from its air conditioning plant and as a heat source when that plant is working in the heat pump mode.

Kensington Branch Library, Brooklyn, New York
This building incorporates an open loop ground source heat pump with both extraction and re-injection wells to provide a heat source/sink for its heat pump system.

IBT Corporate Headquarters, Santa Monica, CA
This office building in Los Angeles features a radiant cooling floor in its all glass lobby to cope with the intense solar heat gain the enters the space. The mass of the floor mitigates the intensity of the peak cooling load, allowing the chilled water system pipes embedded in the floor to remove the absorbed solar heat gain over time.

Pier 1, San Francisco, CA
This remodeled office building in a former pier on the San Francisco Embarcadero features both a radiant heating/cooling floor and closed loop heat exchangers to the San Francisco Bay. The radiant floor system keeps temperatures within the space at comfort levels. The bay heat exchangers allow the building's air conditioning system to reject heat at very low temperatures to increase energy efficiency.

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Standards

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Thermal Energy Storage

EEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐ ○	☐ ○	☐ ○	☐ ○	☐ ○	☐ ○

☐ **Required Component:**
Mechanical systems have utilized bedrock, water cisterns, ice storage or other means to bank thermal energy and offset peak demand charges. A system description in the form of engineering drawings, calculations and specifications is attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Materials Management MEQ-1

Sustainable Design Guidelines Reference Manual
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Purpose: To optimize utilization of site material resources and to facilitate the reduction of waste generated by building occupants that would otherwise be hauled to and disposed of in landfills and/or incinerators.

Action: Implement a Material Management Plan, which coordinates and implements material guideline requirements within the Sustainable Design Guidelines. Describe materials utilized, recycled content, location of manufacture/harvest, agricultural content, sustainable harvest certification expected lifetime maintenance requirements and recyclable/reuse potential at end of useful life. Minimize travel distance for building products and systems and locate sinks for highest recycled use for 'waste' materials in conjunction with MEQ-2 and MEQ-5. Provide infrastructure necessary to implement the recycling requirements of the plan. A central location for appropriately sized recycling facilities must be provided for all buildings. Facilities must include, at a minimum, space for the separation, collection and storage for recycling of paper, corrugated cardboard, glass, plastics and metals, and each of these areas should be clearly identified. Provide easy truck access for the pick-up and removal of recyclables.

Related Guidelines: UEQ-8, SEQ-1, SEQ-7, SEQ-11, EEQ-4, MEQ-2, MEQ-3, MEQ-4, MEQ-5, MEQ-6, MEQ-7

LEED™ 2.1 Requirement: MR Prerequisite 1 (see Submittal Template)

Introduction/Context

In 2004, statistics indicated that buildings consume up to forty percent (40%) of all raw materials in use today, as well as thirty six percent (36%) of total U. S. primary energy: *Pennsylvania Department of Environmental Protection.* When energy used for the development of infrastructure, and for transportation of construction goods is added, this number increases to a staggering 51% of primary energy. Construction and building operations are responsible for the drawdown of enormous quantities of virgin materials, including fossil fuels, depleting the remaining resource base at ever increasing rates. In addition, activities associated with the quarrying, mining and otherwise harvesting of raw materials generate untold amounts of pollution. Transportation, as well as primary manufacturing processes, of these materials contributes to the further degradation of land, air and water resources.

A defining goal of the sustainable design movement is to slow this consumption of raw materials dramatically, eventually achieving a 'cradle-to-cradle' status. In this scenario, all materials that have been removed from their original source (quarry, mine, field, forest, etc.) and have been through at least one manufacturing process will remain in a continuous cycle of use and reuse, relieving the pressure on the resource base. No, or almost no, new materials will be needed to maintain and/or replace existing building stock, construction

materials and consumer goods. Once extracted or harvested, raw materials that enter the manufacturing cycle will be salvaged, reprocessed or re-manufactured indefinitely, becoming, through this process of reuse and/or recycling, the raw material base of tomorrow.

This approach to the management of existing building materials and building stock may sound like science fiction, but there are already signs of great success with material programs which have value in today's marketplace, such as in the recycling of metals, which is a generally profitable operation. There is no steel manufactured in the United States today that does not have, at a minimum, recycled steel content of twenty five percent (25%). Logically, the percentages for all metals must increase over time. Other programs are developing, including the used carpet recycling program, where new technologies for the 'up-cycling' of surface nylon into new, high-grade, nylon carpet fiber rather than waste, are having the effect of making old carpet (previously only valued for its backing material) a valuable commodity. It costs less, uses less energy and causes less pollution to re-manufacture practically every known material, than to obtain and convert it from its original raw state.

Specifying materials that are manufactured within five hundred miles of New York City reduces transportation costs as well as fuel and delivery time, and cuts the amount of embodied energy captured in those materials. Subsequently, this strategy reduces the amount of pollution associated with the burning of fossil fuels used in materials transportation. Many re-manufactured products are available within the metropolitan area and its immediate environs, as recycling tends to be undertaken by smaller, regional organizations.

Using products that replace themselves within a ten-year cycle – rapidly renewable materials -- such as poplar, bamboo, linseed oil, cork and wool, among others, or products that are made from by-products or waste from agricultural food production, such as wheat and straw board, makes sense both practically and economically. In addition, so long as these materials are replanted or reproduced as part of the normal food production or consumer goods cycles (wool, silk, flax, etc), a continuous supply of such materials for future use is ensured. Requiring wood and lumber materials, including engineered wood products, to carry sustainably harvested certification and Chain of Custody (CoC) labels, supports the health of the future lumber industry. Further, this strategy supports day-to-day forestry work, creates a livelihood for local and indigenous populations in all parts of the world and ensures a stable future supply of both local and exotic timber. This strategy contributes to fighting global warming: by maintaining value in the forests through the certified wood program, indiscriminate clear-cutting is less likely. Known as the 'lungs of the world' these vast, essential tropical and boreal forest ecosystems circumvent the planet, absorbing carbon dioxide. In this way, they are critical to the planet's well-being, contributing significantly to the management of the carbon cycle, while producing oxygen.

A full materials management program involves more than meeting the specifications of the types of materials noted above. Materials selected also need to contain recycled content and to be recyclable themselves. Each project must include appropriately sized facilities for the sorting and separation of recyclables (LEED offers a table indicating recycling facility size relative to building size). Convenient truck access for the collection of recyclables is also a consideration. The architectural team might consider researching local 'sources and sinks' as part of the materials management plan, in order to ensure that the highest amount

of materials come from local or regional manufacturing sources (within 500-miles of the city) and that those leaving the site – C&D waste, for example – are recycled at their highest, best use. Down-cycling (crushing and/or mixing materials for roadbed and other non-discriminatory uses) is discouraged, as the recovery of pure materials suitable to retain in the cradle-to-cradle loop is made more difficult by this process.

Relevant Issues

Ecological

Every day garbage trucks cart-away massive amounts of unsorted materials that contain valuable, reusable resources. These resources are either incinerated or deposited in landfills. In either case, this common and extremely wasteful practice has multiple negative environmental impacts. Finite material resources are lost permanently in this process, as well as the investment in energy and time used to obtain the original raw materials from their sources. Embodied energy used in their transportation cannot be recaptured, nor energy used in their primary manufacturing process. Even more insidious, incineration tends to release toxic gasses such as dioxins and benzo-furans (from phthalates released during the burning of PVC, for example) and vaporized mercury to the atmosphere, while unsorted materials dumped in a landfill often create unpleasant odors and leach toxins into the surrounding land and groundwater, creating brownfield conditions and extreme levels of environmental pollution.

Economic

Comprehensive resource management has significant financial benefits. When materials -- from C&D 'waste', to building products that have reached the end of their practical life-cycle -- are collected for recycling, in many cases the *owner is paid* by the recycling company rather than *paying* the dual cost of removal/transportation and incineration or landfill tipping fees. Using fewer materials and promoting more efficient use of materials also has economic benefits. In a sustainably managed materials program, materials that have been installed and well-used over a number of years, but which have finally reached the end of their usefulness through wear, aesthetics or change of building use, can be viewed as resources rather than waste. Such materials can be salvaged or re-used elsewhere, or re-manufactured through a recycling operation.

Materials from local or regional sources may offer a benefit in terms of reduced transportation costs. In addition, consciously specifying such materials, and following through to make sure that local sources are used, helps to maintain the robustness of the local economy, while use of both local/regional manufacturing facilities and recycling centers supports these newer industries and contributes to the strength of the workforce in the region.

Neighborhood

The adoption of comprehensive resource management practices by the construction industry, as well as by building operators, has significant implications for members of the community. Reuse and recycling of materials creates less pollution, which is beneficial for the health of all who live and work in the community, and these actions conserve finite resources. The need for landfills and neighborhood incinerators is diminished, contributing to better air quality, as well as the protection of open land.

When there is a demand, local manufacturing plants and recycling centers become fully operational, increasing job opportunities in the community.

Methodology

Design Strategies

Design teams may choose to develop a comprehensive Materials Management Plan (see MEQ-01-P), which considers specifying materials that embody a number of the sustainable characteristics discussed above. These include:

- Recycled content
- Composition that offers opportunities for future salvage, reuse or recyclability
- Manufactured at locales proximate to site (500 miles radius)
- Sustainably managed/certified forest products
- Agricultural waste and/or renewable material content
- Low in toxicity (See IEQ-06)

In the design of the building include adequate facilities for the recycling of all office waste. This involves providing separate spaces or recycling areas – at a minimum, one on each floor of the building, plus a centralized location, preferably on the ground floor or basement - for the collection of all recyclables. The spaces must be large enough to allow for the separation of materials, such as white paper, other paper (colored, coated, etc.), newsprint and cardboard, plastics, glass and all metals. More than one recycling room per floor may be necessary in the case of buildings with large floor-plates. A useful strategy in high-rise buildings is to include a chute or chutes for the vertical transportation of recyclables, which generally facilitates recycling efforts by building occupants. Such built-in equipment simplifies collection, and reduces the labor associated with the collection of recyclables.

Means and Methods

During construction, establish a dedicated outdoor space for the separation and collection of all C&D waste and recyclables. Identify and establish contracts with local and regional recycling centers and/or manufacturer's take-back programs for major materials. Programs which up-cycle or reuse materials such as steel, aluminum, concrete, masonry, carpet, drywall, ceiling tile, glass, wood, etc. at their highest use are preferred. 'Highest use' is defined as reusing the material for the same or a similar product as its first use. Programs that down-cycle or consolidate materials by methods such as melting down the top fiber, intermediary layers and backing materials of carpet tile into a solid mass of commingled plastics, or mixing wood chips and plastic to make a new, but commingled material where separation at a later date is difficult, are preferably avoided.

Inside the building, a single vertical chute with multiple openings or a revolving access design, or several chutes, each with its own access door may be used to facilitate recycling by building occupants. These chutes run the length of the building and are accessible on each floor in the recycling rooms. The chutes will terminate at the ground floor or basement recycling facility. Easy access by direct route or freight elevator from this facility to the loading dock should be planned. Newsprint and

glass must still be collected manually from each floor recycling room and brought to the centralized recycling facility. Balers for cardboard, corrugated and newsprint located in the centralized facility are helpful in consolidating these materials.

In buildings that include the collection of biodegradable materials, make sure that there is a secure retaining area, with metal bins raised off the ground in order to assist with pest management. Composting is still not permitted in office buildings in New York City, however a centralized World Trade Center composting site might be available. Truck access for all recyclable materials, both during construction of the building and its subsequent operation, is an important factor in the Materials Management Plan.

Case Studies

Home Box Office (HBO) Headquarters, New York City

The management of HBO has made a concerted effort to lessen their negative impact on the environment and save operating costs in the process. As part of the development of their Corporate Policy on Environmental Affairs, HBO has taken various steps to promote environmental stewardship including the efficient management of office materials. An Environmental Focus Group was created within the company, whose primary task is interdepartmental coordination of environmental concerns. This group elected volunteer floor captains who meet twice a month to discuss the manner in which the company's day-to-day operating procedures can be altered to benefit the environment as well as their own bottom-line. By establishing an environmental leadership team with the goal of investigating money-saving opportunities, they have effectively insured that waste prevention is an integral part of decision-making at all levels of the company. Outside of the management of HBO, the involvement of two other groups of people was obtained to make material management a success. The Environmental Focus Group requested that employees at every level of the company provide insight into methods for reducing waste production. The group also worked with their product vendors to trim waste where possible. These suppliers were asked to reduce superfluous packaging, take back and reuse packaging when possible, and provide products that were more durable, reusable, or refillable; more efficient; and less toxic. HBO saves over $150,000 per year on material expenditures because of these efforts.

Reference

Definitions

Down-cycling: This term refers to a process where materials lose their intrinsic value by being commingled, crushed or otherwise adulterated so that reconstitution into a viable 'raw' material state, capable of being 'up-cycled' is permanently lost. Examples include mixed crushed concrete, masonry, glass, etc. used for roadbed fill, and 'plastic' wood.

Up-cycling: This term refers to the highest use of a recycled material. In this process, a post-consumer product may be remanufactured into a new product of a similar nature as the original, or another product of equal or

higher value. Examples include the remanufacturing of all parts of nylon carpet, where the previously down-cycled nylon is now made into new nylon fiber for the carpet industry. Similarly, used wallboard and ceiling tile is now able to be reprocessed to form similar products of equal value to the original.

Recycled content: This term refers to materials that contain, as an integral part of their composition, previously manufactured product. They may be made from totally recycled materials or contain a mix of recycled and new materials. There are two types of recycled material to consider as follows:

Post-industrial recycled content: refers to products containing material that has been *recycled*, but not *used* by consumers. Post-industrial content is made up of reprocessed factory waste, such as off-cuts, overrun from manufacturing processes, sub-standard production, broken, damaged, returned or otherwise unusable materials, etc. Products containing post-industrial content are less-highly valued than those with cost-consumer content.

Post-consumer recycled content: refers to material that has been used and is being discarded because it has reached the end of its useful life in that product form. Post-consumer material content is constituted from *remanufacturing* products that have been 'used' by consumers and which require complete reprocessing. Products containing whole or part post-consumer materials are more highly valued than those containing post-industrial content.

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Materials Management Plan MEQ-1-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Objective of the Materials Management Plan is to coordinate and implement materials' guideline requirements within the Sustainable Design Guidelines in order to optimize material resources and facilitate the reduction of waste. Materials are to be evaluated on a number of criteria including embodied energy, recycled content, recyclability, proximity of manufacture and original source, renewable or agricultural content and toxicity levels. The plan is designed to address waste management strategies for site materials during construction, as well as waste material flows after the building is occupied, which are addressed by the incorporation of recycling facilities.

Plan Components

I. Project Description (Plan Summary)

A. Provide a description of major building materials being considered for the project. Include materials to be used in the structure, envelope and as primary architectural finishes.

B. Provide materials' flow descriptions for the construction process and for the building once occupied. Include descriptions of the materials management facilities and systems, such as receiving and storage areas, segregated area for containers for the collection and separation of recyclable waste materials, location of organic waste disposal, recycling facilities, etc., and any special measures designed to support materials reuse or recycling.

C. Describe local waste handling requirements. Include analysis of local code requirements, city rules and special neighborhood circumstances which will have an impact on this plan.

II. Construction Material Inventory

Evaluate all major materials and products that are to be utilized during the construction process based on the following criteria:

A. Durability -- and expected length of use of material.

B. Recycled Content and Recyclability – The goal is to choose materials, products and systems that both contain a measure of recycled content and that can be recycled into similar or other, high-end uses in the future. Specifying materials with recycled content is a first step in the concept of the 'cradle- to-cradle' or closed loop process that will eventually lead to a significant reduction in the need for the extraction and/or harvesting of virgin materials. Choosing materials for their recyclability completes the circle, creating a 'new source of feedstock' for materials from already processed goods, thereby reducing the impact on the virgin materials resource base. These actions minimize the drawdown of natural resources, and contribute to the preservation of our natural ecosystems. Further,

still viable materials are diverted from the waste stream, conserving landfill space and reducing potential pollution caused by landfills and incinerators. This approach stimulates both the national and regional marketplace for recycled products. It also reduces the amount of fossil fuels used along with their associated pollutants, as remanufacturing and reuse of previously processed materials are typically significantly less energy intensive.

C. Proximity – Choosing to use materials that are from sources and manufacturing facilities close to the site offers a number of benefits, both environmental and economical. The reduced use of fossil fuels and their associated pollutants, such as greenhouse gas emissions (carbon dioxide, nitrous oxides, sulfur dioxides, carbon monoxide, and particulates) that are a direct result of the transportation of these goods, protects air quality, while conserving the fossil-fuel base. The local/regional economy and small and start-up recycling and reprocessing industries are supported and encouraged, enhancing both material re-use and the labor base. Specifying locally available materials often reinforces the use of vernacular building materials and the 'sense of place'.

D. Low Toxicity Products – Products with low levels of toxicity are wise choices, protecting both people and the environment on many levels. Understanding the nature of materials and choosing to deliberately avoid specifying those containing chemicals known to adversely affect human well-being and/or the environment will lead to environmentally cleaner manufacturing processes and a reduction in the use of such chemicals. This strategy will minimize the exposure of workers to toxic chemicals in manufacturing facilities, as well as building occupants. In many cases, facilities that produce materials incorporating such chemicals are responsible for toxic releases to the air, water and/or soil, contaminating the environment.

   Eliminating demand for materials made with known toxicants will begin to reduce the current levels of contamination in the natural environment and limit adverse effects on habitat. Once a part of the built environment, materials with lower toxicity levels lead to improved indoor air quality (IAQ), which has been demonstrated to increase productivity, reduce absenteeism, and enhance quality of life.

E. Renewable Content -- Today there are numerous materials to choose from which are made either in total or in part with content that can be termed 'rapidly renewable'. The sustainable movement has created a demand for such materials and the manufacturing base has responded with a number of new and exciting products, including a whole range made from agricultural waste materials (agri-products). In addition, manufacturers have revived an interest in marketing older products in this category, such as linoleum and wool carpet. Specifying such materials is important because it allows longer growth cycle materials such as hardwoods to achieve full maturity, and therefore full yields, prior to being harvested. It captures and utilizes materials such as wheat straw and seed husks that were previously burnt as waste, creating huge amounts of air pollution. Materials with renewable content also support an entire labor market, which is engaged in the cyclical process of planting or seeding, tending, feeding, harvesting and subsequently processing these materials, often on an

annual, but always on a predetermined, cyclical basis – i.e. the seven year cork tree growth and bark harvesting schedule.

F. Reused/Salvaged Material – Salvaged materials differ from recycled materials in that they are 'found' products at the site (or from other sources), which are reusable without being remanufactured. They may require some repair or restorative work. These materials can be used in the renovation or rebuilding at the site where they are found, or they may enter the salvaged materials market, where they will be stored until required on another project. Salvaged materials may have intrinsic value, or be of historic significance, such as parts of the existing building stonework, terracotta embellishments or brickwork, decorative elements like paneling or millwork -- or they may simply be reusable, as in the case of certain hardware, doors, decorative light fixtures and metalwork, without major processing. This adaptability distinguishes salvaged materials from recycled materials, which must always be reprocessed before being reused.

G. Low-Embodied Energy – The embodied energy of a product includes all of the energy that goes into the realization of that product. It includes the energy used in the extraction or collection of its raw materials, in its processing, packaging and transportation, its installation, and, at the end of the product's usefulness, the energy required to dismantle, recycle or dispose of it. That energy is basically gone – it can never be replaced. The purpose of utilizing materials with low-embodied energy is to minimize the use of fossil fuels, conserve resources and avoid contributing to environmental degradation associated with the extraction and transportation of those fuels, such as spills and soil and water contamination. This strategy also reduces emissions of greenhouse gases such as carbon dioxide, vaporized mercury, nitrous oxides, sulfur dioxides, carbon monoxide, and particulates related to more energy intensive processing and manufacturing methodologies.

III. Management Strategies

Outline project strategies for materials and waste management. Address each of the following categories.

A. Material Flow Management
   1. Construction Materials.
      a) Construction Waste Management Plan
      b) Material life-cycle.
         - Use products/materials with recycled content. See chapter discussion of post-consumer and post-industrial content (MEQ-04).
         - A minimum of 20% of all building materials (based on cost) must be manufactured within a 500-mile radius of the project site.
         - At least 50% of the wood products and materials are to be provided from sustainably harvested wood sources and each submission must be supplied with a chain of custody and FSC certification.
         - Teams must demonstrate that they have employed the use of rapidly renewable building materials and products made from plants and

other natural resources, such as wool that are renewed on an annual basis, or are typically harvested within a ten-year cycle, such as poplar trees and cork.

2. Operational Material Flows
   a) Design Considerations
   Provide a central, appropriately sized location for sorting recyclable materials. Facilities must include, at a minimum, space for the separation and temporary storage of paper, corrugated cardboard, glass, plastics and metals. Provide easy access to the loading dock and/or garbage pick-up location, and easy truck access for the pick-up and removal of recyclables

B. Material Maintenance
   a) Select materials that are durable and easy to maintain. Look at the track record of typical materials and specify those that are known to be hardwearing and simple to clean without the use of harsh or toxic chemicals such as chlorine or heavy solvents. Provide the owner with maintenance schedules for all finishes such as carpet, making sure that procedures with the least environmental impact, such as dry cleaning of carpets are included in the recommendations.

C. Material impacts on indoor air quality
   Reduce the quantity of indoor air contaminants that are odorous, potentially irritating and/or harmful to the health, comfort and well-being of installers and occupants, by using:
   1. Adhesives and sealants with low VOC content: per current version of the SCAQMD Rule 1168.
   2. Paints and coatings with low VOC content: per Green Seal GS-11 and GC-03.
   3. Carpet, carpet systems and carpet adhesives with low VOC emissions: per CRI Green Label Plus and Green Label Indoor Air Quality Test programs and the SCAQMD Rule 1168.
   4. Composite wood with no added urea-formaldehyde such as might be used in the bonding agent.

IV. Targets

Establish and describe project targets for the following

A. Construction Waste Management Plan MEQ-02-P (Plan requirements appear under specific plan).
B. Project material management operations upon completion.
   Include at a minimum paper, plastic, beverage containers, cardboard, tenant refurbishments (carpet, furniture etc.) and food (for facilities serving food). Describe facilities in place for receiving, sorting, storing and disposing of materials.
C. 5 year and 10 year plan for project material management.

V. Evaluation

Upon project completion, compare established targets for IV.A and IV.B with results. If targets have not been met, provide explanation and, if necessary, revise 5 year and 10 year plans to accommodate revised results.

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Material Managements

MEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
A Comprehensive Material Management Plan is attached and includes the following:

- Coordination with and implementation of each of the individual Material Environmental Quality Guidelines of the Reference Manual.
- A description of materials utilized, materials reused, recycled content, location of manufacture/harvest, renewable content, sustainable management certification and CoC number, expected lifetime, maintenance requirements, and recyclable/reuse potential at end of useful life.
- A minimized travel distance of building products and systems with location of sinks for highest recycled use for "waste" materials coordinated with MEQ-2 and MEQ-5.

☐ **Required Component:** *(Note: this will satisfy LEED™ 2.1 Materials and Resources Prerequisite 1: Storage and Collection of Recyclables)*
The necessary infrastructure has been provided to implement the recycling requirements of the Comprehensive Material Management Plan. This includes a central location for the on-going recycling of occupant waste materials, that offers appropriately sized recycling facilities for all buildings. These facilities include, at a minimum, space for the separation, collection, and storage for recycling of paper, corrugated cardboard, glass, plastics, and metals. Each area is clearly defined and easy truck access has been proved for pick-up and removal of recyclables.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Construction Waste Management MEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce the amount of construction and demolition (C&D) waste going to landfills and/or incinerators and to conserve resources through reuse and recycling.

Action: Implement a Construction Waste Management Plan to divert construction, demolition and land clearing debris from landfill disposal to redirect recyclable and/or recovered resources back to the manufacturing process and to redirect salvageable materials to appropriate sites. Recycle and/or salvage a minimum of 50% of construction, demolition and land clearing waste, calculated by weight. Divert a minimum of 50% of construction waste by weight from landfill.

Related Guidelines:

Potential LEED™ 2.1 Credits: 2 possible with MR 2.1 and 2.2 (see Submittal Template)

Introduction/Context

"About 94% of the materials extracted for use in manufacturing durable products become waste before the product is even manufactured. Overall, America's material and energy efficiency is no more than 1 or 2%". *(Hawken 1997)*

In 1998, according to the EPA, more than 136 million tons of C&D waste, excluding waste associated with infrastructure such as roads, bridges, etc., went to landfill as a result of the indiscriminate dumping of commingled materials from building construction activities. Ninety-two percent (92%) constituted materials directly associated with demolition and renovation of existing structures. With a growing concern relative to landfill capacity issues, and lack of new landfill sites, solid waste management presents an enormous challenge all across the United States today. Added to these problems are rising disposal costs and a greater public awareness and concern about the increasing depletion of natural resources, as well as the pollution of land and ground water, as toxins leach from commingled waste materials in aging landfills and containment structures.

Incineration, once thought to be a solution to the growing waste problem, is in and of itself, extremely controversial. The high-heat incineration process creates significant air pollution, releasing odors and particulate matter, and is always unpopular among community residents. Chief among the complaints is that the burning process releases highly toxic substances such as mercury vapor, dioxins and furans (from phthalates in PVC and other plastics, which are carcinogenic), as well as many other substances known to adversely affect human health.

Solid waste disposal is a problem of great significance to New York City, with landfill sites at capacity, and few new sites or disposal options available. As a result, in October 2004, the

city introduced new (draft) legislation addressing a long-term plan (2004 to 2024) for both residential and commercial solid waste management, called the 'New York City Department of Sanitation: Draft Comprehensive Solid Waste Management Plan'. In Attachment IV of the Plan: 'Commercial Waste Quantities and Projections for Plan Period', the following rising statistics for New York City's non-putrescible C&D waste are given:

- 2000: 6.35 million tons
- 2002: 7.90 million tons
- 2003: 8.64 million tons
- Incremental data for the years 2005 through the end of the plan period indicate that the total amount of non-putrescible solid C&D waste in 2024 is expected to climb to a maximum of 10,862 million tons. Of this amount, clean fill accounts for some 67%.

The plan indicates that for the year 2003, the city generated approximately 20,000 to 25,000 tons of non-putrescible C&D waste daily. Much of this waste could have been recycled and retained within the useable materials inventory.

Relevant Issues

Ecological

Source reduction, use of recovered materials or salvaged materials, recycling and the use of products with recycled content all lead to a lesser draw-down of the raw material resource base and a lessening of the amount of materials destined to be land-filled. The energy and labor to extract or obtain and process raw materials may be as much as 95% more than that needed for recycling (i.e. extracting bauxite for aluminum manufacturing versus recycling aluminum). Transportation impacts are also minimized.

It has now been demonstrated that landfills with unsorted C&D waste contain toxic materials such as lead, mercury, PVC, brominated fire retardants, phthalates, arsenic and chromate acids and a huge variety of other noxious substances. Through the natural beak-down overtime by sunlight and water, toxic substances and chemicals are released from their host materials, leaching into the surrounding soil and ground water, thereby creating hazardous conditions for which there is literally no remedy. Recently developed landfills are designed to be 'contained'; however, the containment materials themselves are prone to cracking, allowing for unanticipated contamination. In addition, landfills such as the huge Fresh Kills Landfill on Staten Island create air and water pollution on a scale that has engendered lawsuits against the city.

Use of incinerators to dispose of some types of C&D waste is questionable, as this process is suspected of disseminating toxic fumes and particulate matter into the atmosphere. Incineration facilities are expensive to operate and create air pollution in the local community, where they are often seen as an eyesore as well. As people become more aware of the downside of this disposal system, their presence, and the possibility of building new incinerators, is becoming increasingly challenged. Fumes and smoke generated by the burning of certain materials such as PVC, plastics,

foam rubber and pressure treated wood have a seriously adverse affect on air quality, releasing gaseous chemicals including arsenic compounds, dioxins and furans, which are carcinogenic and dangerous to human health.

New laws are beginning to enforce the separation of hazardous or difficult to handle waste materials from regular construction C&D waste and debris. Products such as lighting ballasts that were manufactured prior to 1979 generally contain polychlorinated biphenyls (PCBs), while fluorescent and high intensity discharge lamps and the type of light switches called 'silent switches,' contain mercury. Older thermostats and lighting controls also may contain mercury. (Mercury containing vessels can now be recycled at specials locations). Waste paint containers may contain lead, chromium and other deleterious substances, including heavy amounts of VOC's (solvents). Lead-contaminated waste of any kind must be handled as hazardous waste, as well as pressure treated wood containing CCA, CZCA, creosote and other toxic preservatives. Asbestos containing materials, from shingles to flooring tile, and materials that have been abated from piping etc. in buildings, are hazardous waste. Many states are beginning to offer guidance on the proper removal, transportation and disposal of these materials, which must be separated from regular C&D waste and hauled to sites designated to receive hazardous waste. Enforcement of this law is beginning to clean up the disposal industry, and in the long run will reduce the toxic nature of regular landfills.

Composting of foodstuffs and paper or cellulose products at the building site is an alternative strategy for biodegradable materials, which has environmental benefits. Most of the composting systems approved for use in urban settings are entirely closed, and create no smell. The process eliminates the need to retain spoiling food in bins in or near the building until scheduled pick-up times, and helps to manage the pest problems commonly associated with food waste. It results in rich, clean composting material that can be used at the site for landscaping purposes or exported to neighboring sites.

Economic

Even a few years ago, raw materials were relatively inexpensive when compared with the cost of labor, and supplies were plentiful. There was also readily available space in nearby landfills, making dumping of C&D waste both convenient and inexpensive. All that has changed: Today, with a cost premium for almost all building materials and practically no available landfill space within easy reach of New York City, other solutions to waste disposal must be found. In fact, the City is under enormous pressure to address its solid waste problem. While the city does have long-term contracts to ship garbage to out-of-state landfills in Pennsylvania, Ohio, South Carolina and Virginia, trucking the garbage to distant sites is becoming more and more uneconomical. An evaluation of recycling vs. landfilling suggests that when tipping fees exceed $50.00 per ton, recycling becomes an attractive alternative. Together with trucking costs, the expense of land filling (at a cost of $162 per ton for the full disposal service (2004 figure). (See SEQ-11: Recovery of Resources) to New York City, now greatly exceeds this breakpoint..

The long-term solution to the city's commercial C&D waste disposal problem may lie in simply reducing the amount of construction debris. Strategies that encourage this approach include resource reduction – the conservation and reuse of existing

building stock and infrastructure, purchasing only what is needed, as well as paring down the quantity of finish materials. For instance, the cost of a gut and major renovation project is only about two thirds of the cost of building new and conserves a significant amount of materials. Commercial recycling strategies are already in place, and many are economically successful. For instance, ready markets for the recycling of all metals, concrete and masonry, asphalt, paper and packaging materials such as cardboard already exist. Recycling these items -- all either used or left over -- reduces trucking and tipping fees and in addition, many are saleable for hard cash. Further, recycling such materials takes them out of the waste stream and provides the new 'raw' materials base to sustain the many fledgling recycling/re-manufacturing businesses in and around the city, supporting the local economy. While prices for used materials fluctuate with market demand, as recycling becomes a more accepted and 'normal' manner of doing business, cost schedules are being stabilized.

Among more recent sources for reusable materials are the huge 'take-back' programs instigated by national manufacturers. Used and/or demolished items such as carpet, carpet tile, wallboard and ceiling tile are now eagerly sought by the original manufacturers (both their own and similar products made by other manufacturers) to feed the new remanufacturing programs. These corporations have discovered that it is less expensive and less energy intensive to recycle previously manufactured goods than to make new product from raw materials. It has taken several years for such programs to become effective, as considerable infrastructure has had to be built to accommodate the remanufacturing processes associated with the separation of finished materials for remanufacturing, and new manufacturing techniques have had to be put in place. While these programs do not pay out cash to the contractor or owner -- yet, they do take a tremendous amount of the solid C&D waste associated with renovation work out of the waste stream, thereby reducing trucking costs and tipping fees, conserving space in landfills, conserving resources and reducing manufacturing impacts.

Neighborhood

Communities benefit when landfills and incinerators are reduced in number and size. In addition, they benefit as a result of the new, more stringent laws, which prohibit the dumping of hazardous materials in regular fills, and which regulate the types of materials that can be incinerated. When foodstuffs are handled in composting systems at the site, much of the odor and poor air quality may be avoided, both around the building and at the landfill where the material would otherwise have been deposited. These strategies help to maintain higher air quality and to protect land and ground water from contamination.

An informed public is becoming more concerned about depletion of natural resources, as well as the ability to be competitive in difficult economic times. Reducing consumption through conservation strategies – resource reuse and recycling – contributes to mitigation of both of these concerns. Communities based in and near the World Trade Center site will benefit from the protection of the resource base, while the new recycling/remanufacturing industries create local jobs.

Methodology

- **Design Strategies**
  Oregon law has "established a hierarchy for the management of solid waste. The first objective is to prevent the generation of the waste. If that is not possible, reuse is the next best option, followed by recycling, composting, and energy recovery. Safe disposal is the last option, if none of the others is feasible." This approach makes perfect sense and succinctly presents the objectives of an ideal Construction Waste Management Plan.

  Develop a Construction Waste Management Plan that addresses all potential site conditions. Reuse existing buildings and infrastructure on the site where possible, and/or use deconstruction methodologies rather than a gross demolition approach, which results in co-mingled C&D waste when structures must be removed in part or in whole. Indicate that the maximum amounts of materials are to be salvaged for future reuse and identify potential markets for these materials. Track the amount of salvageable material by actual or estimated cost for inclusion in the documentation of project strategies. Include a requirement for on-site equipment in the plan to reprocess (crush) otherwise unusable, stone-like materials, concrete and masonry for use in the project foundations, and/or in developing the surrounding infrastructure: i.e. concrete aggregate and asphalt for roadbed construction.

  The Plan needs to indicate all materials that have a potential to be recycled, and to identify local/regional recycling centers. The objective is to 'up-cycle': that is to reuse materials at their highest potential, rather than 'down-cycle' where materials lose their premium quality and cannot be reused in their original capacity. To achieve this goal, research must be included to determine which recycling centers and/or manufacturers' take-back programs have the capability to generate each specific, reprocessed material and product at a quality commensurate with the original quality. Estimate costs associated with the additional labor for the deconstruction, separation of materials and recycling portions of the work, and include cost-benefits achieved through fees paid to the contractor for materials for recycling, as well as reduced haulage and tipping or incineration fees.

- **Means and Methods**
  In order to achieve effective material recovery and recycling programs, a balance in the supply and demand for recyclable materials is essential. At this point in time most C&D materials collected have some assurance of a market, although prices fluctuate, making it difficult to assess the financial pros and cons of a major, site-wide recycling initiative. Transportation costs associated with a recycling program are also a consideration; however, they do not begin to compare with the high cost of long-distance hauling of waste materials to remote states, which is the current solution in effect in New York City. Commercial recycling programs and procurement policies which create a demand for goods made from recycled material are gaining greater acceptance: the greater the supply of C&D waste materials available for recycling, the more materials are returned to the marketplace with partial or total amounts of recycled content.

Where possible, reuse the foundations and shell of existing buildings around the site that fall within the jurisdiction of the WTC Guidelines. This approach may save up to one third of the cost of building new, and is less disruptive to the community, as less noise is generated and trucking impacts are reduced. This approach captures some of the original embodied energy of the structure and preserves already processed resources. There is little opportunity to use existing, above ground structures at the core of the Trade World Center site; therefore resource reduction must focus on efficiency of planning and ordering, on the optimum use of materials, and on maximum recycling of C&D waste, followed by a rigorous approach to recycling within the completed facilities.

Careful planning will ensure that minimal excess materials are ordered. New materials and products must be stored in safe, dry locations to avoid potential contamination and wet conditions that might adversely affect them, resulting in additional waste and cost associated with their replacement. Minimization of packing materials is an important strategy, contributing to waste reduction. The Construction Waste Management Plan for each project designates the area where C&D materials will be separated, sorted and stored. This area needs to be protected from the elements, and have easy truck access for pick-up. Recycling containers must be clearly labeled in Spanish as well as English. On-site training of construction workers will ensure that all personnel understand, and are able to comply with, the objectives of the waste management plan.

A C&D manager must be appointed early in the design process, by the Construction Manager or General Contractor. Since goods for recycling are measured and paid for by weight in most cases, record keeping is a critical part of tracking achievement in this area of endeavor. Feedback on the operation and success of the plan is essential. Weekly meetings with personnel from each major sub-contractor, and coordination with other meetings/site strategies can help to manage the process and quickly identify problems.

Municipal solid waste and biodegradable materials and food should be kept separate from the C&D containers to avoid contamination and lessen the attraction for pests such as rats and cockroaches. If possible, a site-wide composting program can be used to manage biodegradable waste, eliminating the need for independent project or building storage, as well as the costs of haulage and tipping fees. Hazardous materials must also be kept separate from C&D waste, and clearly labeled in accordance with all legal requirements, prior to shipping to appropriate disposal facilities. Even with all of these strategies in place, a 100% reuse of C&D waste is probably not possible and there will continue to be a need for available disposal options to take care of the residual materials.

Case Studies

Sports Arena, Portland Oregon

A car wash and exhibit hall were demolished to make way for a new sports arena in Portland that began construction in November of 1993. By October of 1994, the project was merely 30% complete but had already recycled 98% of its construction and demolition waste. 35,000 of 36,888 tons of total waste was prevented from being dumped in a landfill. 30, 482 tons of that waste was recovered concrete and

asphalt rubble, which was reprocessed as clean fill and road surfacing. 392 tons of metal were recovered and went to two recycling companies in the Portland Area. 678 tons of wood were diverted from the waste stream, some made into composite particleboard and some burned as fuel in industrial boilers. 6 tons of cardboard were collected and shipped to another local recycler. Site-clearing debris went to a compost company and excavated soil went to various places, including the project site. At this point in the project the contractor had already saved $85,000 in avoided disposal fees and only spent about $8,000 for the actual cost of recycling services obtained. (BuildingGreen.com 1994)

MIT Media Lab, Cambridge, Massachusetts
During this project 4,519 tons of material was recycled for a total waste reduction rate of 96 percent. Before the demolition of the existing building, the client began searching for ways to donate unwanted interior furnishings and equipment, including office dividers, desks, and blackboards. They donated 20 desks to the Cambridge School System: they also offered surplus items through a chain of recipients that began with faculty and worked its way down to the community at large. After everyone had their chance to take materials they might want, the rest was handed over to the demolition company. A construction waste clause was part of the project contract and helped insure that as much waste as possible would be diverted from landfills. Key tenets of this program included a list of specified materials that were to be reused or recycled, a requirement that reuse or recycling would be mandatory whenever it was less expensive than disposal, and a requirement for the contractor to devise a construction waste management plan. (Massachusetts 2005)

Reference

Definitions

Putrescible waste is organic waste that decays through exposure to natural environmental elements. Food waste is a primary example.

Up-cycling: This term refers to the highest use of a recycled material. In this process, a post-consumer product may be remanufactured into a new product of a similar nature as the original, or another product of equal or higher value. Examples include the remanufacturing of all parts of nylon carpet, where the previously down-cycled nylon is now made into new nylon fiber for the carpet industry. Similarly, used wallboard and ceiling tile is now able to be reprocessed to form similar products of equal value to the original.

Down-cycling: This term refers to a process where materials lose their intrinsic value by being commingled, crushed or otherwise adulterated so that reconstitution into a viable 'raw' material state, capable of being 'up-cycled' is permanently lost. Examples include mixed crushed concrete, masonry, glass, etc. used for roadbed fill, and 'plastic' wood.

Recycled content: This term refers to materials that contain, as an integral part of their composition, previously manufactured product. They may be made from totally recycled materials or contain a mix of recycled and new materials. There are two types of recycled material to consider as follows:

Post-industrial recycled content: refers to products containing material that has been *recycled*, but not *used* by consumers. Post-industrial content is made up of reprocessed factory waste, such as off-cuts, overrun from manufacturing processes, sub-standard production, broken, damaged, returned or otherwise unusable materials, etc. Products containing post-industrial content are less-highly valued than those with cost-consumer content.

Post-consumer recycled content: refers to material that has been used and is being discarded because it has reached the end of its useful life in that product form. Post-consumer material content is constituted from *remanufacturing* products that have been 'used' by consumers and which require complete reprocessing. Products containing whole or part post-consumer materials are more highly valued than those containing post-industrial content.

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Construction Waste Management Plan MEQ-2-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objective

The Objective of the Construction Waste Management Plan is to identify and evaluate all resources created during the construction process and to establish plans and areas dedicated to recycling these resources to greatly reduce the amount of material going to landfills and/or incinerators, while encourage the reuse of resources at their best and highest use.

Plan Components

I. Project Description (Plan Summary)

A. Provide a physical description of the project. Include a description of significant construction waste potentials for recycling and re-use.
B. Outline plan for managing construction waste. Include construction timetable, areas set aside for waste storage and sorting, and anticipated transportation requirements to remove materials from site.
C. Provide information on local codes and city construction waste programs/initiatives.

II. Construction Waste Resources Inventory

Provide a detailed list of construction waste resources and potential recycling or reuse centers for the following materials.

A. Metals – Steel, Aluminum, Copper, Zinc, Stainless Steel, Iron, etc.
B. Clean Dimensional Wood
C. Cardboard
D. Plastics - Beverage Containers, Packing Materials, etc.
E. Gypsum Wallboard
F. Ceiling Tile
G. Concrete
H. Masonry
I. Concrete Formwork
J. Gypsum Wallboard
K. Other

III. Management Strategies

A. Research regional construction waste Recycling Centers and identify a minimum of three centers for each type of construction waste.
B. Calculate savings in disposing of materials through recycling centers or vendors interested in material re-use as opposed to landfill and tipping costs.
C. Identify means of protection of materials stored on site.
D. Indicate materials handling procedures

E. Itemize on-site reuse potentials.
F. Itemize off-site reuse potentials.
G. Indicate transportation management strategies.
H. Indicate methods used to handle biodegradable waste
I. Indicate methods used to handle hazardous waste

IV. Draft Construction Waste Management Plan

Provide a draft construction waste management plan incorporating the following;

A. Inventory of proposed jobsite waste as outlined in II above.
B. Inventory of recycling centers and/or alternatives to landfilling waste.
C. Inventory of landfill options.
D. Waste management goals.
   For each type of waste material, the report should list the following:
   - Quantity
   - Destination
   - Means of transportation
   - Cost of handling and transportation
   - Expected revenue from saved materials
   - Tipping fee savings resulting from alternative strategies
   - Net cost/savings anticipated
   - Estimate of comparative cost if materials had been landfilled
   - Total comparison of cost or savings.

   The report should total all materials at the end and give an overall figure of cost or net savings realized from all alternative strategies to landfilling the project waste.

V. Final Construction Waste Management Plan

Complete a report at the end of construction that calculates the net cost or savings as a result of implementing this plan.

Construction Waste Management MEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

☐ **Required Component:**
The attached Construction Waste Management plan has been designed and implemented to divert construction, demolition and land clearing debris from landfill disposal to redirect recyclable and/or recovered resources back to the manufacturing process and to redirect salvageable materials to appropriate sites.

☐ **Required Component:** *(This will satisfy LEED™ 2.1 Materials and Resources Credit 2.2: Construction Waste Management – Divert 50% from Landfill)*
This certifies that a minimum of 50% of construction, demolition and land clearing waste (as calculated by weight) has been salvaged or recycled. A minimum of 50% of construction waste (by weight) has been diverted from landfill.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Materials and Resources Credit 2.2: Construction Waste Management – Divert 75% from Landfill)*
This certifies that a minimum of 75% of construction, demolition and land clearing waste (as calculated by weight) has been salvaged or recycled and been diverted from landfill.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Resource Reuse MEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To incorporate previously used building materials and products into new construction.

Action: In coordination with the Materials Management Plan consider the use of salvaged, refurbished or reused materials and products in the building. Materials for reuse typically include reclaimed lumber and wood such as salvaged wood flooring and wood doors and cabinets, structural metal work such as beams, and miscellaneous metal such as doors, door hardware, etc. Decorative and specialized items such as salvaged wood and glass panels, banquettes, front and back bars and decorative or period lighting fixtures may be used in special public locations such as cafeterias or restaurants, and can contribute to this credit.

Related Guidelines: SEQ-1, SEQ-7, SEQ-11, MEQ-1, MEQ-2, MEQ-4, MEQ-5, IEQ-6

Potential LEED™ 2.1 Credits: 2 possible with MR cr. 2.1 and MR cr. 3.2 (see Submittal Template)

Introduction/Context
The use of salvaged and/or previously used materials and products is an exemplary, sustainable materials strategy. Not only does this action extend the life of such materials, it eliminates duplication of the embodied energy originally consumed to obtain and manufacture them. The draw-down of raw materials that would be necessary to (re)make such materials or objects is avoided. In addition, the energy and costs associated with their disposal need not be expended. For the purposes of this Guideline, strive to use materials that have been salvaged or previously used for 2% of the total value of the project.

Salvaged and refurbished materials, and materials that are reused on a project, differ from recycled materials in that they retain their integrity and are used, essentially, in the form in which they were originally cast. While they may need refurbishment – cleaning, repainting or refinishing, reupholstering -- they do not require to be *remade*. Use of recycled materials, on the other hand, implies the use of remanufactured materials. Because of the 9/11 tragedy, finding salvaged materials at the site may be a challenge for World Trade Center projects; however, this strategy should be encouraged, and the New York area offers plenty of opportunities to acquire interesting and appropriate salvaged materials from other buildings of note and historical sources. Materials such as architectural stonework, figurative terracotta tiles, decorative light fixtures, metalwork, millwork and antique outdoor furniture, urns, cast concrete figures, etc. may well be found at such places as Urban Archaeology in New York City, United House Wrecking in Stamford, CT and the Elemental Garden in Woodbury, CT, among many other reclamation centers.

Relevant Issues

Ecological

Reducing the demand for new materials protects the resource base. Reusing materials that have already been extracted or harvested, transported to manufacturing locations, manufactured or processed and again transported to the site, saves raw materials, energy, fossil fuels, labor and time. The cost and energy of disposal, as well as landfill space, are avoided. Potential atmospheric, land and water pollution contributions are avoided at every step, resulting in cleaner air and a healthier natural environment.

Economic

The economic benefit of resource reuse as discussed in this section is only a small part of the sustainable benefit realized through these strategies. To-date, there is insufficient material, and limited demand, to support many economically significant salvage operations, though such operations do exist in and around New York City. The effort involved in refurbishing can be significant, with a high price tag in some cases. However, the avoided cost in carting and tipping fees, together with the reuse of some of the more available and economically viable materials such as wood flooring, doors and furniture systems, can make a noticeable dent in first costs. Salvaging unique, historical building artifacts and decorative details such as friezes, stonework, decorative cornices, tile work and hardware -- items which are irreplaceable in today's market – can enhance and contribute to a new structure's interest and quality, grounding it in an appropriate historical context.

Neighborhood

The larger community benefits from the reuse of materials and products that have already been assembled or manufactured by the avoidance of the pollution that would be associated with the transportation and manufacturing processes of similar, replacement items. The reduced impact on landfills leaves more room, and more time, before newer facilities must be found for disposal. The reuse of materials and products for the building industry is usually a local/regional business, supporting the local economy and distributing work to smaller refinishing/ refurbishment shops, and local trucking operations. In some cases, use of appropriate 'mementos' or materials that have an intrinsic or historic significance in reference to a particular building that has since disappeared, or to a neighborhood, garden or plaza, may add a clear dimension of commemoration to a particular site, even when used in a new, purely decorative context.

Methodology

Design Strategies

In designing the building, look for opportunities to include used or historical materials, either for basic applications like salvaged wood flooring, or in specialty areas, where appeal and context can be high-lighted through the use of interesting, or even unique artifacts. New York and some of the nearby states offer several sources for such items, including demolition companies, salvage companies and those dealing in building artifacts and historical or decorative stonework, tiles, ironwork, period millwork, hardware and fixtures. Other companies specialize in doors, paneling, window frames, and light and bathroom fixtures.

Building elements such as weathered brick, steel beams and decorative terra-cotta tiles may also be appropriate for use, not necessarily in their original application, but as decorative elements within the design of public spaces, such as main public lobbies, conference centers, cafeterias, and staff break rooms. Indoor and outdoor garden areas can make use of salvaged decorative elements such as benches, statues and even fountains, as well as tiles and stonework. Refurbished furniture and especially furniture systems are readily available commodities, with many sources in the City specializing in such items. In LEED, they contribute to earning this credit for the tenant fit-out. Antique furniture and rugs also qualify as 'used' or salvaged materials under the interiors portion of this credit.

Means and Methods

To determine if the requirements of this credit have been met, the cost of all salvaged, reused and/or refurbished materials must be quantified and reviewed in terms of their collective percentage of the total cost of materials for the entire project. Assess the materials cost for the entire project, excluding labor and installation costs. Develop a spreadsheet listing all materials that have been salvaged, reused and/or refurbished on the project, together with their prices. The sum of the salvaged, reused and/or refurbished materials is divided by the total cost of materials for the project, with the resulting figure being multiplied by 100 to determine the percentage of their cost to the project. To meet the requirements ~~of LEED v2.1~~, the cost of salvaged, reused and/or refurbished materials must represent a 5% value of the total cost of materials for the project for one point, and a 10% value for a second point.

Case Studies

CK Choi Building at the Institute of Asian Research, The University of British Columbia

Over 50% of the building materials used on this project were either salvaged from elsewhere and reused or contained recycled content. 65% of the building's heavy timber structure was salvaged from a building that was demolished across the street. 100% of its exterior brick cladding was salvaged from streets in an older section of Vancouver. Salvaged materials used within this building included: the main stair handrail, atrium guardrails, all doors, sinks, toilet accessories, and some electrical conduits. In addition to a high percentage of salvaged materials, the project demonstrated exemplary use of recycled materials.

CCI Center, Pittsburgh, PA

The adaptive reuse of an existing structure means that the shell of this building is essentially a salvaged material, however this falls under credit MR 1.1 to 1.3 in LEED. As part of the changes made to the existing building other salvaged materials were used extensively including: brick, lumber, the floor and joist system, carpet, windows, kitchen case-work and equipment, and furniture. In addition to salvaged elements, local materials with recycled content were specified whenever possible. The owner also instituted a policy to require the use of materials that are either salvaged, contain recycled materials, or are FSC Certified for all future renovation within the building.

Big Dig Buildings by Single Speed Design, Cambridge, MA, Winner of Metropolis Magazine 2004 Next Generation Prize

This project proposed to salvage and reuse structural elements from sections of the highway in Boston that had been disassembled as part of the Big Dig Project. Rather than merely salvaging material content, the design proposal uses the former highway materials intact, reconstructing them in a different configuration as an apartment building. Steel columns formerly used to support the road now hold up the building's floors. The floors themselves are assembled from concrete panels that once comprised the highway road-bed. Interestingly, the building form, by necessity, takes on the same curvature as the former highway off-ramp, from which its building-blocks were salvaged. Pre-cast concrete panels from the highway are used to create balconies. Other salvaged materials are also planned to be incorporated into the building. Marine-grade plywood once used for concrete formwork, and old timber beams that were buried at the bottom of the harbor, are planned as cladding for the apartment structure.

Reference

Definitions

Salvaged materials: There is often confusion between 'reused' or salvaged and 'recycled' materials. Reused or salvaged materials do not need to be re-manufactured. They may be cleaned and refinished, but they retain their essential integrity and shape, and are used either in their original context, such as in flooring, doors, furniture systems and hardware, etc. or as decorative elements and memorabilia, such as cast iron and terra-cotta building details. Recycled materials, on the other hand, are generally reconstituted or remanufactured from existing products.

Recycled content: This term refers to materials that contain, as an integral part of their make-up, previously manufactured product. They may be made from totally recycled materials or contain a mix of recycled and new materials. There are two types of recycled material to consider as follows:

Post-industrial recycled content: refers to products containing material that has been *recycled*, but not *used* by consumers. Post-industrial content is made up of reprocessed factory waste, such as off-cuts, overrun from manufacturing processes, sub-standard production, broken, damaged, returned or otherwise unusable materials, etc. Products containing post-industrial content are less-highly valued than those with cost-consumer content.

Post-consumer recycled content: refers to material that has been used and is being discarded because it has reached the end of its useful life in that product form. Post-consumer material content is constituted from *remanufacturing* products that have been 'used' by consumers and which require complete reprocessing. Products containing whole or part post-consumer materials are more highly valued than those containing post-industrial content.

Standards

Standards have not been included for this Guideline.

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Resource Reuse

MEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	○	○ Ⓔ	○ Ⓔ	○	○

☐ **Required Component:**
This certifies statement certifies that salvaged, refurbished, or reused materials and products have been used in the construction of this building in accordance with the Material Management Plan (MEQ-1-P). A list of salvaged, refurbished and/or reused materials is attached. This project strived to provide salvaged, refurbished, or reused materials and products for 20% of the total value of its materials.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Materials and Resources Credit 3.1: Resource Reuse – 5% requirements)*
This certifies that 5% of the materials used in the building are salvaged. This has been calculated by dividing the total cost of all salvaged materials used in the building by the total cost of all materials used in the building. These calculations and a list of each material or product used to satisfy this requirement have been provided.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Materials and Resources Credit 3.2: Resource Reuse – 10% requirements)*
This certifies that 10% of the materials used in the building are salvaged. This has been calculated by dividing the total cost of all salvaged materials used in the building by the total cost of all materials used in the building. These calculations and a list of each material or product used to satisfy this requirement have been provided.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Materials with Recycled Content MEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To incorporate materials with recycled content and increase market demand for building materials and products that incorporate recycled content.

Action: Specify materials with recycled-content in conjunction with the Materials Management Plan. The value of the recycled content portion of materials is to be at least 10% of the total project materials value (mechanical and electrical components are not to be included in these calculations).

Determine recycled content value according to the following formula: For post-consumer recycled content determine percentage of recycled content in the material and multiply by value of material. For post-industrial recycled content determine percentage of recycled content in the material, multiply by ½ and then multiply by the value of the material.

Related Guidelines: SEQ-1, MEQ-1, MEQ-2, MEQ-3, MEQ-5, IEQ-6

Potential LEED™ 2.1 Credits: 2 possible with MR cr. 4.1 and MR cr. 4.2 (see Submittal Template)

Introduction/Context

As recently as a decade ago, the concept of recycling, and especially of buying materials with recycled content, was extremely alien to an American public brought up to understand that 'new' was the only acceptable description for high quality goods. While some prescient manufacturers had always absorbed post industrial 'waste' material from their production lines into newly manufactured products, there was a certain degree of shame attached to the practice in a society that demanded 'new', and few companies admitted that they engaged in such endeavors. However, within a notably short time-span, the picture has changed dramatically. Today, the use of recycled or previously manufactured content is seen to make eminent sense, ecologically, economically and practically. Manufacturers of many common, utilitarian products such as steel, aluminum, carpeting, wallboard, ceiling tile, plastics, etc., struggle to obtain a sufficient backlog of used or 'waste' materials to offset the high costs of obtaining and processing virgin materials.

Materials with recycled content are those that contain, as an integral part of their make-up, previously manufactured product. They may be made from totally recycled materials or contain a mix of recycled and new materials. There are two types of recycled material to consider: post industrial recycled content, which is material that has been manufactured but not used by consumers, and post consumer recycled content, which is material that has been used and is being discarded because of wear, fashion change, tenant turn-over, etc. In this case the material may be said to have reached the end of its useful life in one form. Post industrial content is made up of factory waste, such as off-cuts, waste from manufacturing processes, broken, damaged, returned or otherwise unusable materials, etc.

Post consumer material, which is the more highly valued of the two, is constituted from remanufactured products that have been 'used' by consumers and which require complete reprocessing. This group includes items such as remanufactured steel from the steel in cars or from the demolition of buildings, recycled carpet, made from used nylon fiber and carpet backing and reprocessed glass from light bulb manufacturing and the demolition of buildings and vehicle windshields, among many others.

Relevant Issues

Ecological

Recycling materials involves the reprocessing of previously manufactured products into new products, either of a similar nature as the original product (up-cycling), or for a different, possibly less critical use (down-cycling). In most cases, reprocessing requires much less energy than that necessarily expended in the extraction or harvesting of raw materials, their transportation and first processing to acquire useable substances suitable for the manufacturing of recognizable goods. A clear example of this can be seen in the processing of aluminum from bauxite: it takes only 5% of the original energy to 'reprocess' an existing aluminum can into a new aluminum can (Aluminum Now, 2004). For this reason alone, recycling is an effective environmental strategy.

Of equal importance is the minimization of life-cycle impacts of materials as a result of the reuse of those already in production. The world's resource base, though vast, is in fact finite – it is essential, therefore, that the maximum amount of material enters into a cyclical pattern of use and reuse – a concept known as 'cradle-to-cradle', so that the natural environment is not consistently ransacked for materials, and eventually devastated. In addition, through this methodology, enormous amounts of still viable materials are diverted from the solid waste stream, conserving vital space in landfills and avoiding the pollution associated with incineration.

The environmental benefits of recycling and buying products with recycled content are numerous. They include protection of the remaining natural resource base, the capture of embodied energy associated with the primary effort to obtain, transport and process the original materials, and a significant reduction in time and energy needed to remanufacture and deliver these reprocessed materials back to the marketplace in the form of highly desirable new products. By diverting valuable materials from incineration or landfilling, the pollution and degradation of air quality, land and water associated with their disposal is avoided.

Economic

Costs involved with recycling have had a slowing effect on the speed with which these strategies have been adopted. Issues of collection, transportation and processing, especially at the individual consumer level, are significant. In addition, it has taken most industries considerable time to adapt their processes and equipment to handle recycled materials. Many are still in the process of working towards this goal, while others have not yet started. This slow start, along with lack of available materials for recycling, has put several recycling operations at risk of going out of business almost before they have started! However, the growing demand for construction materials and those used in the interiors of buildings with recycled

content is having a huge and positive impact. Increasing numbers of industrial and manufacturing plants have been remodeled and retooled to accommodate this 'new' approach to the manufacturing of materials, and as demand grows – in step with the green building movement -- products suitable for recycling become more available and economically viable.

Neighborhood
The community at large benefits from recycling. Once the concept has taken hold, and an economic base for recycling, remanufacturing and reselling is established, the cost of such operations will diminish. Many of the collection and recycling operations are new, small businesses, feeding into large-scale operations, similar to the model of dairy farms and milk collection. Reduced pollution from incineration processes, especially in heavily built-up areas contributes to cleaner air, while diverting materials from landfills defers the need for new or expanded waste facilities.

There is some concern that the reprocessing of materials allows for off-gassing of mixed media materials and products such as adhesives or binders. However, much of the volatile nature of such products has been given up and dispersed in the ten or more years of the previous life of the product. Any remaining chemical binder is probably less volatile than that associated with new manufacturing processes. Manufacturing organizations are cautioned to observe the protective rules of OSHA for all industrial processes associated with the handling of products that may contain volatile organic compounds (VOC's) and other toxic chemicals and substances.

Methodology

Design Strategies
In the early planning of the project, during the development of the Comprehensive Material Management Plan, specify major building and interior fit-out materials with recycled content. As time goes on, this assignment becomes less and less challenging, as many of the most common and highest quality materials and products are now available with varying degrees of post-industrial and post-consumer recycled content. These alternatives include structural steel, aluminum, aggregate and fly ash for concrete mixes, wallboard, ceiling tile, carpet, etc. Specifying large scale, large impact items, especially those with *post-consumer* recycled content, will achieve the goals of this credit, and will have the most positive environmental and community impact.

It is worth noting that in almost all cases, products made using recycled materials, in whole or in part, are indistinguishable in terms of quality and durability, as well as aesthetics, from those made with virgin materials. Further, the availability of recycled materials has encouraged the introduction of many new product lines, in linoleum and rubber tile, vitreous tile, quarry tile and carpet, to name a few, where a unique aesthetic is derived specifically from the inclusion of recycled content.

Means and Methods

It is important to distinguish between materials with recycled content and those that are able to be reprocessed from demolition materials at the site, such as existing concrete slabs and masonry, which may be crushed with a mobile crusher at the site and used as aggregate in the project's concrete mixes for pavement and roadbed. Such materials are essentially 'salvaged', not recycled in this context, and may contribute to achieving credit MEQ-3 Resource Reuse. However, if the concrete source and crushing operation is off-site, they may be purchased as high quality recycled aggregate for all types of mixes, and are considered to have validity under this credit.

The Federal Trade Commission's 'Guide for the Use of Environmental Marketing Claims', 16 CFR 260.7 (e) addresses environmental marketing claims, and defines the meaning of the terms post-industrial (or pre-consumer), and post-consumer. The document lays out the differences between true and false claims relative to the inclusion of one or both of these materials in a product. Since the credit is achieved by the weight and cost of recycled content in materials specified for the project, with differing values indicated for each type of recycled content, it is essential to understand these differences.

Beyond specifying, purchasing and installing products with recycled content, it is also critically important to specify products that can themselves be recycled. To complete the cradle-to-cradle loop, materials must be used, remanufactured and reused in a ceaseless cycle, ensuring a diminishing drawdown of raw materials and the protection of the natural resource base. The project materials need to be easy to maintain, and durable, but at the end of their useful, aesthetic and/or functional life in the building, ideally they must also be able to be recycled. Specifying materials with this sustainable strategy, or endgame in mind, avoids sending viable material to landfills, and maintains the essential cyclical pattern which optimizes the goal outlined in this credit.

Case Studies

Naval Base [at] Ventura County: Building 850 (Port Hueneme Energy and Sustainability Showcase Building)

This building functions as an "Energy Showcase" facility through which the U.S. Navy illustrates cutting-edge strategies in energy-efficient, sustainable facility design, construction, and operation. The structure is located in Port Hueneme, California and is the base-of-operations for the Public Works Department of the Naval Base [at] Ventura County. The client's main objective was to create an environment in which the Naval Staff could experience green building principles first-hand. An effort was made to specify recycled-content materials in the building's construction. Post-consumer recycled materials designed into the building include PET plastic toilet partitions and clothing lockers, gypsum wallboard bought from manufacturers who take-back and recycle post-consumer scrap, mineral fiber insulation, structural steel, carpet with recycled plastic backing, and reclaimed aggregate used as a parking base. An example of post-industrial recycled content incorporated into the project is the fly ash that composes 30% of the building's concrete masonry.

Energy Resource Center (ERC), Downey, CA
The Southern California Gas Company Corporation owns and occupies this building which they maintain as a comprehensive "idea shop" for customers who want to invest in the most efficient, economical, and environmentally sustainable solutions to their energy needs. Roughly 80% of the materials used to construct the building, including interior furnishings and displays, are recycled, contain recycled content, or are made of renewable resources. Building materials comprised of recycled content include steel, glass tiles, and plastic bathroom partitions. The flooring of the lobby was reprocessed from a former Banana Republic warehouse. The rebar in the building's concrete was made from confiscated weapons provided by the L.A. Sheriff's Department. The ERC's owners also participate in a carpet "lease back" program ensuring that their carpet will be reused elsewhere when they are finished with it.

The Public Library of Youngstown and Mahoning County: Poland Branch, Poland, Ohio.
The client's main design goal for this project was to create a prominent example of sustainable architecture as an educational tool for its occupants. The building was to illustrate first-hand, the potentials of recycled materials in order to promote their use to the general public. Many building components with substantial recycled content are showcased by the design. Its Ecostar roofing is composed of recycled rubber and plastic and simulates the look of natural slate. Hardie Plank siding made from recycled wood fibers and cement emulates traditional wood siding. The window and door frames in the building are made of 95% recycled aluminum, and the glass has 15% recycled content. Hardwood flooring on the project was recycled from vintage New England barns. Recycled tires and recycled asphalt comprises the parking surface adjacent to the building. The carpeting used in the building was also made from reclaimed materials.

Reference

Definitions

Reused or salvaged materials: These materials do not need to be re-manufactured. They may be cleaned and refinished, but they retain their basic integrity and shape, and are used either in their original context, such as in flooring, doors, furniture systems and hardware, etc. or as decorative elements and memorabilia, such as cast iron and terra-cotta building details.

Up-cycling: This term refers to the highest use of a recycled material. In this process, a post-consumer, used product may be remanufactured into a new product of a similar nature as the original, or another product of equal or higher value. Examples include the remanufacturing of all parts of nylon carpet, where the previously down-cycled nylon is now made into new nylon fiber for the carpet industry. Similarly, used wallboard and ceiling tile is now able to be reprocessed to form similar products of equal value to the original.

Down-cycling: This term refers to a process where materials lose their intrinsic value by being commingled, crushed or otherwise adulterated so that reconstitution into a viable 'raw' material state, capable of being 'up-cycled' is

permanently lost. Examples include mixed crushed concrete, masonry, glass, etc. used for roadbed fill, and 'plastic' wood.

Standards

U.S. Federal Trade Commission. Guide for the Use of Environmental Marketing Claims, 16 CFR 260.7 (e). Washington: USFTC, 1992.

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Materials with Recycled Content

MEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◉	◉ Ⓔ	◉ Ⓔ	◉	◉

☐ **Required Component:** *(This will satisfy both LEED™ 2.1 Materials and Resources Credit 4.1: Recycled Content – 5% and Credit 4.2: Recycled Content – 10%)*
This certifies that the value of the recycled content portion of materials is at least 10% of the total project materials value (excluding mechanical and electric components). The value of the recycled content portion of materials has been calculated as follows: For post-consumer recycled content the percentage of recycled content in the material has been multiplied by the value of the material. For post-industrial recycled content the percentage of recycled content in the material, has been multiplied by ½ and then multiplied by the value of the material. These calculations are attached.

(Note: WTC Guideline MEQ-4 requires 10% value of recycled content, while LEED™ 2.1 allows for either 5% or 10%, giving 1 Credit for each benchmark. Compliance with WTC Guideline MEQ-4 will, by default, satisfy the requirements for both LEED™ 2.1 Credits.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Material Proximity

MEQ-5

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce environmental degradation resulting from transportation impacts by increasing the demand for building materials and products that are extracted and/or manufactured in close proximity to the building site.

Action: Utilize local/regional materials in conjunction with the Materials Management Plan (MEQ-1-P. Use a minimum of 20% of all building materials (based on cost) that are manufactured within a 500-mile radius of the site. Manufactured in this context means the location where 'final assembly' takes place.

Related Guidelines: UEQ-8, SEQ-1, MEQ-1, MEQ-3, MEQ-4, MEQ-6, MEQ-7

Potential LEED™ 2.1 Credits: 2 possible with MR cr. 5.1 and MR cr. 5.2. (see Submittal Template)

Introduction/Context

The requirement to purchase local and/or regional materials offers benefits well beyond the simple cost of transportation, to incorporate important issues relative to reduced atmospheric degradation, reduced roadbed/infrastructure wear and reduced wear and tear on transportation vehicles and tires, as well as being an important fossil fuel(s) conservation strategy. In addition, this approach increases work opportunities for the labor force within the 500-mile radius of the project, and helps to sustain a critically important manufacturing base within the New York City area. Purchasing materials that are regionally extracted, harvested or salvaged, keeps the local economy vibrant and represents a vital link in a healthy economy's chain of supply and demand. This effort can be aided even further by using materials that are 'manufactured', remanufactured or assembled regionally, as well. For the purposes of this Guideline, strive to have 50% of the raw materials that are locally or regionally manufactured also be locally extracted (within a 500-mile radius of the site).

Relevant Issues

Ecological

One of the most important characteristics of buying locally manufactured products, or those that are harvested or extracted within the region centers on the reduced consumption of fossil fuels needed for shorter haul transportation. Burning gasoline, diesel and jet fuel to power trucks and cargo planes, as well as generating steam and electricity from mixed fuel sources for cargo ships and freight trains, contributes considerably to the generation of pollution associated with greenhouse gasses (CO, CO2), acid rain (NOx, SO_2) and even ozone depletion (through the operation of leaky vehicular air conditioning equipment still reliant on chlorofluorocarbon (CFC) technology). Air-borne atmospheric pollution has far-reaching, negative impacts on local air quality and the health of the entire global ecosystem.

Economic

The economics of purchasing local/regional materials and products may be clearly seen in reduced transportation costs, measured in fuel and often, in time saved. In addition, less impact on infrastructure and vehicle repair is a consideration. A major, less obvious economic benefit may be seen through a reduction in smog nationwide, and in New York City in particular. (Smog is created through a mixture of ground-level ozone and VOC's released through the combustion process, and sunlight). Fewer incidents of asthma and other related respiratory illnesses add up to reduced health care costs across the country.

Neighborhood

Materials purchased within the proximity of the building site help to maintain an economic power-base within the community, while contributing to a high employment rate and to maintaining a stable tax base. Strategies to reduce global atmospheric pollution have a wide impact and are recognized as an increasingly important form of social responsibility among industrialized nations. Any reduction in the release of nitrogen oxide and sulfur oxides, chemicals which contribute to the formation of acid rain and which are released through the burning of fossil fuels, helps to minimize damage to vegetation, wildlife habitat and water bodies. Similarly, reductions in the release of vaporized mercury, and mercury particulate matter reduces the introduction of this bio-accumulative poison into water bodies across the North Eastern United States. All of the North Eastern states, including upstate New York and New Jersey have been, and continue to be, affected by pollution-laden wind carrying acid rain and vaporized mercury components. A lessening of the deposition of these chemicals represents a contribution to the well-being of the larger community.

Methodology

Design Strategies

The metropolitan area offers enormous opportunity to achieve the goals of this credit. The South-East corner of New York State is well-situated to draw from the area's rich materials manufacturing base. Strategies to optimize this potential include a pre-design review of possible options and development of a database or listing of all regionally available manufacturing sources for major building materials.

Manufacturing, in this instance, means the final assembly of materials that may, or may not, come from regional raw material sources. All specified materials and products for use under the Sustainable Guidelines must be in keeping with any physical and aesthetic requirements and/or sustainable restrictions already established for the rebuilding of the World Trade Center site.

While the requirements of this credit, the manufacturing or 'final assembly' of materials is not unreasonably challenging in the New York area and for World Trade Center projects, there is a potential opportunity to achieve a further sustainable goal -- the second part of this credit in LEED. This part of the credit requires that 50% of the locally manufactured materials indicated in the first part of the credit, must be obtained via extraction, harvesting or recovery within a 500 mile radius of the site. Achievement of this second point presents a challenge, as most of the raw materials for steel, which are key, large-scale components of this credit, are extracted in locations beyond the 500-mile radius of the World Trade Center site. World Trade Center projects, which are able to achieve this LEED credit may use it as a substitution for the Recycled Content credit – see NYGBTC 638.7(b) Substitution Options 4.

Means and Methods

The success of this credit depends largely upon developing a knowledge base of local/regional manufacturing sources within the 500-mile limits set by the reference documents. The New York City Chamber of Commerce can provide a list of local manufacturers, and there are, in addition a number of city and state agencies for economic development, which may be able to provide additional information. During the pre-planning phases of the project, research to identify local/regional manufacturing and materials' sources, and the appropriateness of their products for each construction project at the World Trade Center site, is critical. Prior to design concept, develop a database of materials suitable for the building site, which are manufactured, or assembled, within the 500-mile radius of New York City. During construction, ensure that the materials specified are shipped from *the specific sources identified*, taking special care to confirm regional sourcing from suppliers who have multiple, often widely distributed and inappropriately distant, manufacturing locations throughout the United States.

Once selected, the cost of these materials is quantified and reviewed in terms of their collective percentage of the total cost of materials for the entire project. Assess the materials cost for the entire project, excluding labor and installation costs. Develop a spreadsheet listing all materials from local/regional sources, together with their prices. The sum of the local/regional materials is divided by the total cost of materials for the project, with the resulting figure being multiplied by 100 to determine the percentage of their cost to the project. The cost of local/regional materials must represent a 20% value of the total cost of materials for this credit to be achieved.

(Note: development of a total materials cost for the project is an important tool, and will serve as baseline information for achieving many of the materials credits.)

The following part of this credit, which is offered as a second point in LEED, with a substitution option in the NYSGBTC, seeks to confirm that 50% of the regional materials used in the project, are extracted, harvested or recovered from within the

500-mile radius of the City. Another calculation to determine if this point is achievable must be undertaken. Develop a second spreadsheet listing all of the materials in this category, together with their costs and determine the collective value. Divide this sum by the total cost of the local/regional materials as identified above and multiply this by 100. The resulting percentage must represent a value of 50% of the cost of local/regional materials to achieve the credit.

Case Studies

Nidus Center for Scientific Enterprise, Creve Coeur, Missouri

61% of the materials (by cost) used in the construction of this building were produced within a 300-mile radius of the project site. These included brick, metal roofing, earth fill, concrete block, steel, drywall, doors, and window blinds. (US EPA 2003) (USGBC 2005)

Viridian Place, Lake Oswego, Oregon

55% of the materials used in this building (by cost) were manufactured within 500 miles of the project site. This included concrete, masonry blocks, metal stairs and railing, wood products and drywall. In addition, 51% of those materials were harvested, extracted or recovered within a 500-mile radius of the project as well. (USGBC 2005 [2])

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

Standards have not been included for this Guideline.

Bibliography

U.S. EPA. "Nidus Center for Scientific Enterprise, St. Louis, Missouri". Laboratories for the 21st Century: Case Studies. October 2003. United States Environmental Protection Agency. 15 January 2005. <http://www.nrel.gov/docs/fy04osti/34348.pdf>

USGBC. "Nidus Center for Scientific Enterprise." LEED Certified Project Summary. USGBC. 15 January 2005. <http://www.usgbc.org/Docs/Certified_Projects/Cert10.pdf>

USGBC. "Viridian Place." LEED Certified Project Summary. USGBC. 15 January 2005. <http://www.usgbc.org/Docs/Certified_Projects/Cert_Reg103.pdf>

Material Proximity

MEQ-5-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◎ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	◎	◎ Ⓔ	◎ Ⓔ	◎	◎

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 5.1: Regional Materials – 20% Manufactured Regionally)*
This certifies that a minimum of 20% of all building materials (based on cost) are manufactured within a 500-mile radius of the site. Manufactured in this context means the location where 'final assembly' takes place. A copy of the calculations used to determine this is attached. This project strived to have 50% of its regionally manufactured materials also be extracted or harvested within a 500-mile radius of the site. A list of these materials indicating the total percentage achieved is attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 5.2: Regional Materials – 50% Extracted Regionally)*
This certifies that a minimum of 50% of the materials used to satisfy the requirement above are extracted, harvested or recovered (as well as manufactured) within a 500-mile radius of the site. A copy of the calculations used to determine this is attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Wood Certification

MEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To specify wood which has been harvested according to sustainable forest management principles.

Action: Utilize wood materials certified under the Forest Stewardship Council's Principles and Criteria (FSC) in conjunction with the Materials Management Plan. These materials may include dimensional framing components, flooring, doors, paneling, millwork and furnishings, handrails and trim, etc., as well as temporary lumber and wood construction materials. Request vendor's chain-of-custody certificate number to verify certification.

Related Guidelines: MEQ-1, MEQ-5, MEQ-7, IEQ-6

Potential LEED™ 2.1 Credit: 1 possible with MR cr. 7. (see Submittal Template)

Introduction/Context

Within the context of the sustainable building movement there is no strategy more important than the protection of the great temperate, boreal and tropical forests, which together are known as 'the lungs of the world.' Not only do these huge natural systems retain carbon within their elements, they absorb free carbon (carbon dioxide), helping to restore the essential balance between atmospheric pollution and life-giving oxygen. Forests support and enhance biodiversity, offering habitat for a diverse wildlife, the character, scale and medical import of which is far from being fully realized. The forests of the world provide timber and natural food sources such as nuts, fruits and roots, as well as shelter and the basis of livelihood for many indigenous peoples. They support industrial activities around the globe, providing employment for thousands of people through timber-related industries. Strive to specify wood and wood-based materials harvested according to sustainable forest management principles for 25% of the wood used on the project.

In 1993, the Forest Stewardship Council (FSC) was formed as an independent, not-for-profit organization to generate and oversee international standards for the protection of these valuable, but increasingly vulnerable natural resources. This international body accredits certification organizations in order to guarantee the authenticity of their claims and to "...promote environmentally responsible, socially beneficial and economically viable management of the world's forests, by establishing a worldwide standard of recognized and respected Principles of Forest Stewardship." All participation is voluntary, based on each forest manager's request to be involved, and the program works in parallel with all national and international laws, as well as any local initiatives that may be in place to support responsible forestry practices. The ten FSC international forest management standards, taken together, are known as the FSC Principles & Criteria of Forest Stewardship. They represent a systematic approach dedicated to maintaining the health of the forests through

environmentally responsible management practices, ensuring continued timber productivity and economic viability, while protecting indigenous people's rights, forest biodiversity and wildlife habitat including water, and methodologies for sustaining clean air and water as well as the management of waste.
There is considerable controversy concerning the choice of the Forest Stewardship Council as the single forest management certification program accepted in LEED and by several other mainstream environmental organizations. Most other forestry certification programs are industry based, while the FSC has been set up as an international, independent review body, which accredits other certification organizations once it has been determined, to the FSC's satisfaction, that these organizations are able to consistently meet the established criteria (Policies and Standards). While both LEED and other interested parties are actively reviewing options for broadening the approval basis for this credit, for the meantime, the FSC remains the only organization whose certification is acceptable.

Relevant Issues

Ecological

According to the Policies and Standards of the FSC, "... forest resources and associated lands should be managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations." Clear-cutting and poor forest management cause untold damage, not just to the landscape, but also to entire ecosystems. Loss of topsoil through erosion, sedimentation of streams and water bodies, reduction of wildlife habitat, and further threats to endangered species, as well as air and water pollution, are just some of the negative environmental impacts that occur as a result of clear-cutting, indiscriminate road-building and irresponsible felling of significant tree stands deep within the forest. The FSC, through its own efforts, and by supporting other certifying bodies, strives to alleviate these practices.

Through its stated principles, which are noted below, and which must be adopted and enforced by all participating programs, the FSC establishes both protective and restorative forestry practices aimed at maintaining the character, cultural resources, habitat and health of participating forest areas, while securing forest resources for the future. Among the many strategies in play, this means that the homelands and livelihood of indigenous peoples are protected, wildlife habitats are preserved and no more timber is cut than is replanted in a rotation that ensures the cyclical availability of mature trees, indefinitely. Endangered tree species are vigilantly protected and propagated under the FSC principles. Roads and trails are carefully designed to minimize destruction, both at the time of building, and during their use in the appropriate harvesting of significant single or remote wild tree stands deep within the forests. Subsequently, the erosion of top soil is controlled and minimized, retaining this vital resource within the forests, protecting water bodies and forest streams from sedimentation (and the terrible fish kills associated with this condition), and protecting air quality.

FSC Principles and Criteria

Principle 1: Compliance with Laws and FSC Principles
Principle 2: Tenure and Use Rights and Responsibilities
Principle 3: Indigenous People's Rights
Principle 4: Community Relations and Workers' Rights
Principle 5: Benefits from the Forest
Principle 6: Environmental Impact
Principle 7: Management Plan
Principle 8: Monitoring and Assessment
Principle 9: Maintenance of High Conservation Value Forests
Principle 10: Plantations

Economic

Forest products represent a major source of economic wealth for both industrialized nations and third world countries. The worldwide demand for lumber, especially for the construction market is enormous and growing annually, with the needs of emerging markets such as the Eastern European countries, Russia and China increasing demand exponentially. In 1970, international trade in forest products tallied less than $12,7 billion, according to the World Resources Institute's document '*EarthTrends*', while by the year 2002, it had grown to $133,2 billion. Through logging operations, as well as timber transportation, sawmills, veneer operations, the pulp and paper industry and millwork shops, forests and their primary product provide employment for literally millions of people around the globe. The economic import alone, of preserving, growing and maintaining this natural resource, cannot be overestimated.

Energy from wood-based biomass (bark, wood residues, and organic elements such as spent chemical pulping liquors) is an increasing form of renewable energy, still used primarily at pulp and paper mills where up to 70% of the energy used for all related operations comes from these 'waste' sources. While there is a negative air quality impact from the burning of these waste materials – as from burning any fuel -- controls are used to minimize releases. Many of the industries involved in wood processing, such as these, are expected to become net energy producers within the foreseeable future.

The initial cost of FSC certified wood is slightly more than using non-certified wood. The certification process is still in early development; however, with an increased understanding of the issues relative to maintaining healthy, productive forests, more self-certifying bodies are beginning to seek the umbrella categorization of FSC approval, and more certified wood and wood products are becoming available. These actions are already having an impact on certified wood markets, making products both more competitive with non-certified products, and more readily available.

Neighborhood

Mismanagement of forests, such as clear-cutting is now well documented as a destructive and inappropriate approach to lumbering, though it is still practiced worldwide. The slash-and-burn approach used by itinerant 'farmers', often the indigenous forest dwellers who have lived for centuries in harmony with their environment, and who have now been up-rooted from their forest homes and traditional livelihoods by clear-cutting, is common in the tropics. The slash-and-burn process, which destroys yet more forest, is sometimes the only way these displaced people can scrape a living from their cleared land. It leads to the erosion of top soil and the swift exhaustion of the shallow, infertile soils of the forest floor, resulting sooner rather than later in failed crops, sedimentation of streams and rivers – which destroys water quality and kills the fish population – and the constant need to 'move on', continuing the desperate, uninformed destruction of land best suited to the growth of timber.

On an international scale, forests absorb carbon dioxide, a greenhouse gas largely generated by the burning of fossil fuels, thus helping to reduce the impact of global warming. In addition forests produce – exhale -- massive amounts of oxygen. They provide the raw materials for many industries, creating employment opportunities in multiple industries around the world. In well-managed areas, the livelihood and well-being of native peoples is ensured, as is wildlife habitat and the protection and propagation of endangered species, both flora and fauna.

Plantation tree growing is seen as a way to provide 'rapidly renewable' and uniform quality building materials. In addition, it contributes to employment opportunities for local people and as a way to simplify timber harvesting. However, it is not encouraged by the FSC. Where they occur, plantations are evaluated on their ability to contribute towards the protection, conservation and restoration of natural forests. To qualify under the FSC certification program, a plantation has to be part of a carefully organized forest growth pattern in scale and location, supportive of biodiversity, wildlife corridors, and it must preferably be focused on a mosaic of various, indigenous tree species. After 1994, plantations occupying land that has been converted or 'stolen' from a natural diverse forest area will not be considered for certification except under special conditions.

Methodology

Design Strategies

It is possible in today's marketplace to find and specify almost all lumber, engineered wood and finish (veneer and solid) wood materials for a building that carry the Forest Stewardship Council's certification and a vendor or manufacturer's chain of custody (CoC) certificate. It is helpful to determine early on in the project planning which wood finishes are appropriate for the project – regionally grown hardwoods such as cherry, ash or maple, or more exotic tropical species -- for example, and then to determine availability of the selected species through a FSC certified source, or sources. On finding the desired product, it may be prudent to pre-purchase specific finishing materials, such as matching veneer flitches for millwork that are required to match, as the supply of certified wood is still modest and tends to fluctuate with market demand.

A further potential strategy is to specify some of the lesser-known tropical species that are becoming available in the US. These woods add variety and character to a project, while reducing pressure on better-known species. Endangered woods should not be avoided -- so long as they are purchased through FSC certified programs and come complete with chain of custody certificates. The practice of specifying limited amounts of these woods encourages small-scale forest industries, as such timber tends to come from trees that grow wild, usually in single stands. It supports the work of local peoples who harvest these remote stands by creating a market for their products.

Low-grade rough lumber from sustainable sources is also available and its use is encouraged. In fact, as a maximum of 20% of all hardwood forest production is graded First and Second (FAS) by the National Hardwood Lumber Association, it is recommended that lower grades of lumber be specified for all concealed applications, provided they meet the structural engineering requirements. In keeping with the intent of this credit, these grades can be specified to be FSC Certified. Consult the Architectural Woodwork (AWI) Institute's handbook and the National Hardwood Lumber Association (NALA) for specific wood grades and appropriate applications.

Means and Methods

The Forest Stewardship Council has accredited a number of forest management certification bodies in America and abroad. The two that are most often referred to as sources for certified wood in the US are the Rain Forest Alliance's 'Smart Wood' program, and Scientific Certification System's Forest Conservation Program. Both are accredited to conduct third-party forest management and chain of custody audits, here and internationally, in accordance with the FSC Policy and Standards.

In addition to these, the FSC has accredited a number of forest management and chain of custody certification bodies around the world. Some of the most significant include the following: The international SGS Group's Forest Certification 'QUALIFOR' Programme, the Swiss Association for Quality and Management Systems (SQS), ICILA, the Italian certification body for wood and furniture industries, and SABS, the South African Bureau for Standards.

The Forest Stewardship Council's website (www.fsc.org) provides links to the list of certified wood providers worldwide. Monthly updates to the certificates issued by FSC accredited certification bodies are provided. These certificates are awarded to forestry managers who oversee forestry practices that meet or exceed the requirements of the certifying organization and successfully complete the FSC forestry practices audit.

To earn a 'Chain of Custody' (CoC) certificate, companies that buy, process, manufacture and distribute products carrying the FSC 'Forest Management Certificate' must demonstrate that these materials are managed in a responsible manner. The companies are required to complete an audit that addresses the correct use of the FSC name and logo, meet minimum requirements for FSC wood fiber in engineered or composite wood products, and maintain storage and

production facilities that ensure that certified and non-certified wood materials are appropriately segregated in all manufacturing and distribution systems.

Use of a significant amount of certified timber resources grown in the North-East of the United States, especially New York State, New Jersey, Connecticut, Pennsylvania and Massachusetts, all within 500 miles of the World Trade Center, will allow the project to earn Credit MEQ-5 'Materials Proximity' as well as this credit. Similarly, Credit MEQ-7 'Agricultural Materials' (which includes composite wood materials) may also be considered as contributing to this credit. Specifying recently introduced products, such as *certified* MDF board and plywood, which are being made with *non-urea-formaldehyde bonding agents*, may achieve credit IEQ-6 'Reduced Contaminants from Materials' under the World Trade Center Sustainable Guidelines. For projects undertaking a LEED certification, at a minimum, 50%, by cost, of all new wood products on the project must be FSC certified. Salvaged timber is excluded from the calculation.

Case Studies

Middlebury College, Middlebury, Vermont

3 new buildings were added to this campus in 2002, each using a considerable amount of certified lumber in their construction. Between a residence hall and dining hall, 58,000 board feet of certified wood from five local woodlots was used. A new recycling center was built using 16,000 board feet of certified spruce that was harvested from college land. Local artisans, using only certified wood from Vermont, crafted all of the furnishings for these buildings, including tables, chairs, display cases, and sofas. (US EPA 2003)

Cedar River Watershed Education Center, Seattle Washington

This project established a new measure of success for the use of certified wood. The design pre-dates LEED, however, the design team set a personal goal of maximizing the use of certified wood for two primary reasons: The project consists of a compound of wood-intensive buildings thus making wood a dominant factor in the project's ecological footprint; and a focus on forest management practices is a particularly relevant consideration regionally and harmonizes well with the Education Center's mission of watershed stewardship. To this end, 98% of the wood products used to build this environmental education center originated in certified forests. These elements included formwork, framing, sheathing, trusses, finishes, cabinets, windows, doors and cedar siding from a local Forest Trust. (Cascadia 2005)

Reference

Definitions

FSC Certified Forest: This term refers to a forest or a forest manager who has demonstrated all of the requirements of the Forest Stewardship Council's sustainably managed forest criteria and has completed the requirements of the FSC certification program. Such organizations are permitted to use the labels and logo of the FSC, indicating their forests are sustainably managed

and that wood and wood products that come from their forests have been sustainably harvested.

FSC Chain of Custody Certificate (CoC): This system connects responsible forest management practices to end products to consumers. By tracking FSC certified material all the way through the production process, end-users, such as architects and designers, can be assured that their specified woods are in fact, FSC certified. Vendors and suppliers who seek the FSC CoC must demonstrate that they have the ability to identify and control their sources, have the facilities to allow for separate storage of FSC-labeled material from regular wood supplies, and that they use the FSC trademark and labels responsibly.

Plantation: often refers to an estate or area where monoculture, cash crops are grown on a large scale. A tree plantation, as used in the context of sustainable forestry, refers to the planting of specific tree-types, either to provide 'rapidly grown' wood supplies, or to reduce the pressure on, and provide protection for, existing forests by providing supplemental lumber and wood-based products. The FSC questions the use of plantations generally, as they tend to focus on supply only, and not to address the full extent of 'stewardship' embraced by the FSC Principles and Criteria.

Standards

Standards have not been included for this Guideline.

Bibliography

Cascadia Region Green Building Council. Cedar River Watershed Education Center. 15 January 2005. <http://www.ci.seattle.wa.us/util/stellent/groups/public/@spu/@rmb/@shedmgmt/@pubculted/documents/spu_informative/education_200401211405034.pdf>

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Forest Stewardship Council: 'Policy and Standards'

United Nations: Timber Bulletin LVII (2004) No. 3: 'Forest Products Annual Market Review' 2003-2004.

UNECE (United Nations Economic Commission for Europe)

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Wood Certification

MEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	○	○ Ⓔ	○ Ⓔ	◉	◉

☐ **Required Component:**
A list of locations and types of certified wood used on this project is attached. This indicates the amount of certified wood used, both as a percentage of all new wood products and as a percentage of the value of all materials used on the project. This project strived to specify certified wood for 25% of the wood materials used. Copies of the FSC certifications for each product, plus the CoC numbers for each item are also attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 7: Certified Wood)*
This certifies that a minimum of 50% of wood based materials and products used are FSC certified. A copy of the calculations used to determine the above percentage is attached, along with the vendor's or manufacturer's FSC chain-of-custody certificate number for all products used to satisfy this requirement.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Renewable Materials

MEQ-7

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To encourage the specification of materials which are renewable and that grow in such a way as to support biological diversity and the health of the ecosystem.

Action: In coordination with the Materials Management Plan use renewable and rapidly renewable building materials and products. Materials with annual growing cycles or which regenerate naturally within a 10-year-cycle are considered to be rapidly renewable materials. These materials include bamboo, poplar, cork, wool, cotton, jute, sisal, and soy-based products. Agricultural 'waste' materials such as wheatgrass, sunflower seed husks, and straw also qualify under this category. Release agents for concrete forms, which are made from plant oils such as corn oil, are included. Use agricultural compost for site applications, including, but not limited to, turf, plantings and erosion control.

Related Guidelines: SEQ-1, MEQ-1, MEQ-5, MEQ-6, IEQ-6

Potential LEED™ 2.1 Credit: 1 possible with MR cr. 6. (see Submittal Template)

Introduction/Context

There are many ways to reduce the impact of construction activities on the natural environment. One of the less well known, but increasingly significant, centers on the use of natural materials that are typically characterized as 'agricultural waste', and other natural resources that achieve maturity in a short, natural growth cycle. Use of such materials protects the finite, raw material base and allows longer-cycle, natural materials to mature fully, prior to being harvested, while providing a ready supply of high quality, easily replaceable materials for the marketplace. Together, these products, which are briefly described below, are commonly referred to as 'rapidly renewable materials'. Strive to specify rapidly renewable materials for 2.5% of the value of total project materials.

Prior to the sustainable design movement, many of the agricultural waste materials in this category were burned as the easiest method of disposal, thereby destroying a potentially useful, and basically free, supply of raw materials, while contributing to atmospheric pollution and to global warming. Wheatgrass stalks, straw and sunflower seed husks, the remnants left of each crop once all food value had been stripped out, fell into this category. Now, these waste materials are consistently made into attractive, durable panel products, useful in non-structural, construction applications, millwork and furniture design.

The second group of materials includes many that have natural replacement cycles of less than ten years, growing to maturity within that time-span. These include bamboo, with a maturation rate of approximately three years, and which is used for new strip and parquet flooring applications; poplar, which is the basis for much of the orient strand board (OSB) and chipboard in the market place; and cork, with its established seven-year harvesting cycle, and multiple flooring, wall, acoustical and furniture applications.

The third group centers on the use of annually renewable crops – where much of the value is found in the product's intended use for building interiors and architectural projects. Typical materials include fibers such as cotton, flax, sisal and jute. Wool, an annually renewable fiber also falls into this category, as does down, which is heavily used by the furniture industry and silk, used as a high-end finish material. In addition, with a huge surplus in supply, soybeans are also being used to make new architectural products, while other surplus products such as corn and vegetable oils are being developed into non-toxic release agents for use with concrete forms and plastic molds. An exciting new industry, bio-based plastics, which are made from cornstarch, is in development, and is expected to provide environmentally benign alternatives to many petroleum-based plastics in the foreseeable future.

Relevant Issues

Ecological

Because the agricultural materials in this category are grown primarily for their food value, the 'waste' materials, which are purely remnants or by-products, have no *independent* impact on the environment during their growing cycle. After harvesting and removal of the nutritional elements, they form the raw materials for what amounts to a new industry, the manufacturing of 'agri-products'. In most cases these products, primarily panels, are made with urea-formaldehyde free bonding agents, and can be used to replace construction materials such composite or engineered wood panels, which typically have a more demanding life-cycle and greater environmental impact. Elimination of the burning of agricultural waste materials is a positive, contributing factor to cleaner air quality.

Use of rapidly renewable materials encourages farming of specific tree species, creating new opportunities in forestry practices. Rapidly renewable, farmed trees and plants such as poplar and bamboo, can be planted, grown to maturity and harvested for use in a continuing short cycle of supply and demand, while permitting natural, bio-diverse forests to remain intact. As with other 'crops' these trees do well when grown in rotation with other rapidly renewable materials. Clear cutting and/or poor forestry practices are reduced, minimizing damage such as that which occurs during the harvesting of single tree stands in densely wooded forests, and there is a reduction in soil erosion and the subsequent sedimentation of rivers and ground water streams. However, farming of trees, or the concept of plantation growing, must be viewed in association with MEQ-06, Wood Certification, as the Forest Stewardship Council does not always support this practice.

Use of surplus agricultural crop materials for new processes such as the emerging bio-plastics industry, is beginning to create a viable market for alternatives that are environmentally cleaner, biodegradable substitutes for petroleum-based products. Encouraging this strategy preserves the fossil fuel base and also reduces our dependence on domestic and foreign oil.

Economic

Agricultural land, which produces an annual crop providing both food and materials for the new agri-products industry provides a clear economic benefit – a win-win

situation. Other short growing cycle materials make more efficient use of the land than regular tree and plant materials, which have as much as a twenty to forty year growing cycle. In the case of hardwood trees, this cycle can extend to more than one hundred years to achieve full maturity. Use of natural materials such as wool, silk and linen that are harvested and naturally replaced every year, reduces the industry's dependence on synthetic fibers, many of which are petroleum-based.

Due to the newness of the agri-products industry, some of these materials are not yet cost-competitive with similar use products. It is important to note that any premium is a first cost issue only, and does not have a negative impact on the life cycle of the product. Bio-based plastics are still fairly rare and not yet in common use. However, as these products become mainstreamed, this discrepancy should disappear. The two new industries that are growing out of these agricultural materials' initiatives discussed above, and that have come to the fore recently -- agri-products, and bio-based plastics – both have enormous potential to modify the negative impact of building-related materials on the natural environment. In addition, they both provide economic incentives and new job opportunities in the less populated areas of the United States.

Neighborhood
The use of agricultural materials and rapidly renewable materials benefits the community by reducing waste and reducing the burning of viable 'raw' materials, resulting in less pollution and cleaner air. The management of the growing cycle – planting, cultivating and/or harvesting – of rapidly renewable and agri-materials provides a sustained work flow in many rural areas where other industry -- and jobs – may be scarce.

The potential to reduce the country's dependence on fossil fuels is a critically important issue relative to this credit. As demand for the bio-based products discussed in this section, grows, so will the potential for these new, alternative and sustainable industries.

Methodology

Design Strategies
Specify wheatboard or strawboard in place of more typical composite wood materials. These boards or panels should not be used to replace plywood because, as with all composite panels, they lack the structural integrity of solid or laminated materials. Include some of the more decorative panels, which may be stained or left natural, and sealed with low-VOC products similar to those used for wood veneer.

Specify lumber from rapidly renewable sources, FSC certified if possible. Bamboo flooring is available with non-urea-formaldehyde adhesives from a number of sources. In addition to its other qualities as discussed here, this material is both naturally insect and moisture resistant.

Use materials that are constituted from agricultural and other natural materials, such as linoleum, which is made in large part from cork, wood flour and linseed oil, with natural (clay) fillers and pigments. Cotton batt insulation with high R-values is readily available, as is wool carpet and wool, linen and silk upholstery fabrics.

Means and Methods

To determine if the requirements of this credit have been met, the cost of all agricultural-based and rapidly renewable materials is quantified and reviewed in terms of its collective percentage of the total cost of materials for the entire project. Assess the materials cost for the entire project, excluding labor and installation costs. Develop the typical MEQ credit spreadsheet listing all materials from local/regional sources, together with their prices. The sum of the agricultural-based and rapidly renewable materials is divided by the total cost of materials for the project, with the resulting figure being multiplied by 100 to determine the percentage of their cost to the project. To meet these requirements, the cost of rapidly renewable and agricultural-based materials must equal a 5% value of the total cost of materials used on the project. When these types of materials are found in a pre-built assembly, making it difficult to separate out the cost, a calculation by weight may be used, per the equation describer in LEED MR-4.

Case Studies

World Resources Institute Offices, Washington, D.C.

Building a work environment that incorporated natural and sustainably harvested materials wherever practical was an important goal for the WRI since one of their main missions is biological resource stewardship. The building's reception area is floored with a bamboo product from China. For the floor in the elevator lobby, the designers used cork, which has been harvested sustainably on the Iberian Peninsula for centuries. Natural linoleum was used for the floors in the kitchen and workrooms. All doors throughout the offices are made from compressed wheat-straw fiberboard. The cabinetry used in the kitchens and workrooms of the WRI building are made from two biofiber materials. The structural walls of the cabinets are made from wheatboard, while the finished surface is Dakota Burl, a composite made from compressed sunflower seeds. The kitchen countertops are linoleum on a wheatboard substrate, while the office worksurfaces are made from a biocomposite comprised of soybeans and recycled newspaper. All of the millwork throughout the building was sealed using polymerized linseed oil. The paint used for accent patterns in the lunchroom was milk protein-based . (World Resources 2004)

Real Goods Trading Corporation Showroom, Hopland, California.

This building, also called the "Solar Living Center", was designed to be a model of sustainable building practices. As such, an effort was made to integrate natural or sustainably harvested materials into the building's design. The largest example of this strategy for this project is the composition of the building's rear wall. It was constructed from straw bales that were then coated with PISE, pneumatically impacted stabilized earth. PISE, a mixture of cement, water, and earth, is applied to walls with a spray gun. Besides being all-natural, these 26" walls have an exceptional R-value of 35 and significant thermal mass. Another sustainably produced product used for this building was Hardipanel, a cement and fiber panel made from natural, sustainably harvested fibers. These panels were used as exterior cladding on the south and west walls and to form the building's soffits. (Van der Ryn 2001)

Reference

Definitions

A renewable material is made from a commodity or resource that is inexhaustible or replaceable by new growth.

Standards

Standards have not been included for this Guideline.

Bibliography

Van der Ryn Architects. "Ecological Design Strategies and Features of The Real Goods Solar Living Center". Methods. 2001. Van der Ryn Architects. 7 October 2004. <http://www.vanderryn.com/va/methods-strategies.html>

World Resources Institute. "Mission Design: WRI's Office Environment". Publications and Multimedia. 31 March 2004. World Resources Institute. 9 October 2004. <http://pubs.wri.org/pubs_description.cfm?PubID=3926>

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Renewable Materials

MEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	○	○ Ⓔ	○ Ⓔ	◉	◉

☐ **Required Component:**
A list of all renewable, rapidly renewable and agricultural waste materials that are used in the project is attached. The value of these materials is indicated as a percentage of the total cost of materials for the project. This project strived to specify rapidly renewable materials for 2.5% of the total value of project materials.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Materials and Resources Credit 6: Rapidly Renewable Materials)*
This certifies that products made from rapidly renewable agricultural materials have been used for a minimum of 5% of the total value of all materials and products used for the project. The calculations used to determine this are attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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IAQ Management

IEQ-1

Sustainable Design Guidelines Reference Manual
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Purpose: Establish high indoor air quality (IAQ) for the comfort and well-being of the building's occupants by minimizing the potential for poor air quality, and by establishing minimum IAQ performance and standards.

Action: Provide an Indoor Air Quality Management Plan which employs architectural and HVAC design strategies to establish minimum outdoor air quantities, chemical, biological and particulate source control and on-going air quality monitoring to achieve a positive impact on the overall indoor environment and well being of the occupants. Meet the requirements of ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure.

Prepare plan in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). Draft the plan in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

Related Guidelines: SEQ-1, SEQ-5, SEQ-6, EEQ-6, IEQ-3, IEQ-4, IEQ-5, IEQ-6, IEQ-7, IEQ-8, IEQ-9

LEED™ 2.1 Requirement: EQ Prerequisites 1 and 2. (See Submittal Template)

Introduction/Context

This credit uses compliance with ASHRAE Standard 62-2001 as its baseline requirement. ASHRAE Standard 62-2001 addresses minimum ventilation rates as well as indoor air quality levels that are intended to protect human health and well-being. There are three primary sources of indoor air quality (IAQ) contamination in buildings:

- Building 'loads' which result from off-gassing of the chemical components of construction materials and interior finishes, equipment emissions and related functional activities as well as maintenance materials and methods.
- Moisture intrusion, which creates conditions that support the growth of molds and mildew.
- Particulates, which enter the building in a multitude of ways, but primarily via the HVAC system, materials that shed, and/or through the operation of equipment.

The building occupants also contribute to the introduction of building loads and particulate matter through their clothing (dry cleaning chemicals, heavy detergent residue, fiber shedding, etc), perfume and personal bio-effluents, as well as dirt and dust particles brought in on shoes and clothing. Smoking, though now controlled in indoor environments in New York City, is a contributing factor to poor IAQ in many places.

Building Loads

Many chemicals are used in building materials to enhance product performance, particularly the performance of 'wet' materials such as adhesives, sealants, caulks, paints and coatings, among others. Some of these chemicals off-gas volatile organic compounds (VOC's), which are known to be among the most common sources of building 'loads'. These air-borne gasses are often solvent-based, and the most toxic can be carcinogenic, teratogenic or mutagenic, or they can be endocrine disrupters. Even in miniscule quantities, exposure to such chemicals can be extremely deleterious to human health. Opportunities exist in design and material specifications to minimize the presence of these and other toxicants. The elimination or reduction of toxic substances is a central objective of the sustainable goals of all World Trade Center projects. Heavy perfumes, air 'fresheners' and scented cleaners should also be avoided.

Moisture Intrusion

Moisture enters buildings in a number of ways, such as through the HVAC system and/or water infiltration through the building envelope. Broken or cracked pipes, leaks and excessive or uncontrolled humidity can also be the source of moisture on the inside of the weather barrier. Poor scheduling and management of deliveries can result in vulnerable, absorptive building materials being exposed to rain or damp conditions prior to being installed. Materials can also arrive with original manufacturer's protection and seals broken, or fail to be stored in accordance with manufacturer's instructions. Wet materials provide ideal conditions -- food, moisture and warmth – for the support of microbial growth, often resulting in building contamination. This condition can be the root cause of either 'Sick Building Syndrome' or, when the source of contamination can be specifically identified, 'Building Related Illness'.

Particulates

The third, common IAQ pollutant source is the result of the introduction of particulates, which have many sources, including the two outlined above. Particulates may be drawn in at air intakes from exterior sources such as vehicle combustion, neighboring flues, nearby industrial processes and ambient dust. Particulates are generated also by combustion equipment in the building and by tobacco smoke (ETS). They are emitted by typical office equipment. They are shed by many soft materials such as carpet, fabric and insulation, as well as by hard plastics such as those made with brominated fire retardants (PBDE's), which are used to make computer housings, printers, fax machines, copiers, etc. Particulates are also carried into the building on clothing and especially by footwear. In addition, some commonly used materials break down into fine particles during building renovation, such as crystalline silica (common in drywall compounds and grouts), which affects human lungs and respiratory systems.

When inadequate filtration media are used, particulates enter the air stream and circulate in the ambient air. (Note the requirement in IEQ-07 for MERV 13 filters, which remove 90% of contaminants and represent an effective, passive filtration system. They are required by LEED v2.1). Rigorous maintenance, with a regular replacement schedule for filtration media is necessary to avoid poor IAQ conditions and the reduction of filtration media performance.

The program for the WTC Site infrastructure includes significant space for the access and parking of buses, cars, and delivery trucks. These program components have the potential to introduce pollutants into the building and will require specific dedicated systems to isolate affected areas and minimize introduced toxins.

Relevant Issues

Ecological

Establishing a high level of indoor air quality at the time a building is occupied, and maintaining that level of air quality throughout the life of the building, are important strategies for the support of human health, well-being and comfort. Good indoor air quality has been demonstrated to be a significant, contributing factor to increased productivity. Studies undertaken by Judith Heerwagon, Ph.D, among others, indicate that occupant satisfaction, reduced absenteeism, minimization of errors and reduced 'churn' or turnover of staff, all result from enhanced indoor environments, and that of the several factors that contribute to such overall enhancement, high quality indoor air is a critical component.

Economic

A more rigorous approach to the design of the building, where every effort is made to address all three pollutant paths – building loads, moisture intrusion and particulates – having the potential to lead to future IAQ problems, involves a greater coordinated effort on the part of the design team. However, the learning curve will level out quickly, and no additional time or effort will be required to achieve high quality IAQ once the methodology and benefits are well understood. The return on this investment is both significant and fast, and achieved through worker productivity, reduced owner risk and the ability to attract and retain highly skilled employees. In addition, clean indoor air prolongs the life and efficiency of office equipment, contributing further to economic benefit.

The optimum manner in which to achieve a clean building interior with high quality indoor air is to eliminate contaminants at source, i. e., where possible avoid introducing materials that off-gas to the building interior, and design the building envelope and HVAC system to minimize any potential for moisture intrusion or the formation of unwanted moisture inside the weather barrier.. Provide adequate access for maintenance, the detection of moisture (mold, mildew, etc.) and potential future remediation of equipment that is not immediately visible. The introduction of greater quantities of conditioned, outside air than required by code (which provides only for minimum outside air), can flush-out the building on a continuous or intermittent basis, and will dilute building load concentrations. The old argument that the cost of increased energy to condition this additional outside air cannot justify the return on investment, and is particularly weak in the climate of New York City, which experiences many days in which the temperature and humidity are usable with little or no conditioning beyond filtration. In addition, technologies such as heat recovery can minimize the energy impact of increased outdoor air.

According to the Rocky Mountain Institute in their white paper 'Greening the Building and the Bottom Line' 1994, the national average cost in terms of salaries and benefits, per square foot, per annum, is $318.00, while the equivalent cost for all energy for the building per square foot, per annum, is $2.25. (Figures are averaged and have been up-dated to reflect 2004 conditions by Carnegie Mellon University's Center for Building Performance and Diagnostics). Since productivity increases for people working in green buildings have been demonstrated to range from a low of 2% to a high of 16%, in pure economic terms, it makes sense to invest in enhanced

environmental conditions, particularly high quality air, rather than saving small amounts on the cost of energy. Commercial buildings, such as those envisaged for the World Trade Center site, will be built so that people can work: cost-effective measures that improve work output are a desirable outcome by any standard.

Neighborhood
Good quality indoor air leads to a healthier and more productive building community. IAQ is a localized issue, pertinent to each specific building rather than the community at large. However, striving to create a clean building environment creates conditions in which construction workers are exposed to fewer deleterious chemicals and substances, as well as offering a better environment for building occupants. This is a significant risk management strategy for the broader community of building owners, developers and realtors.

Methodology

- **Design Strategies**
  While all materials are of concern, those that cover large areas, such as floors, walls and ceilings should be the primary focus for sustainable choices, along with those that are known, generically, to have the ability to undermine indoor air quality. 'Wet' materials are among this latter group, such as paints, coatings, adhesives, sealants and caulks. Concealed areas, such as air return plenums and the inside of ducts behind grilles, which may be sealed or painted, should be addressed carefully. Design teams need to work with the referenced standards to make sure that all major materials with the potential to adversely affect IAQ meet the defined parameters

  At the beginning of the 21st century, there are many environmentally superior building materials available, and the designer's choice is rarely limited, unlike just a decade ago. In almost all areas, these materials are now also cost-competitive with their more toxic counterparts. Where there is a cost premium, it is usually defensible in terms of human well-being: because the resulting IAQ will often be of a higher quality with the use of environmentally benign materials, pay-back in terms of increased productivity is usually quickly experienced. Occasionally, a designer and an owner will agree on an environmentally preferable material that may have a cost premium over a material that is, for instance, a known carcinogen, simply on moral grounds.

  In order to minimize IAQ pollution, conduct a thorough review of the composition of all major materials and building products to determine the presence of toxicants.. Reduce the introduction of toxic substances into the indoor environment by eliminating chemicals known to cause serious health affects. The chemicals involved are frequently, but not always, carbon-based, volatile organic compounds, which are easily released to the warm indoor air from their host materials. Off-gassing of volatiles adversely affects indoor air quality (IAQ) and can result in compromised working conditions in the building, which include the potential for adverse health impacts, sick building syndrome (SBS), and reduced productivity. Most of these chemicals of concern are identified on manufacturer's Material Safety Data sheets (MSDs), which must be provided on request for all single component substances: i e –all caulks, adhesives, glues, paints, etc. For composite or multi-component products such as office seating (chairs) and office furniture systems, information on

chemical emissions can be found through a review of the product's chamber test data – also available from manufacturers.

Other substances that are less volatile may not have an immediate impact on building occupants, but may have health impacts on workers during construction, or may generate toxic fumes in the case of a building fire, and/or may become airborne and dangerous to occupant health during future renovations. During the planning stages and in the materials review, include consideration of the longer-term impacts of all toxic components in building materials. Eliminate or reduce their introduction to the interior of the building wherever possible.

Once the team becomes familiar with environmentally benign materials, they will have established the basis of a library for future use. It is important to note that every material must be checked for continuing environmental quality on a regular basis and before each repeat use, which may be accomplished via a review of *current* technical literature and MSD sheets. This is a necessary precaution, as architects and designers have no control over manufacturers, and/or their right, often exercised, to change their product formulae without informing the public.

A poorly performing building envelop will allow weather conditions such as wind and wind-driven rain, for instance, to penetrate the skin and the weather barrier. Most curtain wall and building envelope systems do not perform as well as their manufacturer's claims, once installed. One option to guard against such conditions is to require random or selective testing of the building envelope as constructed. Damp conditions resulting from poorly designed and/or drained ventilation systems allow standing water to be present in ductwork, resulting in moisture 'carry through', especially in HVAC systems that depend on high velocity air delivery. Leaks allow moisture to penetrate into previously installed absorbent materials such as insulation, wallboard, ceiling tile, etc., while rain or water damaged materials and equipment offer ideal conditions for the support of microbial growth.

All of these situations support the growth of bio-contaminants - fungus, bacteria, and molds, which thrive in warm, often concealed interior spaces. Once airborne, these microbes are inhaled by building occupants. They are at the root of 'building related illness' (BRI) and are frequently the cause of serious infections such as Legionnaire's Disease. As previously noted, opportunities exist during the design of the building, especially the building envelope, to minimize the potential for moisture intrusion. Access to ductwork, pipes, valves and other vulnerable locations for observation and maintenance is an important environmental strategy for the long-term maintenance of high quality indoor air and protection of building materials. Care during construction to protect vulnerable materials and equipment from wet conditions is critically important and is the foundation of an effective process. Discard all absorptive materials that have become wet, or have been exposed to moisture prior to installation.

Particulates enter the building through multiple sources. Installation of good filtration systems such as passive MERV 13 filters, noted previously, is one way to control the introduction of particulates via air intakes. Another is to make sure the building is designed with permanent entryway systems at all major entrances. Permanent grille

and recessed entryway systems help capture particulate matter that would otherwise enter the building on footwear.

Within the building, containing particulates generated by the operation of office equipment and maintenance activities at their sources, through direct exhaust of equipment rooms and janitorial closets to the outside, helps prevent their circulation in the ambient, interior air stream. Good maintenance, including the use of high quality, Carpet and Rug Institute (CRI) approved vacuum cleaners is key to capturing and removing particulate matter that does enter the building.

Human activities such as smoking (environmental tobacco smoke or ETS) contribute to the particulate load. Banned now in general areas of occupied buildings in New York City, smoking is restricted to 'smoking rooms', which must be designed with slab to slab partitions, dedicated exhausts to the exterior which afford no potential for the re-entrainment of contaminated air, and negative interior air pressure. It is important to note that this is a prerequisite of LEED™ V. 2.1 EQ Section and is required in order to receive any LEED™ V. 2.1 credits for [Indoor] Environmental Quality.

The following tables define the major factors that are of concern in maintaining high IAQ, including potential sources of pollutants, why they are of concern and basic control methodologies to reduce or eliminate their impact:

Exterior Factors

Item	Indoor Air Quality Issues	Control Options
Climate	Surface and air temperatures, humidity, wind, convective air currents. Wind driven moisture penetration	Design of thermal shell and glazing strategies, HVAC design
Outdoor air quality	Building location, intake air quality, intake air location, wind direction	Locate air intakes remote from sources of contamination, avoid re-entrainment of exhaust air, utilize high performance (MERV 13) filtration media
Infiltration of water	Uncontrolled moisture entry	Design and maintain waterproof construction

Base Building and Systems

Item	Indoor Air Quality Issues	Control Options
HVAC Systems	Fuel choice, minimum code compliant outside air ratios, moisture related bio-contamination, particulate contamination	Clean, renewable energy, building & HVAC system design to allow for high ratios of outside air (beyond code mandated amounts), design to minimize moisture carry through, high

		performance filtration media at air intakes, good maintenance
Finishes	VOC emissions during & after installation, toxic substances in building materials	Specify low or no VOC products, screen for specific toxic materials/chemicals that can become airborne.
Adhesives and sealants	Formaldehyde, xylene, toluene & other VOC emissions	Specify low-emission products in accordance with SCAQMD Rule 1168, current version.
Building insulation	Formaldehyde, Isocyanurate and other VOC emissions	Specify low-emission products. Avoid use of chemicals such as urea-formaldehyde that off-gas at room temperature.

Building Interior

Item	Indoor Air Quality Issues	Control Options
Absorbent finishes: Ceiling tile, wallboard, carpet, wall covering, insulation	Material 'sinks' absorb VOC's and/or moisture	Develop a construction sequencing plan where wet materials are first installed, then when dry, absorbent materials are installed. Keep all absorbent materials dry and clean during construction process
Composite wood products	Formaldehyde & VOC's	Avoid products bonded with urea-formaldehyde, select low-emission products and overlay adhesives
Laminates	VOC emissions from adhesives	Select low-emission adhesives. Avoid products bonded with urea-formaldehyde
Ceramic tile work	VOC emissions from adhesives/grout Crystalline Silica	Select low-emission materials Avoid use of products with added crystalline silica
Carpet	Long-term emissions of VOC's and plasticizers in backing materials and adhesives	Select low-emission carpet systems that meet or exceed the Green Label Plus and Green Label IAQ testing

		protocols established by the Carpet and Rug Institute.
Resilient flooring	Long-term emissions of VOC's and plasticizers in backing materials and adhesives	Select low-emission materials and adhesives; avoid use of chlorinated plastics, such as PVC.
Equipment & Appliances	VOC's, organics and low-level ozone from photocopiers & printers, combustion by-products from gas & fuel appliances	Dedicated ventilation of copier areas, exhaust flues to outside
Occupant activities	Cooking, laundry/dry cleaning, janitorial activities/smoking	Dedicated ventilation or building restrictions on indoor activities. Include separate sinks for all janitorial closets and chemical (cleaning material) mixing areas. Provide separate, isolated smoking rooms. Use environmentally benign cleaning/maintenance products.
Occupant bio-effluence	Odors; skin flakes, etc.	Good ventilation, high number of air changes per hour, use of environmentally benign building cleaning protocols
Cleaning Products	Volatile organic emissions from products, dust disturbance	Low-emission environmentally benign cleaning products, high-efficiency vacuum cleaners
Pest management	Pesticide residues, indoor and outdoor, animal droppings and dander, poisons	Develop an integrated pest management plan focused on environmentally benign treatments
Waste management	Recycling of waste on premises, potential for unsanitary conditions, pest problems	Develop a waste management plan, regular, high quality maintenance

Means and Methods

ASHRAE Standard 62-2001 includes minimum ventilation rates and lists indoor air quality levels that are considered to be the minimum to adequately protect human health and well-being. The building must be designed to meet these requirements to be in compliance with the code. Two procedures are described in ASHRAE 62-2001: The Ventilation Rate Procedure and the Indoor Air Quality Procedure. The Ventilation Rate Procedure is the preferred approach and is required for LEED Prerequisite 1: Minimum IAQ Performance (this procedure applies to mechanical ventilation systems only). Comply with all relevant sections of ASHRAE Standard 62-2001, which are important components of this standard and go beyond minimum ventilation and HVAC requirements. In addition, comply with Section 7, which addresses construction strategies. A sustainable building will strive to introduce more outside air than required by ASHRAE Standard 62-2001, which establishes *minimally* acceptable and therefore not *optimal,* rates for enhanced IAQ. The key therefore, is the ability for all mechanical systems to be able to use 100% outside air for distribution through the system at those times when enthalpic conditions are adequately cool and dry. In New York, the temperature ranges that are acceptable for this strategy fall between 55° and 85° F, when the relative humidity is between 30 and 60 % (NYGBTC)

In order to help meet the conditions of this chapter under the World Trade Center Guidelines, design teams must undertake the two separate, mandatory processes as required in IEQ-5 Construction IAQ Management Plan. These criteria are fully described in the EO-111/NYSGBTC, and are briefly outlined as follows:

1. NYSGBTC 638.7(d) (1): This section of the Tax Credit describes an Indoor Air Quality Testing procedure that must take place within 30 days after occupancy, and subsequently on an annual basis for five years. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOC's.

2. NYSGBTC 638.7(g) (1): In addition to the mandatory testing noted above, a one-week purge (seven days/twenty four hours) with air handlers operating at 100% outside air must be completed on every floor, prior to occupancy.

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease,

hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure.

EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991

EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998

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Miller, E. Williard, et al. Indoor Pollution: A Reference Handbook. ABC-CLIO, 1998.

Moffat, Donald. Handbook of Indoor Air Quality Management. Prentice Hall, 1997.

Wabeke, Roger. Air Contaminants and Industrial Hygiene Ventilation: A Handbook of Practical Calculations, Problems, and Solutions. CRC Press & Lewis Publishers, 1998.

Indoor Air Quality Management Plan IEQ-1-P

Sustainable Design Guidelines Reference Manual
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Objectives

The Indoor Air Quality (IAQ) Management Plan is designed to improve indoor air quality for the comfort and well-being of building occupants and to provide the means to address promptly any indoor air quality problems that may arise, thereby minimizing any potential impact to the building occupants. This Plan is distinct from the Construction IAQ Management Plan IEQ-5, which is more specifically designed to address air quality issues, which arise during construction. Prepare plan in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). Draft the plan in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

Plan Components

I. **General Requirements**

A. Define Indoor Air Quality characteristics including; temperature range, humidity level, ratio of CFM/per person, air changes per hour, percentage of outside air vs. percentage of remixed air at any given time, and VOC, particulate and microbial contaminant load.

B. Designate an IAQ Manager for coordinating plan requirements and achieving plan objectives. This Authority must include on-going building inspections, and have immediate access to those who are in a position with to implement stop work orders for nonconformance with the Plan.

C. Establish means of communication and notification between all parties to prevent and resolve IAQ difficulties.

D. Outline local codes and city/state requirements.

II. **Base Profile**

At time of substantial completion of the building, establish an IAQ profile of the base building. This profile is to be based on the following.

A. Existing Records:

1. As built drawings
2. Commissioning documents.
3. Testing and Balancing Reports
4. Maintenance and Operations Manuals.
5. Material Safety Data Sheets for all major installed building materials and products
6. The Integrated Pest Management Plan (IPM)

B. After Occupancy
   7. Records of complaints in regard to temperature and/or humidity
   8. Records of complaints in regard to IAQ issue

C. Walkthrough.
   1. Visual inspection of all installed HVAC equipment
   2. Review locations of ventilation air delivery grilles
   3. Review locations of air supply and return registers
   4. Review independent (personal) airflow and temperature delivery locations and functioning of these systems
   5. Review locations of all monitoring devices and confirmation of calibration against documentation provided
   6. Visual inspection of isolation strategies at smoking rooms and rooms where high volume copying (over 40,000 pages/month) or janitorial activities, such as mixing of chemicals occurs
   7. Check negative pressurization of rooms itemized in 6 above.
   8. Check functionality and working order of independent exhaust systems associated with rooms itemized in 6 above.
   9. Inspection of janitorial and maintenance spaces to ensure that each is supplied with separate sinks and waste plumbing.
   10. Review entryway systems to confirm that all are equipped with grilles where appropriate, and/or permanent recessed mats to limit intrusion of mud, water and dirt.

Bring to the attention of the Owner and Architect any discrepancies found in the substantially completed building that are not in conformance with the drawings and planning intent for superior IAQ performance of the building, or that are not fully functional at this time.

III. Evaluation

A. Pre-Occupancy/Immediate Post-Occupancy IAQ Procedures and Evaluation.

At the time of 'substantial' completion, prior to the hand over of the building, the Architect shall undertake a one-week building flush-out using 100% outside air at a cool temperature. New filtration media shall be used during the flush-out. On completion of the flush-out, all filtration media shall be replaced with new MERV 13 filters, except for filters that only process outside air.

In addition, within the first 30 days of occupancy, conduct a baseline indoor air quality testing procedure that randomly selects sampling points for every 20,000 square feet, or for each contiguous floor area, whichever is smaller, to measure concentration levels for the chemical contaminants listed below. These tests must be conducted by a qualified IAQ expert or an industrial hygienist, and must conform to the conditions outlined in the NYSGBTC:

Chemical Contaminate	Maximum Concentration
Carbon Dioxide (CO_2)*	700 ppm above background
Carbon Monoxide	9 ppm for an 8 hour average maximum
	or 35 ppm for a 1 hour average maximum
Formaldehyde	50 parts per billion
Particulates (PM10) average	150 micrograms per cubic meter over a 24 hour
TVOC	200 micrograms/cubic meter
Radon	4 picocuries per liter

*NOTE: This (CO_2) measurement refers to a fully occupied building during testing. Where the maximum concentration limits of any of the noted concentrations are exceeded in any building area, a flush-out must be conducted for that area until and re-testing undertaken until the required IAQ levels are achieved.

B. Post-Occupancy Testing.

Executive Order 111, with reference to the NYSGBTC 638.7(d)(1,2 and 3), requires that the baseline IAQ test be repeated on an annual basis for the first five years of building occupancy. The test for radon may be excluded from these follow up tests, provided the indicated concentration level was not exceeded during the initial test.

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IAQ Performance

IEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◎ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Prerequisite 1: Minimum IAQ Performance)*
An Indoor Air Quality Management Plan is attached and meets the requirements of ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure AND is prepared in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). The plan has been drafted in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Environmental Quality Prerequisite 2: Environmental Tobacco Smoke (ETS) Control)*
Documentation is attached, which clearly demonstrates that an adequate number of 'smoking rooms' has been provided within the project to prevent the potential of Environmental Tobacco Smoke (ETS) from circulating in the ambient indoor air, as required by New York City law. All smoking rooms are fully isolated and have been designed with impermeable, slab-to-slab partitions, separate, dedicated exhaust fans to the exterior, designed to prevent the re-entrainment of smoke, and a negative pressure differential of at least 7PA (0.03 inches of water gauge) to the surrounding area.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Daylight and Views IEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Provide building occupants with connections to the outdoors through the introduction of daylight into habitually occupied areas of the building. Provide building occupants with views via direct line of sight to the outdoors from regularly occupied spaces when possible.

Action: Towers: Provide a 2% minimum daylighting factor to 75% of regularly occupied tenant spaces. Build an exemplar tenant office fit-out (5,000 SF) to demonstrate optimum daylight access, louvers and glare controls, and ceiling geometries intended to optimize daylighting strategies. Quantify performance of integrated curtain wall and tenant fit-out with proposed savings

Retail: Seek to maximize daylight penetration to concourse areas and below grade retail areas. Provide views to the outdoors from concourse areas to assist users in wayfinding and orientation.

Related Guidelines: SEQ-11, EEQ-1, EEQ-2, EEQ-8, IEQ-10, and IEQ-12

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 8.1 & 8.2. (See Submittal Template)

Introduction/Context

Daylight has long been recognized for its beneficial effect on human beings. Individuals isolated from natural light become disoriented and listless. Workplaces without adequate daylight, it is now known, result in less than optimum occupant productivity. Access to natural light, even 'borrowed' light, provides a sense of time of day and season of the year, resonating within the sub-conscious human mind, reinforcing the circadian rhythm and contributing a sense of well-being.

Studies confirm that access to daylight is a vital component of human well-being, supporting mental health, productivity, and a sense of connectivity to nature. The human mind acknowledges this, both consciously and unconsciously. People consciously choose to sit at the restaurant table near the window; the corner office, with windows in two directions, is always the prized location. Recent studies have found that workers with good access to daylight have a more positive attitude and work experience. They also tend to rate job satisfaction higher than those who do not, as demonstrated in the new Herman Miller, Inc. facility in Holland, Michigan, studied by Heerwagen and Wise in 1998. In another study by Roger Ulrich and Rachel Kaplan, it was shown that having access to a window and outdoor views while working reduced stress significantly, and contributed to an enhanced state of mind. For these, as well as the economic reasons noted below, all World Trade Center site buildings should be designed to maximize day-lighting, and to take full advantage of the multiple human and conservation benefits offered through this sustainable strategy.

Utilizing naturally day-lit spaces has the potential to improve building economics in several ways. Reducing the need for electric lighting in all areas at all times saves energy, and therefore money, while also reducing pollution. A reduction in the electric lighting load diminishes heat build-up within the building, creating conditions where less air conditioning is needed to satisfy the cooling requirements. Also, as shown by the studies above, people are more content and healthier in day-lit spaces. Productivity goes up, and absenteeism goes down. When VeriFone, a California-based technology company, renovated one of its basic administrative and shipping centers in Costa Mesa, to include day-lit spaces for all workers, the company saw a 60% savings in energy costs, a 5% increase in productivity and a 45% drop in absenteeism when measured against a similar facility. Such savings have a significant effect on the bottom line of any business.

In recent times, public transportation centers and retail concourses have not focused on natural lighting as a design feature -- concern for the management of glare and solar gain was minimal, while views to the outdoors were not even considered. With the new understanding of the importance of this element, more and more, day-lighting is being utilized as a major design element in new transportation facilities and other large public spaces. For example, at the Interface Flon Railway and Bus Station in Lausanne, Switzerland, the ground surface is peeled back to allow a view corridor to the outside, as well as natural daylight to flood in, penetrating down to the covered rail platform below. Also, many of the new rail stations along London's new Jubilee Line purposefully have large areas of glass to allow daylight to penetrate several levels underground.

Relevant Issues

Ecological

Daylight is a form of free energy. Lighting accounts for 20%-25% of electricity consumption nationwide (and upwards of 30% of the energy load in corporate offices), so maximizing the use of natural light can save a significant amount of electricity. Recent examples of sustainable building -- such as The Natural Resources Defense Council's Headquarters New York, NY (1988), and the Development Resource Center, Chattanooga, TN (2002) -- have demonstrated that incorporating multiple, deep day-lighting techniques into a building, save more than 60% of lighting energy. Saving electricity is an important way to conserve natural resources and reduce the air and water pollution typically associated with the generation of electricity at power plants. Therefore, lessening the lighting load by taking advantage of a free resource not only saves on costs, but helps to mitigate such ecological problems as acid rain, global warming, and the proliferation of nuclear waste. Less demand for electricity generation supports the reliability of the regional power supply with peak demand reduction, while also contributing to improved local air and water quality.

Economic

Any incremental cost to initial project costs associated with optimizing day-lighting through integrating sustainable measures will be quickly offset by readily quantifiable benefits. Day-lighting strategies save money on electricity expenses, especially when used in conjunction with occupancy sensors and photometric lighting controls, which ensure that lights turn off when not required and/or when daylight levels are adequate. Since high levels of daylight are available and may be tapped during hot

summer afternoons when electrical usage in commercial buildings for air conditioning is typically at peak demand, benefits may accrue both through reduced consumption and by avoiding the higher peak demand charges typically levied by power utilities. When natural light is introduced in a controlled manner in conjunction with other sustainable strategies, such as smart glazing and appropriate louvers and/or window shades designed to prevent the build up of solar heat gain, daylighting also saves energy and money, as well as reducing the pollution related to building cooling.

Some types of electric lighting, such as incandescent sources produce significant heat themselves, which increases the cooling load. In many installations, this may be avoidable with reduced use of high heat generating lamps through increased use of daylighting. Besides these direct energy savings, daylighting may also contribute to a reduction in employee labor costs. Optimized access to day-lighting minimizes lamp usage and therefore replacement turn-around time and associated maintenance costs. Studies have shown that workers in daylit offices with views to the outdoors tend to be more productive, have better performance in tasks that require visual acuity, and are less prone to absenteeism. All of these factors translate into greater profits for business owners.

Neighborhood

Day-lit spaces tend to produce more satisfied occupants. This holds true for a variety of situations from typical office occupancies, to transportation centers, restaurants and retail establishments. Studies have shown positive health benefits including better sleep cycles, less instances of depression, and fewer people with symptoms of sick building syndrome (SBS) as a result of spending longer hours in day-lit interior spaces. Exposure to natural light and views has also been linked to greater and more positive social interaction, increased relaxation, and faster recovery from illness. The integration of daylight into building projects can be used as an aid in 'wayfinding'. Light can be modulated to direct movement and make people feel more secure and comfortable.

Methodology

Design Strategies

Orient buildings on their site to maximize daylight potentials. Incorporate glazing in quantities and locations to maximize daylight transmission while minimizing energy loads. Plan the building form in a manner that maximizes the ratio of perimeter space to internal space and make efforts to incorporate outdoor spaces such as courtyards into the building design, especially where a large floor-plate is contemplated. Use design strategies and technologies to maximize daylight penetration into occupied spaces of the building. For The Towers provide at least a 2% daylighting factor to 75% of regularly occupied spaces. This will satisfy the requirements for one LEED® Credit. To maximize energy saving potential, coordinate the control of electrical lighting systems with the amount of daylight available. To set a precedent for tenants, provide a sample tenant fit-out that illustrates ideal daylighting goals and methods by which to achieve them. Quantify the proposed savings that a tenant can expect if they follow this exemplar. Bring daylight into spaces below grade and use it in conjunction with wayfinding cues. Design the concourse areas to have a visual connection to the outside to further

support wayfinding and orientation. A second LEED Credit will be achievable if a direct line of sight to vision glazing can be provided for building occupants in 90% of all regularly occupied spaces. Studies in recent years have indicated the importance of views from interior spaces, the significance of which is only now beginning to be realized.

Means and Methods

Both physical and computer modeling techniques can be used to design a building for daylighting. Daylighting software can accurately simulate lighting conditions inside a building and allow designers to study variables, such as building form and orientation, aperture location and size, and elements to help bounce daylight inward. Based on knowledge gained from such lighting studies, designers can follow a series of strategies to produce a successfully daylit space. To orient a building to capitalize on daylight potentials, it is essential to have a thorough understanding of the characteristics and movement of the sun across a site, as it varies throughout the day and year. It is also important to consider the impact of shading from existing and future buildings as this too affects the quality and of daylighting and its access.

Formal strategies to maximize daylighting include such measures as keeping the building floor plates narrow, and/or including open courtyards or sky-lit atria in the design. The inclusion of a sufficient number of apertures such as windows, clerestories, and skylights, as well as their careful placement, is critical. The interior layout of the building will benefit from an open plan or interior glazing at partitions to allow the light to pass, as borrowed light, deeper in towards the building core.

The sectional geometry of a building can have a major influence on its ability to be effectively daylit. Ceilings that slope and are light in color can help draw daylight inward. Elements such as interior light shelves, exterior fins, louvers, and adjustable blinds can also bounce light deep into a space. Light reflective colors on large surfaces such as walls, ceilings and floors, help to distribute light deeper into the building. Furniture that is set back from the window wall, leaving an outboard corridor, allows for uninterrupted light access, while low partitions at furniture systems further enhance this strategy.

Other daylight transport technologies can be use to bring natural light into a building. Some of these technologies are passive, like light pipes that use mirrors to bounce light multiple times until it reaches the building's interior. Other options include active technologies like the Himawari system which, when located on a building's roof, actually tracks the sun and transports natural light into the building through small fiberoptic tubes.

When incorporating large expanses of glazing into a building to maximize daylighting potentials it is important to avoid energy liabilities. Advanced glazing with high R-values and low emissivity coatings may be used to minimize heat loss during the heating season. These new smart glazing characteristics, along with the use of special reflective films and coatings, can help control excessive solar gain during the cooling season, while also mitigating uncomfortable glare.

Control technologies are essential to any daylighting system. Photosensors integrated with the building management system can be used to coordinate between daylight and electrical lighting. Daylighting will produce energy savings only if the electric lights are dimmed or turned off when not needed.

Case Studies

Genzyme Center, Cambridge, MA

This office of a biotechnology company, a LEED Platinum building, was designed to incorporate a number of daylighting strategies both fundamental and novel. The building has an open floor plan to allow exterior daylighting to penetrate to the interior. A large atrium at the building's center brings daylight into the innermost spaces. Sweeping views of the exterior surroundings are visible from virtually all areas of the building. Photo and occupancy sensors detect lighting conditions and dim the overhead electric lights as more daylight enters the building. These controls are expected to reduce lighting energy use in the building by around 45%. An additional system was designed to help bring greater amounts of natural light further into the building. A series of roof-mounted heliostats track the sun's movement in the sky and bounce light to a series of fixed mirrors that in turn reflect the light to prismatic louvers at the top of the atrium. The louvers, which also move with the sun, reflect glaring direct sunlight back to the mirrors but allow only diffuse light to enter the atrium. The diffuse light is reflected to the building's floors by an innovative system of hanging prismatic mobiles, reflective panels, and a reflective light wall on the inner surface of the atrium. Glazed walls on the building's perimeter are equipped with horizontal, reflective, motorized blinds that direct light up to reflective ceiling panels that bounce it deep into the building's core.

California State Automobile Association (CSAA) District Office, Antioch, CA

The CSAA felt that the daylighting design of this prototype building was so successful that they adopted the design as a day-lighting standard for their future offices, nationwide. The building's ceilings are sloped downward from its center to its perimeter to help distribute light uniformly. Triple-pane, low-glare skylights introduce daylight throughout the office. Skylights are placed in wells that are splayed at a 45-degree angle to provide optimal lighting quality and dispersion. Louvers incorporated at the top of the skylight wells are controlled by photosensors and continuously modulate the amount of light entering the building to maintain a glare-free illumination level of around 70 footcandles. The electric lighting system uses highly efficient T-8 fluorescent lamps with dimmable electronic ballasts. Controlled by data from photosensors, these ballasts provide continuously adaptable dimming that can reduce light output from 100%down to 20%, and power requirements from 100% to 40% as daylight levels increase. When illumination levels from daylight exceed 60 footcandles, the electric lighting shuts off. Task lighting with energy efficient fluorescent lamps and electronic ballasts is located at workstations to provide additional light in specific areas and for light-sensitive work or highly detailed tasks. High R-Value glazing with a spectrally sensitive coating provides views to the outside world without creating a major energy liability. Fixed-pitched perforated window blinds control glare without eliminating visibility.

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

Standards have not been provided for this Guideline.

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Heerwagen, J. and Gordon Orians. "Adaptations to windowlessness: A study of the use of visual decor in windowed and windowless offices", Environment and Behavior 18(5), 1986: 623-638.

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Daylight and Views

IEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		◉ Ⓔ	◉ Ⓔ	◉	◉

Towers:

☐ **Required Component:** *(This will satisfy LEED™ 2.1 Indoor Environmental Quality Credit 8.1: Daylight and Views – Daylight 75% of Spaces)*
75% of regularly occupied tenant spaces have a daylight factor of at least 2%. A 5,000 SF tenant office fit-out has been built to demonstrate optimum daylight access, use of louvers and glare controls, and ceiling geometries intended to optimize daylighting strategies. The performance of the integrated curtain wall and tenant fit-out has been quantified with respect to anticipated/proposed savings.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Indoor Environmental Quality Credit 8.2: Daylight and Views – Views for 90% of Spaces)*
Direct line of sight to vision glazing has been provided for building occupants in 90% of all regularly occupied spaces.

Retail:

☐ **Required Component:**
Daylight penetration to concourse areas and below grade retail areas has been maximized, where possible. Views to the outdoors have been provided from concourse areas to assist users in way-finding and orientation.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Air Quality Monitoring IEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To retain high indoor air quality standards by establishing monitoring protocols to assist in maintaining appropriate ventilation rates for the comfort and well-being of building occupants.

Action: Indoor air quality must be tested annually and must meet minimum criteria for five years in accordance with minimum requirements of NY State EO-111 reference to NYSGBTC 638.7(d)(1). Once radon measurements are found to be satisfactory, subsequent testing for this contaminant is not required. Where concentration levels of noted contaminants exceed the established parameters in any specific area during this 5-year period, seek to locate and remediate/ eliminate contaminants, then flush out area with 100% outside air for a minimum of one week and retest until a satisfactory result is achieved.

Consideration should be given to a permanent indoor air quality monitoring system with centralized controls that provides feedback on ventilation performance and contaminant concentrations based on a combined carbon monoxide, carbon dioxide and volatile organic compound monitor.

Related Guidelines: SEQ-5, EEQ-6, IEQ-1, IEQ-4, IEQ-5, IEQ-6, IEQ-7, IEQ-9

Potential LEED™ 2.1 Credit: 1 possible with EQc1. (See Submittal Template)

Introduction/Context
In the USA, ventilation standards for mechanically ventilated buildings are established, maintained and up-graded on an on-going basis by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). ASHRAE, an independent organization, establishes standards that define the *minimum* amount of outside air that must be delivered in cubic feet per minute (cfm) to a specific building type such as a corporate office, or area of activity within that building, such as a gym, in order to achieve code compliance. This air, together with the building make-up air, needs to be monitored to ensure that its quality is consistently safe and is maintained at optimum levels for occupant comfort and well-being.

Historically, one of the most common methods of assessing the quality of indoor air was to measure CO_2 levels within the building against a pre-determined, outside air baseline. All outside air carries an ambient load of carbon dioxide (CO_2), which mixes with the carbon dioxide generated by the occupants' respiratory systems within the building. In order to provide a relevant monitoring methodology, a table that addresses occupant activity differentials, acceptable CO_2 levels, and therefore acceptable IAQ, is provided in ASHRAE Standard 62-2001 Appendix C. For typical office space, this level has been established at, or below, 530 ppm above outside ambient air CO_2 levels. Recently, monitoring CO_2 levels as the only indicator of air quality has begun to be challenged by more advanced thinking among building professionals and through new approaches being developed for green buildings.

Relevant Issues

Ecological

Ventilation rates in excess of the minimum standards, along with good filtration, provide better indoor air quality over the long term, and have been demonstrated to contribute to increased productivity and occupant satisfaction. Reduced absenteeism, less building–generated malaise and sick building syndrome (SBS) among workers can contribute to greatly increased profitability. High quality indoor air can best be maintained in mechanically ventilated buildings by the use of a monitoring system that addresses a broader spectrum of factors known to have the potential to adversely affect IAQ, and subsequently human well-being.

EO-111 and the NYSGBTC require annual monitoring of a series of air-borne contaminants for the first five years after occupancy.,This process is intended to establish and reconfirm that the World Trade Center buildings are maintaining appropriately high indoor air quality. Licensed industrial hygienists or IAQ professional engineers will undertake this work. However, this credit addresses a permanent monitoring system that will be used on a day-by-day basis by building personnel (the manager and/or the building engineer) to analyze, modify if necessary, and maintain air quality in the building, to help ensure a comfortable environment for all building occupants.

Economic

Increased ratios of outside air that are drawn from clean sources and are well filtered reduce the potential for the build-up and concentration of contaminants entering the building via the HVAC system, or generated within the building by material loads, systems, tenant activities and the occupants themselves. The argument concerning the cost of increased energy necessary to condition this additional outside air vs. return on investment in terms of human well-being and productivity is addressed in IEQ-1 IAQ Performance.

A comprehensive, permanently installed monitoring system that tracks pollutants in both densely occupied spaces such as conference rooms, cafeterias, etc. as well as typical office occupancies, adds cost to the construction of the building. However, the cost of monitoring equipment and a direct digital control (DDC) system (including installation and maintenance) that provides performance feedback to building personnel, is likely to be quickly off-set by pay-backs in worker satisfaction, reduced complaints about subsequent maintenance, and increased productivity. There is also an energy benefit as conference rooms, cafeterias, etc. are not typically used continuously.

Neighborhood

In these times of greater awareness and sensitivity to human well-being and comfort, with all associated benefits, it is important to provide optimum conditions for a healthy environment. A comprehensive IAQ monitoring program can contribute to a healthy environment and increased personnel comfort, thereby reducing absenteeism and medical costs, as well as increasing the life of the HVAC system. It is an investment in the quality of the building and the buildings' greatest assets, the workforce that it houses.

Methodology

Design Strategies

The design and inclusion of a comprehensive air quality monitoring system is considered to be both appropriate and well within the technological scope of the Class A office buildings designated for the World Trade Center site. This investment is well worth it as it will increase the life as the HVAC system. It is important to maintain CO_2 monitoring for all densely occupied spaces and spaces that have fluctuating populations, such as conference and meeting rooms, auditoria, places of assembly, training rooms, classrooms, break-rooms and cafeterias. Locate all CO_2 sensors within the breathing zone of each space. In addition, an outdoor airflow monitoring system may be considered to address other spaces which are subject to different contaminant releases in the building.

Design a CO_2 / outdoor airflow monitoring system which is connected to a DDC system capable of both trend and alarm functions and which allows for the remote monitoring of IAQ. A centralized DDC system that indicates when ventilation rates are not being maintained at optimum levels and/or senses an unhealthy build-up of air-borne contaminants, allowing for immediate corrective action, is a preferred methodology. The up-dated ASHRAE Standard 62 ventilation rate calculation method indicates a rate for the dilution of bio-effluents, as well as a rate for the dilution of other typical building contaminants. Refer to Addendum 62n of the Standard.

Means and Methods

Layout the location of sampling points and types of equipment intended for use in monitoring ventilation performance throughout the building. Make sure that sensors are calibrated to perform with accuracy. This must be done at the factory – CO_2 sensors must be certified to have an accuracy of 75 ppm or higher, calibrated at start-up. They must be certified to require recalibration no more frequently than once every five years. Both CO_2 and outdoor airflow monitors should be equipped with building automation system alarms that indicate when the outdoor airflow rate drops below fifteen (15%) percent of the minimum rate required by ASHRAE standard 62.1 for any reason.

In order to help meet the conditions of this chapter under the World Trade Center Guidelines, design teams will have to undertake the two separate, mandatory processes as required in IEQ-5 Construction IAQ Management Plan immediately following occupancy of the building. These criteria are fully described in the EO-111/NYSGBTC, and are briefly outlined as follows:

WTC Guidelines (Including EO 111 & NYSGBTC Requirements):

1. NYSGBTC 638.7(d) (1): This section of the Tax Credit describes an Indoor Air Quality Testing procedure that is intended to take place within 30 days after occupancy, and subsequently on an annual basis for five years. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOCs.

2. NYSGBTC 638.7(g) (1): In addition to the mandatory testing noted above, a one-week purge (seven days/twenty four hours) with air handlers operating at 100% outside air must be completed on every floor, prior to occupancy.

Case Studies

Energy Resource Center, Downey California
The Southern California Gas Company commissioned the design of this building to serve as a working model of their commitment to environmental stewardship. As part of the requirements that the ERC offer a healthy working environment for the company's employees, a permanent monitoring system was included to track indoor air quality, and to take corrective action when pre-set levels of contaminants are exceeded. In the main hall of the building, sensors monitor carbon dioxide levels and signal the air handling system to adjust the amount of fresh air at the intake to flush-out excess CO_2 and other contaminants. To further insure a high level of indoor air quality, the buildings' standard maintenance program includes a rigorous schedule for the inspection, cleaning and/or replacement of system components such as cooling coils, drain pans, and air filters. (Southern California 2005)

Pharmacia Building Q, Skokie, Illinois
This LEED V. 1.0 Gold rated building is home to a chemistry laboratory focused on research in metabolism, toxicology, medicinal chemistry, genomics, and process development targeted toward the treatment of arthritis and cardiovascular diseases. Because of the nature of its laboratory program, and in order to keep occupants safe, indoor air quality was a major design concern. The HVAC system supplies 100% outside air that only passes through the facility once and then is directly exhausted to the outside. Although this high air change rate virtually eliminates the buildup of pollutants, a control system is used to continuously monitor the air for carbon monoxide, carbon dioxide, total volatile organic compounds, and particulate levels. The building also has a non-toxic cleaning policy that prohibits the use of chemicals known, or suspected, to have an adverse effect on human beings. The cleaning materials and maintenance program mandates that all products used in the building are low in toxicity, free of phosphates, contain no ethers, and are biodegradable. (USGBC 2004)

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

ASHRAE Standard 62-2001 (Appendix C).

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USGBC. "Pharmacia Building Q." LEED Certified Project Case Study. USGBC. 12 October 2004. <http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=186>

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Air Quality Monitoring

IEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Prerequisite 1: Minimum IAQ Performance)*
This certifies that:

- Indoor air quality (IAQ) testing was completed within thirty (30) days of the initial occupancy of the building and will be undertaken annually for the next four years. Measures will be taken to ensure that IAQ continuously meets the minimum criteria for indoor air quality requirements as established by NY State EO-111 reference to NYSGBTC 638.7(d)(1).
- Radon measurements were taken: if found to be unsatisfactory (levels above 4 picocuries per liter) the owner has taken steps to have the condition mitigated.
- Measurements indicate radon concentrations in the building are at, or are less than, the 4 picocuries per liter level established by the approved test protocol.
- Where concentration levels of noted IAQ contaminants exceed the established parameters in any specific area during the initial 5 year period, actions will be taken to locate and remediate/eliminate contaminants, then flush out area with 100% outside air for a minimum of one week and retest until a satisfactory result is achieved.
- A permanent indoor air quality monitoring system with centralized controls that provides feedback on ventilation performance and contaminant concentrations based on a combined carbon monoxide, carbon dioxide and volatile organic compound monitor has been installed

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 1: Carbon Dioxide Monitoring)*
This certifies that a permanent carbon dioxide monitoring system has been installed and has centralized controls that provides feedback on ventilation performance and contaminant concentrations. A summary of the system, its design, and controls has been provided.

Name	Signature
Company	Role in Project
Date	

Ventilation Air Quality IEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide outside air to all occupied spaces in the building to support the comfort and well-being of building occupants and as an energy conservation measure.

Action: Demonstrate that the requirements of Section 5, 'Best Practices for Maintaining IEQ' of the International Performance Measurement & Verification Protocol, Volume II 'Concepts and Practices for Improved Indoor Environmental Quality', March 2002 have been met. Provide capability for system default to 100% outside air at all times where practicable and in balance with energy conservation.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-6, IEQ-1, IEQ-3, IEQ-5, IEQ-6, IEQ-8, IEQ-10

Introduction/Context

Good indoor air quality has a profound effect on both the morale and productivity of building occupants. The quality of indoor air is influenced by a large number of factors including the generation of indoor pollutants (see IEQ-07), the treatment of recirculated air, the operation of the HVAC System, control of moisture within the building, housekeeping procedures, and, most importantly, the quality and quantity of ventilation air brought into the building. Provision of high quality ventilation air requires control not only of the source of the ventilation, but also its treatment, handling, delivery and control.

Many indoor air quality experts, including industrial hygienists and mechanical engineers, focus on the effects of indoor air quality on human health and productivity. Studies by such well known experts in the field – William Fisk, P. O. Fanger and David P. Wyon, among others, indicate that current code minimums are not optimum for human well-being and that increased levels of outside air are beneficial to all aspects of human endeavor. It should be noted that most of these studies were written prior to the introduction of the up-dated ASHRAE Standard 62-2001, which actually *reduces* mandated amounts of outdoor air from the previous ASHRAE Standard 62-1999. This further justifies all efforts to increase the amount of ventilation, or outdoor, air in a sustainable building.

According to P. Ole Fanger in his article written in 2000: 'Indoor Air Quality in the 21st Century: Search for Excellence ', "Field studies demonstrate that there are substantial numbers of dissatisfied people in many buildings, among them those suffering from sick building syndrome (SBS) symptoms, even though existing standards and guidelines are met. The reason is that the requirements specified in these standards are rather low, allowing a substantial group of people to become dissatisfied and to be adversely affected. A paradigm shift from rather mediocre to excellent indoor environments is foreseen in the 21st century". Since this article was written, code mandated ventilation air rates in the US have been lowered!

Relevant Issues

Ecological
Well-documented studies clearly indicate the positive qualities in the relationship between increased levels of highly filtered, conditioned outdoor (ventilation) air and human well-being. While ASHRAE 62-2001 sets a standard for minimum amounts of outdoor air in buildings, a sustainable project, which looks to enhance the quality of the indoor environment, will endeavor to increase those amounts in order to reduce the pollutant load and support known productivity benefits and human comfort factors found in response to such a strategy.

Economic
Indoor air pollution is one of the five most urgent environmental problems facing the United States, according to the EPA. Numerous studies have demonstrated that improved indoor air quality increases productivity, reduces absenteeism, improves employee health and lessens the potential for litigation. A 1997 joint study between the U.S. Department of Energy and Lawrence Berkley National Laboratory estimated total costs to the U.S. economy of poor indoor air quality range as high as $168 billion/year.

There is an argument, frequently proffered by experts in energy conservation that it is 'too expensive' in terms of energy costs to introduce outdoor air in greater amounts than mandated by code. It is true to say that this additional air must indeed be treated – conditioned, dehumidified, filtered, etc. -- which does use some energy. However, use of heat recovery systems, among other technologies, can offset the energy impact of increased ventilation. Further, when weighed against the impact of human well-being, increased productivity and personal job satisfaction, this argument loses much of its validity in terms of economic value. The Rocky Mountain Institute's study of staff costs versus various facility costs, including energy, for a typical office building indicates that for every $2.25 spent as the annual cost of energy per sq. ft., $318.00* are spent as the annual cost of salaries and benefits for staff, per sq. ft. It therefore follows that maintaining a desirable interior environment with high quality indoor air that meets the comfort criteria of the office staff, makes enormous economic sense.

**Note: Figures are based on national averages and were updated by Carnegie Mellon University's Center for Building Performance and Diagnostics, 2004.*

Neighborhood
Ventilation air quality is an interior building issue and does not have a significant impact on the neighborhood. Avoiding health issues that could arise from poor quality indoor air lowers health insurance premiums for businesses, which benefits both employer and employee.

Methodology

Design Strategies

The International Performance Measurement and Verification Protocol, Chapter 5: 'Best Practices for Maintaining Indoor Environmental Quality' outlines 6 widely accepted best practice strategies, as follows:

1. Limit pollutant emissions from indoor sources
2. Assure adequate quality of intake air
3. Maintain minimum ventilation rates
4. Ensure proper filtering of recirculating indoor air
5. Institute a regular preventive maintenance schedule for the HVAC System
6. Integrate IEQ measures into a whole building approach

Measures 2 and 3 relate directly to the quality, quantity and control of outside ventilation air. The following strategies help insure that these practices will be observed:

1. Acquire outside ventilation air from locations remote from pollution sources.
2. Treat outside ventilation air to remove pollutants.
3. Avoid pollution of ventilation air from off-gassing or particulate shedding materials within air-handling systems.
4. Avoid creation of high relative humidity environments that will foster biological growth within ventilation air supply system.
5. Monitor airflow volume to insure adequate ventilation air provision to all locations of the building.

Means and Methods

An increased amount of outside air over the current code, ASHRAE 62-2001, has been demonstrated to contribute to productivity and human well-being and is one of the distinguishing characteristics of a sustainable building. In addition, all outside air inlets need to be located as high as possible and away from vehicle exhausts, building exhausts, cooling towers, flues, and other potential pollution sources. Avoid the introduction of pollution streams from adjacent buildings. The use of higher efficiency particulate filtration at ventilation air intake avoids the introduction of particulates into the ventilation air distribution system.

Reduce building loads, especially solvent-based, butyl sealants for ductwork and components of the air handling system. Utilize silicone sealants for air-handling applications. Only non-fibrous duct liner or fibrous duct liner encased with a non-porous anti-microbial coating should be used. The coating must not adversely affect the surface flammability, and must maintain a flame spread/smoke of less than 25/50 when tested by ASTM E-84. Such coatings must be made without the use of halogen-based flame retardants, as these chemicals will generate toxic gases when heated to extreme temperatures (as in the case of a building fire). Coatings should show a growth reading of zero by ASTM G-21, and should show greater than 99% effectiveness in the reduction of a mixed bacterial inoculum by ASTM G-22, and should also have demonstrated fungicidal action.

Dehumidify ventilation air upon introducing it into the building. Long distribution runs of untreated outside air through conditioned space can cool the conveyed ventilation air, thus raising its relative humidity to levels sufficient to sustain fungal growth.

Install systems with positive dynamic control of outside air ventilation rates, rather than systems that rely on a static outside air damper. Utilize control systems that consider the outside air fraction of the circulated, conditioned supply air when setting the minimum airflow rate for zones in variable air volume systems. Zones operating at a lower part load when the air handling system is operating near design capacity may receive less than minimum outside air ventilation unless the control system raises the minimum airflow rate in response to outside air fraction.

Utilize carbon dioxide sensing to establish outside air ventilation rates for critical spaces within the building. Select diffusers and diffusion strategies with ventilation effectiveness to insure proper delivery of air to spaces and to avoid stagnant areas within occupied spaces.

Case Studies

4 Times Square, New York, NY
Tenants in this residential tower are provided with ventilation that surpasses the relevant codes Outside air is supplied to the building at 0.20 cfm/ft^2 and occupants can adjust their own supply to as much as 0.50 cfm/ft^2 if they desire. If the need for an emergency flush-out arises, the HVAC system has the capacity to perform a complete flush-out using 100% outside air on any three floors of the building at the same time. All fresh air for this building is drawn in high above the street beyond the reaches of traffic emissions. Air is monitored centrally and ongoing periodic air quality testing for carbon dioxide and carbon monoxide helps ensure that tenants are breathing high quality air. The skin of the building was designed to allow up to 30% relative humidly without the problem of condensation forming on windows even in the winter months.

Cambria Office Building Pennsylvania DEP Ebensburg PA
Specifications for this project included an IAQ Management Plan for construction that mandated protection and/or cleaning of ventilation systems prior to occupancy and insured reduced levels of construction contaminants in the building by requiring a 2-week flush out with 100% outside air and the changing of filter media. The building is equipped with permanently installed indoor air quality monitoring devices for measuring humidity, temperature, CO_2 levels, and VOC's. Floor-mounted air distribution diffusers provide 100% ventilation efficiency. The diffusers also provide individuals with the ability to adjust their own thermal comfort. Each occupant can control and vary the amount of air delivered to their workspace. Operable windows, for natural ventilation, also exist throughout the building.

The Plaza at PPL Center, Allentown ,PA
Sensors in every room monitor carbon dioxide levels within the Plaza, ensuring that outside air is supplied directly to each building area as needed. This surpasses current best-practices standards for ventilation performance. An enthalpy recovery wheel is supplemented by humidification control to help promote thermal comfort all year through. Interior finish materials including

paints, carpets, adhesives, sealants, and composite wood paneling were selected for low emission of VOCs, urea-formaldehyde, and other contaminants, and all building spaces were flushed-out with 100% outdoor air for two weeks before occupancy.

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

International Performance Measurement and Verification Protocol. Concepts and Practices for Improved Indoor Environmental Quality. Volume II. IPMVP, 2002.

ASHRAE Standard 62-2001 -- Ventilation for Acceptable Indoor Air Quality (ANSI Approved)

ASHRAE 129 Air Change Effectiveness

ASTM D 6245 Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation

Bibliography

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NISTIR 5329. Manual for Ventilation Assessment in Mechanically Ventilated Commercial Buildings

USEPA. An Office Building Occupant's Guide to Indoor Air Quality. United States Environmental Protection Agency; Office of Air and Radiation (OAR); Indoor Environments Division (6604J); EPA-402-K-97-003, October 1997

Wyon, David P. Enhancing Productivity while Reducing Energy Use Technical University of Denmark

Ventilation Air Quality

IEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
Documentation is attached that indicates that the requirements of Section 5, 'Best Practices for Maintaining IEQ' of the International Performance Measurement & Verification Protocol, Volume II 'Concepts and Practices for Improved Indoor Environmental Quality', March 2002 have been met.

☐ **Required Component:**
The capability of the ventilation system to default to 100% outside air at all times has been provided where practicable and in balance with energy conservation.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Construction IAQ Management

IEQ-5

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide minimum standards for the air quality of building areas upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical system filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

On completion of construction and prior to occupancy, conduct a one-week flush out using 100% outside air, in accordance with NYSGBTC 638.7(g)(1). Replace all filtration media used with new MERV 13 filters. Test indoor air quality at random sampling points for every 20,000 sf, or by each floor if smaller, in accordance with recognized national standards, to achieve an air quality profile at time of occupancy which satisfies the specific minimums for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon as per NY State EO-111 reference to NYSGBTC 638.7(d)(2) and include one additional testing procedure for 4-PCh to satisfy all of the Alternate Procedure Requirements for LEED 2.1. Where concentration levels of contaminants exceed the established parameters in any specific area, flush out area with 100% outside air for a minimum of two weeks and retest until a satisfactory result is achieved.

Proposed Changes:

Purpose: To provide minimum standards for the air quality in the building during construction and upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical systems filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

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Related Guidelines: UEQ-8, SEQ-5, SEQ-6, IEQ-1, IEQ-3, IEQ-6, IEQ-7

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 3.1 and EQ cr. 3.2. (See Submittal Template)

Introduction/Context

Construction practices generate dirt, dust, and debris and release particulates, gasses and volatile organic compounds (VOC's) into the air-stream. The presence of moisture within the building can generate and support conditions which allow mold and mildew to establish a foothold, often creating conditions that are difficult to remediate and which affect the quality of IAQ in the building for years to follow. This credit outlines a series of strategies intended to minimize the potential for generation of construction-related pollution and to assist in the containment and removal of any contaminant sources prior to occupancy.

During the construction of new buildings and major renovations of existing buildings, the fabric of the building and its mechanical systems and services, as well as building materials and products, must be physically protected from potential contamination and exposure to moisture. By developing a rigorous Construction IAQ Management Plan, and enforcing its requirements, this can be achieved. The plan must address all issues relating to potential contamination, including protection of the building fabric and systems, use of cleaner or more benign building materials to reduce loads, sequencing of material flows and avoidance of damp or wet conditions...

In compliance with the NYSGBTC 638.7 (g) (1), on completion of the work, and prior to occupancy the building must be flushed out with 100% outside air using clean filtration media for a period of one week. Following this purge, within thirty days of occupancy of either a new or renovated building or tenant space, indoor air quality testing *must* be performed to determine that levels of carbon dioxide (CO_2), carbon monoxide (CO), formaldehyde (HCHO), particulate matter, radon and total volatile organic compounds (TVOC's) are acceptable. Pollutant levels must be at, or less than, those cited in the standards referenced in this credit.

Relevant Issues

Ecological

The protection of air quality during construction is critically important for the future air quality in the building and for the comfort and safety of those who will later occupy the building. It also addresses immediate concerns relative to the well-being of construction workers. By adhering to a rigorous schedule of protective measures that minimizes the presence of toxic materials, reduces and contains contaminants, dust and debris, isolates sensitive equipment and systems, and protects building materials from wet conditions, the design team and construction personnel establish baseline conditions for a clean, well-managed building site. This in turn goes a long way to creating safer working conditions for construction crews and a healthy building for future occupants.

Economic

Many of the strategies in a Construction IAQ Management Plan, in fact reduce potentials for expensive errors at the site, and protect the building from future costly clean-up. Protective measures incur minor costs associated with the purchase of appropriate products, as well as the labor required to move, isolate, cover and generally protect vulnerable materials, systems and equipment from exposure to rain, dust, grit and VOC's generated by construction activities. These costs are a much less expensive alternative to the potential costs associated with the clean-up and/or replacement of damaged or soiled materials and equipment, and especially those that have been subjected to wet conditions at the site.

Of particular concern are factors relating to water damage of HVAC equipment, and to conditions that allow the absorption of moisture by soft or porous materials. The functionality of equipment so damaged can be compromised, while both water-damaged equipment and materials have the potential to support the growth of microorganisms that can lead to mold and mildew in the building. Subsequently, as the building becomes enclosed and warmer, the presence of these contaminants can cause Building Related Illness (BRI), a well-recognized condition which can seriously affect the health of occupants – i.e. Legionnaire's Disease or pneumonitis. It is critical for both economic and health factors that appropriate measures to prevent these conditions from occurring are described in the Construction IAQ Management Plan and, most importantly, are enforced at the job site.

Neighborhood

Maintaining a clean worksite and taking steps to reduce and contain dust-generating activities helps to protect the health of construction workers, as well as occupants in nearby buildings. In addition, utilizing low-VOC products means that workers are exposed to less noxious materials and to lower levels of off-gassing during the construction process. The Occupational Safety and Health Administration (OSHA) regulates conditions required to meet minimum worker safety and health measures, however, a sustainable project seeks to exceed these *minimum* standards wherever appropriate and possible.

Building Related Illness (BRI) is an extremely difficult condition to rectify, requiring a costly remediation process. Once a structure is contaminated by microorganisms, which generally results in the – often unseen -- presence of mold and fungus, not only is a rigorous and complicated clean-up necessary, the perceived 'reputation' of the building is greatly affected, making it lose market value. Avoiding conditions that

allow microorganism communities to grow and flourish in the building is an important preventive action and a pro-active way to support human health and well-being.

Methodology

Design Strategies

A Construction IAQ Management Plan calls for the protection of materials and particularly systems-related equipment as they arrive at the site, are temporarily stored and subsequently installed. All products must be kept clean, dry and undamaged in secure storage areas not affected by construction activities and/or exposed to wet or humid weather conditions. Materials and equipment must also be protected during and after installation, as work often continues in the immediate vicinity around the newly installed items. These measures need to remain in effect until such time as the project is considered to be substantially complete, and the building is clean, flushed out and occupied.

Specifications must include either a comprehensive Construction IAQ Management Plan prepared by the architect, or call for the preparation of such a Plan by the general contractor (GC) or construction manager (CM). The latter option is preferred as the implementation and management of the Plan is ultimately the responsibility of the GC or CM. In either case, the architect and the responsible GC/CM must approve the plan.

The contractor is responsible for establishing a communication pathway between all concerned parties (owner, tenant, design professionals, sub-contractors and their on-site personnel, etc) to discuss and resolve any potential IAQ issues relative to site activities. He or she must ensure that all sub-contractors are aware of, understand and adhere to the instructions outlined in the plan.

The Tax Credit calls for the designation of a representative (also known as an IAQ Manager) with daily responsibility for IAQ issues [NYSGBTC (638.7)(d)(2)(3)(i)]. This task involves the observation, supervision and follow-through on the specific requirements of the Construction IAQ Management Plan. The IAQ Manager will be responsible for advising those in authority if conditions that threaten air quality or that might affect the integrity of materials and/or systems are observed, or when procedures outlined in the Construction IAQ Management Plan are not being followed.

Implementation of the Plan begins in the design and pre-construction phases, where construction details addressing the continuity of the moisture protection strategy between joints is required to be in compliance with NYSGBTC 638.7(d) (2), and the level of construction detail must be as provided by the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction', Chapter 3, Fifth Edition. In addition, in these early phases, low-emitting materials are selected and specified (source control), and during the pre-construction planning, the sequencing for maximum protection of materials and related processes is developed. The SMACNA IAQ Guideline will be a key reference document for this credit.

Means and Methods

Design Strategies (Construction Drawings)

Drawings detailing the continuity of moisture protection strategies at the building envelope must cover all joints between dissimilar materials. Drawings must be three-dimensional when envelope and moisture protection planes intersect in 3 dimensions. Construction details must meet the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association, Architectural Sheet Metal Manual, 5th Edition, 1993.

Control Strategies (During Construction)

Source Control
Work with design team to recommend specification of low-VOC sealants, adhesives, caulks, coatings, paints, cleaning solutions, etc. Provide adequate ventilation of work areas. Modify equipment usage or work techniques to minimize pollution and dust and isolate or seal-off completed areas from on-going construction work. This may include filtering exhaust or exhausting directly to the outdoors. Cover and seal containers of wet products when not being utilized.

Pathway interruption
Provide 100 percent outside air and continuously run HVAC equipment during installation of materials and finishes, beginning after the building is substantially closed. Where a supply air system is already installed, it must have filters in place before work begins. The permanent HVAC system may be used to move both supply and return air provided the following conditions are met. Replace all construction-related filtration media used on permanent HVAC equipment at substantial completion of work. Confirm that all air filters, casing, coils, fans and ducts are clean, before TAB and air quality testing. Permanent air supply ducts must be inspected and/or cleaned to comply with the minimum requirements of "General Specifications for the Cleaning of HVAC Systems" published by the National Air Duct Cleaning Association.

HVAC protection
Protect the ventilation system components and air pathways against contamination during construction. When possible keep system off during heavy construction (only turning it on for installation of finishes, etc. as noted above). Return system openings in and adjacent to construction areas should be sealed. Use high efficiency filtration media at all HVAC return air grilles during construction. Implement cleaning procedures for ventilation system components prior to occupancy in the event that ventilation pathways were not adequately protected during construction.

Good Housekeeping
Store building materials in a weather-tight, clean area protected from dust, debris and moisture. Keep the premises free from accumulations of waste materials, rubbish, recyclables and other debris resulting from work. Identify the storage, disposal and housekeeping practices to be applied to building supplies and waste materials to protect building systems from contamination.

paints, carpets, adhesives, sealants, and composite wood paneling were selected for low emission of VOCs, urea-formaldehyde, and other contaminants, and all building spaces were flushed-out with 100% outdoor air for two weeks before occupancy.

Reference

Definitions

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Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

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Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

International Performance Measurement and Verification Protocol. Concepts and Practices for Improved Indoor Environmental Quality. Volume II. IPMVP, 2002.

ASHRAE Standard 62-2001 -- Ventilation for Acceptable Indoor Air Quality (ANSI Approved)

ASHRAE 129 Air Change Effectiveness

ASTM D 6245 Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation

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Ventilation Air Quality

IEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
Documentation is attached that indicates that the requirements of Section 5, 'Best Practices for Maintaining IEQ' of the International Performance Measurement & Verification Protocol, Volume II 'Concepts and Practices for Improved Indoor Environmental Quality', March 2002 have been met.

☐ **Required Component:**
The capability of the ventilation system to default to 100% outside air at all times has been provided where practicable and in balance with energy conservation.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Construction IAQ Management IEQ-5

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide minimum standards for the air quality of building areas upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical system filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

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Proposed Changes:

Purpose: To provide minimum standards for the air quality in the building during construction and upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical systems filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

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Related Guidelines: UEQ-8, SEQ-5, SEQ-6, IEQ-1, IEQ-3, IEQ-6, IEQ-7

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 3.1 and EQ cr. 3.2. (See Submittal Template)

Introduction/Context
Construction practices generate dirt, dust, and debris and release particulates, gasses and volatile organic compounds (VOC's) into the air-stream. The presence of moisture within the building can generate and support conditions which allow mold and mildew to establish a foothold, often creating conditions that are difficult to remediate and which affect the quality of IAQ in the building for years to follow. This credit outlines a series of strategies intended to minimize the potential for generation of construction-related pollution and to assist in the containment and removal of any contaminant sources prior to occupancy.

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Of particular concern are factors relating to water damage of HVAC equipment, and to conditions that allow the absorption of moisture by soft or porous materials. The functionality of equipment so damaged can be compromised, while both water-damaged equipment and materials have the potential to support the growth of microorganisms that can lead to mold and mildew in the building. Subsequently, as the building becomes enclosed and warmer, the presence of these contaminants can cause Building Related Illness (BRI), a well-recognized condition which can seriously affect the health of occupants – i.e. Legionnaire's Disease or pneumonitis. It is critical for both economic and health factors that appropriate measures to prevent these conditions from occurring are described in the Construction IAQ Management Plan and, most importantly, are enforced at the job site.

Neighborhood

Maintaining a clean worksite and taking steps to reduce and contain dust-generating activities helps to protect the health of construction workers, as well as occupants in nearby buildings. In addition, utilizing low-VOC products means that workers are exposed to less noxious materials and to lower levels of off-gassing during the construction process. The Occupational Safety and Health Administration (OSHA) regulates conditions required to meet minimum worker safety and health measures, however, a sustainable project seeks to exceed these *minimum* standards wherever appropriate and possible.

Building Related Illness (BRI) is an extremely difficult condition to rectify, requiring a costly remediation process. Once a structure is contaminated by microorganisms, which generally results in the – often unseen -- presence of mold and fungus, not only is a rigorous and complicated clean-up necessary, the perceived 'reputation' of the building is greatly affected, making it lose market value. Avoiding conditions that

allow microorganism communities to grow and flourish in the building is an important preventive action and a pro-active way to support human health and well-being.

Methodology

Design Strategies

A Construction IAQ Management Plan calls for the protection of materials and particularly systems-related equipment as they arrive at the site, are temporarily stored and subsequently installed. All products must be kept clean, dry and undamaged in secure storage areas not affected by construction activities and/or exposed to wet or humid weather conditions. Materials and equipment must also be protected during and after installation, as work often continues in the immediate vicinity around the newly installed items. These measures need to remain in effect until such time as the project is considered to be substantially complete, and the building is clean, flushed out and occupied.

Specifications must include either a comprehensive Construction IAQ Management Plan prepared by the architect, or call for the preparation of such a Plan by the general contractor (GC) or construction manager (CM). The latter option is preferred as the implementation and management of the Plan is ultimately the responsibility of the GC or CM. In either case, the architect and the responsible GC/CM must approve the plan.

The contractor is responsible for establishing a communication pathway between all concerned parties (owner, tenant, design professionals, sub-contractors and their on-site personnel, etc) to discuss and resolve any potential IAQ issues relative to site activities. He or she must ensure that all sub-contractors are aware of, understand and adhere to the instructions outlined in the plan.

The Tax Credit calls for the designation of a representative (also known as an IAQ Manager) with daily responsibility for IAQ issues [NYSGBTC (638.7)(d)(2)(3)(i)]. This task involves the observation, supervision and follow-through on the specific requirements of the Construction IAQ Management Plan. The IAQ Manager will be responsible for advising those in authority if conditions that threaten air quality or that might affect the integrity of materials and/or systems are observed, or when procedures outlined in the Construction IAQ Management Plan are not being followed.

Implementation of the Plan begins in the design and pre-construction phases, where construction details addressing the continuity of the moisture protection strategy between joints is required to be in compliance with NYSGBTC 638.7(d) (2), and the level of construction detail must be as provided by the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction', Chapter 3, Fifth Edition. In addition, in these early phases, low-emitting materials are selected and specified (source control), and during the pre-construction planning, the sequencing for maximum protection of materials and related processes is developed. The SMACNA IAQ Guideline will be a key reference document for this credit.

Means and Methods

Design Strategies (Construction Drawings)

Drawings detailing the continuity of moisture protection strategies at the building envelope must cover all joints between dissimilar materials. Drawings must be three-dimensional when envelope and moisture protection planes intersect in 3 dimensions. Construction details must meet the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association, Architectural Sheet Metal Manual, 5th Edition, 1993.

Control Strategies (During Construction)

Source Control
Work with design team to recommend specification of low-VOC sealants, adhesives, caulks, coatings, paints, cleaning solutions, etc. Provide adequate ventilation of work areas. Modify equipment usage or work techniques to minimize pollution and dust and isolate or seal-off completed areas from on-going construction work. This may include filtering exhaust or exhausting directly to the outdoors. Cover and seal containers of wet products when not being utilized.

Pathway interruption
Provide 100 percent outside air and continuously run HVAC equipment during installation of materials and finishes, beginning after the building is substantially closed. Where a supply air system is already installed, it must have filters in place before work begins. The permanent HVAC system may be used to move both supply and return air provided the following conditions are met. Replace all construction-related filtration media used on permanent HVAC equipment at substantial completion of work. Confirm that all air filters, casing, coils, fans and ducts are clean, before TAB and air quality testing. Permanent air supply ducts must be inspected and/or cleaned to comply with the minimum requirements of "General Specifications for the Cleaning of HVAC Systems" published by the National Air Duct Cleaning Association.

HVAC protection
Protect the ventilation system components and air pathways against contamination during construction. When possible keep system off during heavy construction (only turning it on for installation of finishes, etc. as noted above). Return system openings in and adjacent to construction areas should be sealed. Use high efficiency filtration media at all HVAC return air grilles during construction. Implement cleaning procedures for ventilation system components prior to occupancy in the event that ventilation pathways were not adequately protected during construction.

Good Housekeeping
Store building materials in a weather-tight, clean area protected from dust, debris and moisture. Keep the premises free from accumulations of waste materials, rubbish, recyclables and other debris resulting from work. Identify the storage, disposal and housekeeping practices to be applied to building supplies and waste materials to protect building systems from contamination.

Scheduling
Permit adequate drying time for new materials. Sequence the installation of finish materials. Install concrete during unoccupied periods and allow it to cure properly before sealing or covering. Schedule work to ensure that building occupancy is avoided while construction-related pollutants are still present. Submit a construction schedule that addresses the sequencing of absorbent finishes so that they will not act as sinks for the storage and subsequent release of contaminants emitted from solvent-based and other toxic materials, which typically occurs when the building is enclosed and warmer.

IAQ test procedure

The IAQ test procedure as defined in the NYSGBTC requires the testing of indoor air quality at random sampling points for every 20,000 square feet, or by each floor if smaller, or by each separate ventilation zone, in accordance with recognized national standards. Both base building projects and tenant fit-outs must comply with the testing requirements. Each standard includes an appropriate protocol and describes conditions under which the test must be conducted by a professional IAQ expert or industrial hygienist. At the time of occupancy, an air quality profile which satisfies the specific minimum standards for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon as per NYSGBTC 638.7(d)(2) must be met. In addition, for those projects pursuing a LEED Certification, one further test procedure for 4-PCh to satisfy all of the Alternate Procedure Requirements for LEED 2.1 must be completed. Where concentration levels of contaminants exceed the established parameters in any specific area, that area must be flushed out with 100% outside air for a minimum of two weeks and retested until a satisfactory result in line with the minimum contaminant level(s) is achieved. The test standards are listed in the following table:

Indoor Air Quality Standards for New York City Green Building Tax Credit (Abbreviated)

Substance	**Criteria**	**Standard and Source**
Carbon Dioxide	700 ppm above background	ASHRAE 62-1999
Carbon Monoxide	Indoor levels not to exceed background. Background (outside air) at intakes not to exceed: 1) 9 ppm/8-hour average, or 2) 35 ppm/1-hour average	EPA National Ambient Air Quality Standards New York State Air Quality Standards ASHRAE 62-1999
Formaldehyde	50 ppb (parts per billion)	EPA Building Assessment Survey and Evaluation California Resources Board IAQ Guideline

Particulates	150 micrograms per cubic meter (150 ug/m³) 24-hour average	EPA National Ambient Air Quality Standards ASHRAE 62-1999
Radon*	4 picocuries per liter	EPA – Radon Reduction Techniques for Detached Houses Technical Guidance ASHRAE 62-1999
Total Volatile Organic Compounds	200 micrograms per cubic meter (200 ug/m³) above background	EPA Research Triangle Park Research and Administrative Facility Baseline Testing, 2001
4-PCH (4-Phenyl-cyclohexene	6.6 micrograms per cubic meter (6.5 ug/m³)	State of Washington IAQ Standard

*Radon Tests need not be repeated if readings of less than 4 picocuries per liter were recorded during the first test.

WTC Guidelines (Including EO 111 & NYSGBTC Requirements):

1. NYSGBTC 638.7(d) (2): This section of the Tax Credit describes Indoor Air Quality Testing. IAQ testing is required to take place within 30 days of occupancy, and subsequently, except as noted above, on an annual basis for the first five years of occupancy. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOC's.

2. NYSGBTC 638.7(g)(1): In addition, and prior to the mandatory testing noted above, a minimum one-week purge (seven days/twenty four hours) must be completed on every floor, prior to occupancy. This purge must occur with air handlers operating at 100 percent outside air, at 50 percent of the full airflow rate of the fan when the outside temperature falls between 55 and 85 degrees Fahrenheit and the relative humidity is between 30 and 60 percent. When the outside air temperature and relative humidity fall outside these ranges, the fan air flow rate may be operated at a minimum of 25 percent, during typical operating conditions.

Case Studies

Premier Automotive Group North American Headquarters, Irvine California

A Construction IAQ Management Plan was designed at the beginning of the project and adhered to throughout construction of this office and design center for Ford Motor Company. Measures were taken to protect all ductwork and any permeable materials that were stored on site. These items were protected from chemical contaminants, as well as from exposure to moisture, which could lead to future problems with mold and mildew. Before the building was occupied a two-week building flush-out was performed to remove any airborne contaminants and all filtration media was subsequently replaced. (USGBC 2005)

The Patrick H. Dollard Health Center, Harris New York
This building, the first in New York State to employ green building standards that conform to Department of Health requirements, provides specialized medical care for 250 residents. To ensure a healthy environment for these occupants, a Construction IAQ Management Plan was followed. Material Safety Data Sheets for all construction materials were reviewed prior to construction to insure that workers and future building occupants would be exposed to only the minimal amount of dangerous pollutants. No urea-formaldehyde-based plywood underlayment was used on any of the building's floor surfaces. All uncoated paper products, absorbent materials and textiles stored on site during construction were protected from both moisture and exposure to high VOC concentrations. After painting was completed, the construction team waited for a minimum of three days before installing absorptive interior furnishings such as carpet. (BuildingGreen 2005)

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Pneumonitis*:* inflammation of the lungs, which occurs secondary to exposure to a chemical, organic dust, fungus or mold. Chronic exposure can lead to chronic lung changes evident on chest X-rays. Symptoms include cough, fever, shortness of breath and wheezing.

TAB Testing, Adjusting and Balancing of the HVAC system.

Standards

ASHRAE. ANSI/ASHRAE 52.2-1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. Atlanta: ASHRAE, 1999.

Sheet Metal and Air Conditioning National Contractors Association. IAQ Guideline for Occupied Buildings under Construction. Chapter 3, 5th Edition. Chantilly, VA: SMACNA, 1995.

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Construction Indoor Air Quality Management Plan IEQ-5-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objectives

The Construction Indoor Air Quality Management Plan provides a tool to ensure that minimum indoor air quality standards are met upon building occupancy. The plan is intended to assist project teams in meeting the requirements of NYSGBTC 638.7(d)(2) and LEED EQ c3.1 and EQ c3.2, and incorporates the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3.

Plan Components

I. Plan Description and Coordination
   A. Provide description of project objectives.
   B. Indicate team responsibilities and primary participants (owner, architect/engineer, contractor, etc.) and daily responsibilities. Specific Authority must be designated for coordinating plan requirements and achieving plan objectives. This Authority must include jobsite inspections with the ability to implement stop work orders for nonconformance with the Plan.
   C. Establish means of communication and notification between all parties to prevent and resolve IAQ difficulties.
   D. Provide schedule overview.

II. Design Strategies (construction drawings)
   Ensure that the following requirements have been met as part of the Construction Documentation.
   A. Drawings detailing the continuity of moisture protection strategies at the building envelope must cover all joints between dissimilar materials.
   B. Drawings must be three-dimensional when envelope and moisture protection planes intersect in 3 dimensions.
   C. Construction details must meet the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association, Architectural Sheet Metal Manual, 5th Edition, 1993.
   D. Specifications include the requirements of this plan.

III. Control Strategies (during construction)
   A. Source Control
      1. Specifications must clearly indicate the requirement for use of low VOC sealants, adhesives, caulks, coatings, paints, cleaning solutions, etc.
      2. Indicate the methods by which adequate ventilation at work areas will be provided.

3. Indicate source control strategies used to minimize dust and air-borne pollution, including any modification of equipment usage or work techniques, such as the installation of temporary space dividers between construction and non-construction areas of the site, filtering exhaust and/or exhausting directly to the outdoors.
4. Indicate strategies for the protection of volatile substances and minimization of air pollution from containers of wet products when not being utilized.

B. Pathway interruption
   1. Provide data indicating that the fans will be run continuously using 100 percent outside air during installation of materials and finishes, beginning after the building is substantially closed. When the outside temperature is between 55 and 85 degrees Fahrenheit and the relative humidity is between 30 and 60 percent the fan airflow rate must be operating at 50 percent capacity. When the outside air temperature and relative humidity fall outside these ranges, the fan air flow rate may be operated at a minimum of 25 percent, during typical operating conditions. Where a supply air system is already installed, it must have filters in place before work begins.
   2. The permanent HVAC system may be used to move both supply and return air: Indicate in the drawings and specifications that the following conditions will be met during construction:
      a. Replace all construction-related filtration media used on permanent HVAC equipment at substantial completion of work
      b. Confirm that all air filters, casings, coils, fans and ducts are clean, before TAB and air quality testing. Permanent air supply ducts must be inspected and/or cleaned to comply with the minimum requirements of "General Specifications for the Cleaning of HVAC Systems" published by the National Air Duct Cleaning Association.

C. HVAC protection - Ventilation system components and air pathways must be protected against contamination during construction. Provide documentation indicating that the following or similar strategies will be employed:
   1. When possible keep system off during heavy construction.
   2. Return system openings in and adjacent to construction areas will be sealed.
   3. Use of high efficiency filtration media at all HVAC return air grilles during construction.
   4. Identify cleaning procedures for ventilation system components to be employed prior to occupancy in the event that ventilation pathways were not adequately protected.

D. Good Housekeeping
   1. Indicate on the drawings the location of a storage space for building materials, which will be weather-tight, clean and in an area protected from dust, debris and moisture change.
   2. Include a requirement to maintain the premises free from accumulations of waste materials, rubbish, recyclables and other debris resulting from work. Identify the storage, disposal and housekeeping practices to be applied to building supplies and waste materials to protect building systems from contamination

E. Scheduling – Indicate on the drawings and/or in the specifications how the following strategies will be achieved
   1. Adequate airing-out of new materials

2. Sequencing of the installation of finish materials to minimize absorption of contaminants
3. Time allowance for proper curing of concrete before sealing or covering
4. Scheduling of wet trades and installation and finish materials during unoccupied periods
5. Avoidance of building occupancy while construction-related pollutants are still present.
6. Submit a special construction schedule to prevent absorptive finishes from acting as sinks for storage and subsequent release of contaminants emitted from sealants and other toxic finishes and processes.

IV. Before and Immediately Following Occupancy

A. On completion of construction prior to occupancy, conduct a one-week minimum flush out with new MERV 13 filtration media and using 100% outside air, in accordance with NYSGBTC 638.7(d) (2).
B. Replace all base building mechanical system filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy
C. On completion of construction and within 30 days of occupancy, conduct an IAQ test in accordance with NYSGBTC 638.7(d) (2). Test indoor air quality at random sampling points for every 20,000 sf, or by each floor if smaller, or by each ventilation zone, in accordance with recognized national standards, to achieve an air quality profile at time of occupancy which satisfies the specific minimums for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon.

V. Strategy Coordination

A. Outline the scope of the IAQ Management process during construction, including submittal review, inspection and enforcement
B. Outline the expected written work products, including checklists and worksheets
C. Provide an activities schedule.
D. Provide a schedule of IAQ Management Plan meetings for every phase of the project..
E. Outline the IAQ-related training programs that will be provided for the trades.

VI. Management Report

The Construction Indoor Air Quality Management Report documents effective implementation of the Plan. The following documentation is required as part of this report.

A. Meeting minutes, checklists, worksheets, notifications and deficiency or resolution logs related to IAQ issues.
B. Log with all temporary uses of building mechanical plant and filter replacements during construction and prior to occupancy. Include cut sheets of filter media.
C. Progress photographs documenting IAQ measures implemented during construction*.
D. Documentation and log of duct inspection, testing and cleaning, where necessary.

Construction IAQ Management

IEQ-5-T

Sustainable Design Guidelines Reference Manual
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Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◎ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 3.1: Construction IAQ Management Plan – During Construction)*
This certifies that a Construction Indoor Air Quality Management plan has been implemented and will satisfy all of the criteria outlined in the Methodology Section of Sustainable Design Guideline IEQ-5.

Note 1: *in order to satisfy the requirements of NYSGBTC 638.7(d), both a one week pre-occupancy flush-out* ***and*** *an IAQ test to occur within 30 days of occupancy (as described in the NYSGBTC) are required to be completed.*

☐ **Optional Component:** (To satisfy *the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 3.2: Construction IAQ Management Plan – After Construction/Before Occupancy.)*
A two-week flush out with new filtration media using 100% outside air has been completed after construction and prior to occupancy. After purging the building, all filtration media were replaced with new MERV 13 filters.

Alternatively, immediately prior to occupancy, conduct a baseline IAQ testing procedure in accordance with LEEDCI v2. EQ c3.2, which includes testing for 4-PCH, and demonstrates that the listed chemical contaminants are at or below the thresholds established by the referenced standards.

Note 2: *The LEED v2.1 credit language calls for the IAQ test to be conducted prior to occupancy. Through the LEED CIR process, the USGBC will accept that the IAQ test may be conducted immediately following occupancy, which complies with the NYSGBTC.*

Name	Signature
Company	Role in Project
Date	

Reduce Contaminants from Materials IEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce the density of contaminants that are emitted by common building materials and which affect the comfort and well-being of building occupants.

Action: Develop and implement a Materials Management Plan to minimize utilization of materials with high levels of volatile organic compounds (VOC's) and other toxic characteristics, which adversely affect Indoor Air Quality (IAQ). VOC's must meet or be lower than those in the following standards:

Adhesives and Sealants	**Current Version**
Adhesives and Sealants	South Coast Air Quality Management District Rule #1168
Paints and Coatings	
Paint topcoats	Green Seal GS-11
Primers, undercoats, sealers, coatings	South Coast Air Quality Management District Rule #1113
Anti-Corrosive paints	Green Seal GS-3
Carpet, Carpet Cushion and Adhesives	
Carpet and Carpet Tile	Carpet & Rug Institute's (CRI) 'Green Label Plus' Indoor Air Testing Program
Carpet Cushion	Carpet & Rug Institute's (CRI) 'Green Label' Indoor Air Testing Program
Carpet Adhesives	South Coast Air Quality Management District Rule #1168

Where possible use non-urea-formaldehyde-based bonding agents in composite wood and typical millwork applications, such as veneer and plastic laminate applications, etc.

Do not use unprotected insulation in ducts, supply plenums and return plenums per NYSGBTC 638.7(j).

Related Guidelines: SEQ-1, MEQ-3, MEQ-4, MEQ-6, MEQ-7, IEQ-1, IEQ-3, IEQ-4, IEQ-5

Potential LEED™ 2.1 Credits: 4 possible with EQ cr. 4.1, EQ cr. 4.2, EQ cr. 4.3, and EQ cr. 4.4 (See Submittal Template)

Introduction/Context

One of the major goals of all green building guidelines is to introduce a series of means and methodologies that diminish the deleterious effect of the built environment on the natural environment and to enhance conditions for human well-being. Within this context, efforts are made to reduce the use of building materials and products that pollute the air, earth and water. These impacts occur at various times, including during manufacturing processes, transportation, use in construction and/or as impacts within the building, as well as during the final disposal of such products. The four credits in IEQ-6 'Reduce Contaminants from Materials' establish preliminary guidelines for reducing negative impacts from a number of common building material sources on both outdoor and indoor air quality.

Relevant Issues

Ecological

The term 'low-emitting materials' generally refers to products that are low in volatile organic compounds (VOCs) and other airborne toxins, and which minimize contributions to the development of ground ozone or smog. The major areas of concern include the 'wet trades' – paints, coatings,adhesives, glues, caulks and sealants -- as well as carpet systems and engineered woods. Traditionally, all of these products have been made with highly toxic chemicals with the potential to adversely affect human health when concentrated inside buildings, and which, in the case of VOC's, contribute to ground ozone, a major factor in the development of smog. The association between smog and asthma is well documented (see the EPA's brochure: 'Ozone and Your Health').

Ground level or 'bad' ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of VOCs, however, many common building materials also emit these solvents.

Economic

Within the three categories indicated in the chart above, plus non-urea-formaldehyde-based bonding agents, there are now many options for 'low-emitting materials'. Today, because of competition between manufacturers, there is little or no penalty in terms of cost for requiring the use of environmentally preferable products. Using low-emitting materials, and especially those low in VOC's, contributes to enhanced indoor air quality (reduced loads) and the release of less smog generating chemicals. These factors contribute to increased occupant satisfaction, comfort and productivity in buildings, and less ground-level smog with its associated health risks. These in turn are important economic considerations.

Neighborhood

Creating a greater demand for low-emitting products is an effective way to stimulate industry to continue its 'clean up', while providing the market with a wider choice of environmentally superior products. Not only are building occupants found to be more satisfied with their work and learning environments when there is high indoor

air quality, the reduction of toxic chemicals in building materials such as urea-formaldehyde, toluene, benzene, etc. makes for environmentally cleaner manufacturing facilities and safer working conditions for factory workers. Reduced ground-level smog provides a significant community benefit, especially in densely populated, urban areas such as New York City.

Methodology

Design Strategies

These four areas of concern, which fall collectively under the umbrella of IEQ-6, are intended to address products used in the building interior only. They focus on the impact of several interior grade materials which, when made with traditional methods and materials, have the potential to be major pollutant emitters, adversely affecting indoor air quality. The definition of 'indoor' is described as 'all products and materials that are installed inside the weather barrier', and includes interior duct linings, as well as the interior portion of exterior wall construction, thermal insulation, etc. While it is acknowledged that the state of the construction manufacturing industry is not yet at a stage where there are multiple choices for environmentally clean *exterior* building materials, design teams are encouraged to consider the advantages of specifying cleaner building materials throughout the project.

Specifications can be written to include an environmental section in Division 1 requiring the use of environmentally cleaner materials. Both construction materials, such as adhesives and composite wood panels, and interior finish materials such as paint and carpet are included. Language to address each environmental concern can be added to the relevant specification section dealing with paints, coatings, adhesives, sealants, carpet assemblies and composite and engineered wood products.

It is important to consider the full spectrum of each material or product's characteristics, including suitability, aesthetics and demonstrated performance or durability, as well as ease of maintenance, while considering its environmental, low-emitting potential.

Means and Methods

Research into environmentally cleaner materials has become increasingly manageable as a result of readily availably technical data sheets and material safety data sheets (MSDs). These two documents, which can be obtained from manufacturers, generally provide environmental information relative to VOC content of the product in grams per liter (g/L), and also list chemicals that are known to be highly toxic and/or which might appear on the banned or restricted lists as indicated in the relevant standards.

Products that fall within these four areas of concern require careful recordkeeping. Information relative to each product, including technical data, VOC counts and evidence of chemical component compliance must be obtained and kept. If there is

a long period between original specification and purchase of any product for installation, the environmental considerations for each such product or material will need to be rechecked to make sure that there has been no change in manufacturing that would affect the product's compliance with the standards.

Once an environmentally compliant material has been approved for use, it needs to be tracked to ensure that there is no field or contractor substitution and that the installed product meets the environmental requirements as specified.

Reference

Definitions

Volatile Organic Compounds (VOCs) The term 'Volatile Organic Compounds', often referred to as VOCs, means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.
Source: Ron Josephs and Associates

Formaldehyde A colorless gaseous compound, HCHO, the simplest aldehyde, used for manufacturing melamine and phenolic resins, fertilizers, dyes, and embalming fluids and in aqueous solution as a preservative and disinfectant.
Source: The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2000 by Houghton Mifflin Company.

As used in building materials, this chemical is found in many materials, and is frequently used as a binding agent in engineered and composite wood products, as well as a form of biocide in insulation, ceiling tiles, fabric finishing, etc. It comes in two common forms: **urea formaldehyde** used for interior products, and **phenol formaldehyde** used primarily in exterior products. Both forms of formaldehyde are confirmed human carcinogens (IARC, DFG). Urea formaldehyde releases volatile gasses (out-gasses) at room temperature, while phenol formaldehyde requires much greater levels of heat in order to become volatile.

Standards & Bibliography

South Coast Air Quality Management District Rule 1168 (SCAQMD)
This Standard addresses a reduction in VOC levels and has some chemical limitations. Although it does consider the impact of some chemicals, it is not an ideal standard for the purposes of developing criteria for 'green' buildings, as it does not consider the comprehensive health impacts of toxic chemical emissions. However, SCAQMD Rule 1168 does require a reduction in typical VOC emissions, and therefore contributes to the reduced use of toxic chemicals at manufacturing plants, cleaner indoor air and the reduction of ground-level smog.
SCAQMD Rule 1168 is up-dated periodically, with announcements of up-dates (more restrictive requirements) being noted well in advance.

Green Seal – GS-11
GS-11 sets VOC limits for interior opaque, topcoat paints.

Green Seal – GS-03
GS-03 addresses VOC limits for anti-corrosive paints on ferrous metal.

Both Green Seal standards set an Aromatic Hydrocarbon Compound limit of no more than 1% by weight and do not allow inclusion of the following substances.

Halomethanes; Methelene chloride

Chlorinated methanes; 1,1,1-trichloroethane

Aromatic solvents; Benzene, Toluene (methylbenzene), Ethylbenzene

Chlorinated ethylenes; Vinyl chloride

Polynuclear aromatics; Naphthalene

Chlorobenzenes; 1,2-dichlorobenzene

Phthalate esters; di (2-ethylhexyl) phthalate, butyl benzyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, diethyl phthalate and dimethyl phthalate

Semi-volatile organics; isophorone

Metals and metal compounds; antimony, cadmium, hexavalent chromium, lead and mercury

Preservatives; formaldehyde

Ketones; methyl ethyl ketone; methyl isobutyl ketone

Volatile organics; acrolein, acrylonitrile

South Coast Air Quality Management District Rule 1113 (SCAQMD)
SCAQMD Rule 1113 establishes a standard for primers, sealers and all other *architectural coatings*, including clear wood coatings and floor finishes, which are not included in the Green Seal Standards. The Standard lists permissible VOC content levels and chemicals limited by weight or totally restricted for use in these products. SCAQMD Rule 1113 is up-dated periodically, with announcements of up-dates (more restrictive requirements) being noted well in advance.

Carpet & Rug Institute (CRI) 'Green Label Plus' Indoor Air Test Program
In 2004, the CRI introduced a more rigorous and demanding carpet testing program – Green Label Plus -- which will be administered in the same manner as the CRI's original 'Green Label' program. At this time, only carpet (top material) is tested under the Green Label Plus program, which limits emissions from thirteen (13) chemicals known to have negative IAQ impacts, and which are commonly associated with carpet manufacture.

Note: The Green Label Plus standard has been adopted for use by LEED v2.2, CI, EB and all future products, as the original Green Label standard no longer represents a significant sustainable challenge and all projects using carpet were able to achieve the credit.

Carpet & Rug Institute (CRI) 'Green Label' Indoor Air Test Program
The CRI's Green Label Indoor Air Test Program will remain in place for Carpet Cushion until such time as the more comprehensive Green Label Plus program becomes available for these products. Adhesives used in the carpet and/or cushion installation under either CRI program must conform to the requirements of SCAQMD Rule 1168.

Reduce Contaminants from Materials IEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credits 4.1, 4.2, and 4.3: Low-Emitting Materials –Adhesives and Sealants, Paints and Coatings, and Carpet.)*
A matrix listing of all interior paints and coatings and adhesives and sealants used on the project is attached. The matrix has been completed indicating the manufacturer for each product listed, product identification name and/or number, VOC count in grams per liter (g/L) and use for each product. This certifies that the products used meet the chemical component limits of the restricted substances listed in the standards that have been listed, and the amount of restricted chemical content by weight has not been exceeded.

The identifying names and certification numbers indicating that all carpets and carpet systems used on the project are in compliance with the requirements of the Carpet and Rug Institute's IAQ Test Program are attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credits 4.4: Low-Emitting Materials – Composite Wood.)*
A list of all the composite wood products used in the building is attached. This certifies that they contain no added urea-formaldehyde resins.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Chemical and Particulate Control IEQ-7

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To minimize sources of chemical and particulate air contamination.

Action: Design all major entrances with permanent walk-off grilles to minimize particulate transfer. Provide MERV 13 air filters for removal of 90% of particulates at air supply systems and provide building owner with a maintenance schedule for filter replacement. Build slab-to-slab partitions and provide negative air pressure of at least 7PA with isolated exhaust systems of at least 0.5cfm/sf at workrooms with printing and copying equipment, janitorial closets and all chemical use areas. Locate exhausts to ensure that there is no potential for re-entrainment of exhaust air to other supply in-takes. Provide drains for appropriate disposal of liquid waste in spaces where water and chemical concentrate mixing occurs.

Related Guidelines: UEQ-8, EEQ-6, IEQ-1, IEQ-3, IEQ-4, IEQ-5

Potential LEED™ 2.1 Credit: 1 possible with EQ cr. 5 (See Submittal Template)

Introduction/Context

Air in indoor environments is said to be as much as 1,000 times more contaminated than outside air (EPA: Office Equipment: Design, Indoor Air Emissions and Pollution Prevention Opportunities). Low outside air ventilation rates, minimum air changes per hour and limited paths for removal and replacement of contaminant-laden air, along with indoor activities and the operation of equipment, all contribute to the concentration of pollutants within the building. There are many strategies available for the clean-up of the indoor environment, but one of the simplest and most effective is to prevent airborne contaminants and particulates from entering the building in the first place. This can be accomplished, to some degree, through the design of the building and its systems. By building-in measures such as permanent, recessed walk-off grilles at all major entrances, with effective mat material to capture dirt carried on shoes, much particulate matter is prevented from entering the building. Installing high quality filtration media at all air in-takes, and establishing a rigorous maintenance schedule for filter replacement protects indoor air from many common air-borne contaminants.

Many typical activities and office functions that take place within the building also generate pollution, which affects the quality of the indoor environment. Isolating areas where contaminants are typically generated, such as copy and printing areas, and janitorial closets, while carefully managing liquid chemical contaminants and their disposal, goes a long way to making the indoor environment a safer and more comfortable place for human occupation.

Relevant Issues

Ecological

There is little downside to planning for enhanced indoor environmental quality in terms of cleaner air, and considerable reason to include these strategies at an early stage in the design of the project. While the strategies indicated require the use of marginally more raw materials in the construction of the building, the payback in terms of reduced sick building syndrome (SBS), occupant satisfaction with the indoor environment, and in associated productivity, will be significant. Preventing contamination of the water supply is an important health and safely issue, as well as a critical environmental strategy with far-reaching consequences for the natural environment (well beyond the immediate area of the project).

Economic

The design and construction of recessed entryway grilles is in line with best practice in Class A buildings in Manhattan and elsewhere. There is, therefore, no anticipated increased cost impact associated with this strategy for the World Trade Center buildings. Costs associated with the construction of slab-to-slab partitions and separate exhaust systems as required to isolate rooms where chemicals may be released as a result of office or building activities, will be off-set quickly by cleaner indoor air and associated productivity gains. MERV 13 (Minimum Efficiency Reporting Value) filters are more expensive than many other types of air filtration media. However, the performance of MERV 13 filters improves continuously over time. As these passive filters 'load-up', slightly more energy is expended to address their continually increasing resistance over their anticipated lifetime. This is a small penalty to pay when compared to the enhanced IAQ resulting from the use of this ASHRAE Standard 52.2-1999-supported filtration system. The provision of separate plumbing drains for specific chemicals at janitorial closets and other maintenance locations where such chemicals and cleaning/maintenance materials are handled, ensures that building occupants are not inadvertently exposed to these substances. Specialty drains for toxic chemicals, where required, are generally addressed by code and are designed to ensure that the water supply and natural bodies of water beyond the site location are not contaminated by untreated chemical waste.

Neighborhood

Although the issues discussed in this credit require consideration in both the design and construction phases of the building, they are really associated with 'good housekeeping'. Providing high quality indoor air by preventing the exposure of building occupants to air pollutants through design, construction and maintenance strategies has the potential to increase the life of the HVAC system, as well as contributing to the well-being of the building community. As a result, health care costs may be reduced. Managing chemical disposal and contaminated water through separate piping located away from public restrooms protects the building occupants from coming in contact with these substances, while appropriate measures for toxic chemical disposal helps to maintain and protect the water supply and nearby bodies of water such as the New York Harbor and estuaries.

Bibliography

The American Institute of Architects. "20 River Terrace – The Solaire". AIA / COTE 2004 Top Ten Green Projects. Committee On The Environment. 22 April 2004. The American Institute of Architects. 13 January 2005. <http://www.aiatopten.org/hpb/indoorenv.cfm?ProjectID=273>

Brager, Gail, et. al. "Operable Windows, Personal Control, and Occupant Comfort", ASHRAE Transactions, Vol. 110, Part 2, 2004

Fisk, William J. and Rosenfeld, Arthur H.; "*Estimates of Improved Productivity and Health From Better Indoor Environments*", Lawrence Berkley National Lab & U.S. Dept. of Energy: Berkeley, CA, 1997; ISSN 095-6947

Hedge, Alan. "Linking Environmental Conditions to Productivity" presentation at the Eastern Ergonomics conference and Exposition, New York, June 2004

Heerwagen, Judith. "A Balanced Scorecard Approach to Post Occupancy Evaluation: Using the Tools of Business to Evaluate Facilities" Appendix in "Learning from Our Buildings" a Federal Facilities Council Technical Report No. 145, National Academy Press, Washington, D.C., 2003

Heerwagen, Judith. "Sustainable Design Can Be an Asset to the Bottom Line", Environmental Design + Construction, posted on their website 7/15/2002

International Centre for Indoor Environment and Energy website <www.ie.dtu.dk>

Kampschroer, Kevin. "Workplace Making: Innovation and Transformation", presentation at the West Coast Customer Workshop, June 2003

Kats, Gregory H.,. "Green Building Costs and Financial Benefits" Report to California's Sustainable Building Task Force, October 2003 <www.cap-e.com>

Kelly, Kevin. "Workplace 2020/Integrated Sustainability Planning and Design", presentation at GSA Public Buildings Service, Rochester, New York, August, 2004

NYSGBTC 638.7 (d) (3) Operations & Maintenance Plan
(includes an IAQ Profile that requires tracking of occupant complaints with further description of walkthrough for problem identification and corrective action to mitigate problems.)

NYSGBTC 638.8 (e & f) Commissioning:
(Design Intent & Basis of Design requires the identification of thermal zoning, control, and 'space temperature and humidity' criteria that are components of the comfort criteria and further require the identification and validation of features and functions of building systems.)

USGBC. "PNC Firstside Center." LEED Certified Project Case Study. USGBC. 13 January 2005. < http://leedcasestudies.usgbc.org/energy.cfm?ProjectID=62>

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Thermal Comfort

IEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	◉

☐ **Required Component:**
Comfort Criteria determined per ASHRAE Standard 55-2004 Sec. 5 for each thermal zone of the building according to the objective for each space are attached.

☐ **Required Component:**
Design Compliance Documentation is attached as per ASHRAE Std. 55-2004 Section 6

☐ **Required Component:**
Compliance Validation Documentation is attached as per ASHRAE Standard 55-2004 Section 7.6, selecting either the Survey Occupants or Analyze Environmental Variables option
Note: *(The above required components will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 7.1: Thermal Comfort – Compliance with ASHRAE 55-1992.)*

☐ **Required Component**
A commissioning Plan that incorporates these systems and their features and functions is attached

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 7.2: Thermal Comfort – Permanent Monitoring System.)*
A description of installed control and monitoring system for delivery of comfort conditions included in the Systems & Energy Management Manual and O&M Manual is attached

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Pest Control

IEQ-9

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To mitigate health concerns caused by any unwanted pests, their excrement and the chemicals used to control them.

Action: Develop an Integrated Pest Management Plan based on USEPA Best Management Practices, which promotes physical controls and non-pesticide measures over pesticide application. Physical controls include building sealing strategies, improved sanitation, pest-resistant plantings and improved maintenance of wet areas. When necessary, use boric acid or other nontoxic alternatives in lieu of more toxic chemicals to control and eliminate rodent populations from building.

Related Guidelines: IEQ-1, IEQ-3

Introduction/Context

Pesticide use in and around populated areas and in buildings is, by its nature, a process that must be handled with great care. According to the EPA, "pesticides can cause harm to humans, animals or the environment because they are designed to kill or otherwise affect living organisms." These products often contain lethal substances designed to provide control over insect or rodent populations, and while they are effective in repelling and/or killing such creatures, they can also exacerbate human discomfort and can cause unsafe and even dangerous conditions. (Use of pesticides that are extremely toxic to human beings and domestic animals such as the organophosphate or carbamate insecticides -- malathion, diazinon, and chlorpyrifos, among others -- is rigorously avoided in a sustainable Integrated Pest Management (IPM) program. Generally, use of such poisons is replaced by a program which relies on good planning strategies to minimize pest access, strictly enforced sanitation strategies, biological and mechanical pest control measures and, as a last resort where necessary, the use of low-impact, safer chemicals).

It is practically impossible to totally eliminate unwanted pests in urban settings. The objective of an Integrated Pest Management Plan (IPM) is to minimize these populations in and around buildings, thereby reducing the potential health risks associated with them, their dander and excrement, and eliminating the damage they can do to the fabric of the building and its finishes. The IPM must clearly define the means and methods by which to monitor and control pest populations. It will identify a Pest Management Professional (PMP) who will conduct inspections during construction and establish a series of steps intended to inhibit pest access to the building through physical measures, efforts to eliminate conditions which would support and feed pest colonies, sanitation measures, and maintenance strategies for wet areas, landscape areas and open spaces around the building. The work of separate project PMP's will be more effective if it can be coordinated with all other site IPM plans. As a further strategy when necessary, the plan will discuss the appropriateness of a low-toxic chemical application program, targeted to specific pest populations, and which has minimal effect on the safety and well-being of building occupants and domestic animals.

There are several varieties of pests found in most New York buildings in urban settings. Typically these include rodents, such as mice and rats, and insects, such as cockroaches and occasionally ants, silverfish, spiders and fleas. Fruit flies may invade kitchen and cafeteria areas. Moths can infest areas with untreated wool carpets or upholstery. Outdoors, most of the agricultural pests such as ticks and Japanese beetle (*Scarabaeidae*) are absent in urban locations. However, some outdoor pest populations thrive in the city and must be addressed in the plan. Weeds are considered to be pests and are often controlled with highly toxic herbicides, while water in cooling towers, swimming pools, fountains and reflecting pools must be treated to control the growth of water-borne microorganisms.

Fungi and microorganisms including bacteria and viruses are also termed 'pests' and may have serious impacts on indoor air quality and human well-being; however mitigation of such conditions, which can lead to sick building syndrome (SBS) is generally handled in a different manner – see IEQ-05.

Relevant Issues

Ecological

Health Risks of Traditional Pesticide Applications
Typical pest management systems, which employ effective but highly toxic chemicals have been used in recent years to control unwanted pest populations. However, because of their basically poisonous composition (they are designed to kill), they themselves often pose additional health risks for human beings and domestic animals. The risks from traditional pesticide treatments range from inadvertent skin contact with the chemicals, adverse respiratory reaction to airborne toxins and VOCs, and contamination of food exposed to pesticide spray applications, to the small but serious potential for young children and/or pets to actually eat substances such as rat poison. Unpleasant odors and indoor air contamination emitted from the chemicals themselves, and occasionally from dead or dying rodents that have ingested the control substances, and may be in concealed or inaccessible locations, are a further cause for concern.

Vertebrate Pests
Vertebrate pests such as rodents carry disease – the best known example is, of course, the Bubonic plague (Black Death), which, in the Middle Ages, was carried to Europe by shipboard rats and spread by a combination of these animals and their parasitic fleas. Rats and mice are also known to act as intermediary hosts in the transference of several other serious illnesses. They can contaminate food left uncovered in kitchens and pantries, and easily access poorly sealed food supplies, resulting in occasional outbreaks of Salmonella. Mice carry the deadly Hantavirus as well as Lyme disease, while other diseases spread by both rodents include dysentery, foot and mouth disease, swine fever, Chagas' disease, Rocky Mountain spotted fever and trichinosis, to mention only a few. In addition as noted, rats and mice can be the source of fleas in occupied buildings.

Rats cause destruction to the building fabric, gnawing through wood, wallboard, plastic, nylon mesh, and even concrete panels to gain access, and to maintain the sharpness of their teeth, which grow throughout their nine-month lifespan and must be constantly worn down. Both rats and mice gain access to buildings through pipes and sewers, drains, cracks in the building, pipe openings, loading docks and doors. They climb up rough masonry, and nearby bushes and wires, gaining access through air grilles, vents and windows. Once inside, they can travel everywhere via the buildings' concealed, integral system of pipes and ductwork. With access to food and water, they begin to reproduce at an alarming rate.

Insects

Insect infestations in New York are primarily of cockroaches. There are four common species in the city -- the American, the German, the brown-banded and the oriental cockroach. All are nocturnal, living in large colonies in dark, warm and preferably moist locations. They eat anything and everything organic and they need water, though not in great quantities or even frequently. They are dirty and carry bacteria. Their droppings and dry, powdery exoskeletons become airborne and are a known source of respiratory illness, breathing difficulties and asthmatic reactions. Cockroaches are ubiquitous, enduring and practically impossible to eradicate; however cockroach populations can be controlled so that they are less problematic in buildings.

Cockroach detritus contributes to respiratory disease in children and adults. "Research has shown (the) cockroach as the most significant allergen in children and adults with asthma. However, there is very little known about asthma and the elderly. This study suggests that (the) cockroach is a highly significant allergen to all age groups." *(Source: Linda Rogers, M.D., assistant professor, medicine, New York University School of Medicine, and attending physician, Bellevue Hospital Asthma Clinic, both in New York City)*

Where wool carpeting is used -- a preferred environmental option when treated and maintained correctly -- moths may be a problem in New York City. Most imported wool, including the typical Wools of New Zealand brand carpet wool, must be treated with moth-resistant chemicals prior to entering the United States. However, with repeated wet shampooing, some moth-resistant chemicals wash out, and the floor covering becomes vulnerable to infestations of these insects, which are extremely difficult to eliminate. Moths tend to prefer dark, undisturbed spaces, under furniture and at the baseboard, where their damage may not be immediately apparent, giving the colony time to gain a strong foothold. Once established, they lay eggs, larvae hatch, and the carpet may well be destroyed before the infestation is caught and treated.

Although there are many other pests that may be encountered in and around the World Trade Center site, those noted above are the principal ones that will, most likely, have to be managed under the IPM plan.

Economic

Uncontrolled infestations of pests are unattractive and can cause both psychological and physical damage. There is a high cost associated with the management of an

infestation of moths, for instance, where, once established in a wool carpet, the only solution is to replace the entire floor covering. Similarly, large colonies of cockroaches are difficult, and expensive to remove. However, a much greater cost occurs when building occupants become seriously ill, either from exposure to pest detritus, or from the chemicals typically used to control pests.

Investing in an Integrated Pest Management system (IPM) in an urban setting like the World Trade Center redevelopment in New York City, which is close to the port, is generally a smart move. Large projects are well advised to engage the services of a PMP, however, smaller projects may want to invest in a shared plan for the support of a pest management professional (PMP) or pest manager. In either case, it will be money well spent, both during the building planning, and following occupancy.

Neighborhood

Nothing is less attractive and more 'off-putting' than the sight of rats and/or cockroaches scurrying about around the base of a building! The presence of multiple numbers of these creatures blights the entire neighborhood, and suggests that the area is unkempt, dangerous and dirty. The psychological impact is far greater than the unpleasant reality of the rodents and/or bugs. A well conceived Integrated Pest Management Plan can minimize the presence of rats, mice, cockroaches, water-bugs and moths, etc., while causing little danger to the building occupants.

Through the use of planning techniques to minimize pest access to the building(s), and careful methodologies designed to deprive them of a means of survival (food and water) once they do gain access, pest populations can be controlled. It benefits the neighborhood to be as free as possible of these vermin, but only when they are controlled in such a way that the local population is not exposed to further danger; i.e. through the application of an established, low-toxicity IPM plan.

Methodology

Design Strategies

Integrated Pest Management is an environmentally safer, but still effective way to manage and reduce pest populations. It was originally developed for agricultural and urban pest management, and encourages preventative measures and the use of the least dangerous approach to eliminating, or totally eradicating pests commonly found in buildings and their immediate surroundings. Implementing and managing the on-going requirements of an IPM plan requires a full understanding of the nature of each pest, its life-cycle and habits, and the conditions that support its ability to gain access and thrive in the building. The objective is to make 'the site' inhospitable to each type of pest, through the elimination of those conditions.

The IPM plan must include the selection of a person or group who will be responsible for overseeing and managing all parts of the program. An experienced PMP needs to be engaged early in the design phases of the project in order to flesh out the plan, and to work with the architectural team on design issues relative to limiting typical means of access for rats, mice and insects to the project. The main job of the PMP will be to design a specific approach for managing all types of anticipated vermin and

insect populations during design, construction and occupancy of the building on an on-going basis.

Means and Methods
The Pest Management professional could be an employee of the owner or tenant; however it is recommended that a licensed Pest Management Professional (PMP) be selected, as these professionals have the training, skills, resources, equipment and knowledge to design and administer such a program. Most IPM plans are broken down into three distinct but connected areas of responsibility, expertise and implementation, as follows:

- The first step of the IPM program involves strategies to design maximum physical barriers for access for rodents, etc., and is the responsibility of the architectural team working under the guidance of the PMP.
- The second area of responsibility occurs during construction and involves constant inspection of the work. The architectural team, the contractor or CM and the PMP undertake this part together.
- The third establishes the process for the on-going administration and implementation of the program. This is the area of expertise of the PMP and their agents who will need to have a continuing, ever-vigilant role if the project is to remain free, or reasonably free, of pest populations. The PMP will work with assigned building personnel to accomplish this on-going work.

Once the IPM plan outlining the hierarchy of responsibility is established, the team must look for means to prevent pest access to the building as the work proceeds. This can involve limiting vulnerable access points in the basement and ground floor, sealing all holes and cracks, quickly repairing broken pipes and covering all pipe openings, vents and drains with steel mesh, grilles or sheet metal – whichever is most appropriate.

Trees and shrubs must not be planted so close to the building that they brush up against or lean on it, providing concealment, and a method for rodents and insects to elevate themselves to more accessible openings such as windows and vents. Likewise, pipes, wires or conduits against the exterior building walls provide an easy means of access for vermin.

Garbage and recycling areas are particularly vulnerable to pests and must be maintained to a very high degree in order to eliminate unpleasant conditions arising. Ensure during the layout of these areas that they are not close to a building access point, such as the loading dock. Meticulously avoid mixing biodegradable (food) waste with other materials and keep biodegradable materials tightly covered in steel containers, preferably raised off the floor or ground. It is important to be able to clean these areas properly. Provide a wash-down system or an outdoor hose near the garbage and recycling collection areas. An electrical outlet is also appropriate to assist with the use of power cleaning machines.

Inside the building, maintain rigorous requirements for the disposal of food waste, and leave no food uncovered in the kitchens, pantries, break-rooms or dining rooms.

Clean up spills immediately and repair broken pipes, faucets and/or leaks as soon as they occur.

Case Studies

Vermont School IPM, The University of Vermont Extension

A team at the University of Vermont Extension have drafted a sample Integrated Pest Management Plan to be employed at all public schools in the state. Although this plan is intended to be enacted for existing buildings and does not discuss new construction design features for pest control, it does cover how building operations staff can safely and effectively cope with pest problems in an occupied building. The goal of the plan is to prevent unnecessary exposure of building occupants to pesticides by reducing the need to rely on these chemicals for pest management. As part of this, this plan prohibits the preventative use of pest control chemicals. Instead it encourages benign preventative measures such as good sanitation practices and maintenance. In the event of infestation, the plan promotes non-chemical measures such as non-pesticide traps. In cases where the problem is so extreme that pesticides are the only recourse, the plan outlines specific safety protocols that should be used to ensure protection of building occupants. (UVM Extension 2005)

Reference

Definitions

Vermin any of various small animals or insects that are pests; e.g. cockroaches or rats.

Standards

No standards have been included for this Guideline.

Bibliography

The University of Vermont Extension. "Sample School Integrated Pest Management Plan". University of Vermont. 13 January 2005. <http://pss.uvm.edu/pd/schoolipm/documents/sampleplan.doc>

Integrated Pest Control Management Plan IEQ-9-P

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Objectives

Develop an Integrated Pest Management Plan (IPM), based on USEPA Best Management Practices, which promotes physical controls and non-pesticide measures over pesticide application.

Physical controls include building sealing strategies, improved sanitation, food storage and biodegradable waste management strategies and improved maintenance of wet areas. When necessary, use traps, boric acid or other nontoxic alternatives in lieu of more toxic chemicals to control and eliminate rodent and insect populations from building.

Plan Components

I. Project Description (Plan Summary)

A. Physical description of project
B. Physical description of neighborhood
C. Identification of the PMP
D. Requirements of the IPM to be established between the owner, architect, contractor and PMP.
E. Summary of steps proposed to implement the IMP
F. Responsibilities of each party to accomplish the IMP.

II. Pest Inventory

Provide a detailed list of known and anticipated pests at the site and in the area. Organize the plan according to strategies targeted at managing vertebrate and insect populations, and include a section on the management of exterior areas, if and where appropriate, to address insects, weeds and unwanted, invasive plants.

III. Management Strategies

A. IPM Pre-Construction Preventive Measures
   1. Identify and engage a PMP
   2. On the building floor plans – below grade and ground floors, identify vulnerable access points, and locations that must be properly sealed during construction.
   3. Identify methods and materials for sealing holes and cracks such as concrete or similar fillers, sheet metal, steel mesh and grilles.
   4. Indicate methods for protecting access doors, vents, etc.
   5. Indicate all drains and pipe openings where metal grilles will be used to prevent rodent access.

6. On the plan drawings, indicate setbacks for shrubs and trees relative to the building façade where operable windows, vents and grilles could potentially allow access.
7. Indicate location for staging of garbage and/or dumpsters and ensure that they are not near or directly under any potential access point.
8. Indicate the location of a hose bib for washing down garbage staging area.
9. Indicate the location an exterior outlet for use of electrical equipment in cleaning the staging area.

B. IPM Plan -- Measures to be Adopted During Construction:
   1. Indicate approaches to maintaining clean premises at all times. Include instructions to contractor requiring separation of leftover food and biodegradable materials (sandwiches, paper wrappers, cartons, etc. from construction workers on-site meals, etc.) to prevent commingling this waste with construction debris. Require provision of special steel waste receptacles with lids for these materials. Waste receptacles, identified for this purpose, must be clearly marked in English and Spanish.
   2. The Plan will establish a schedule of inspections by the PMP to make sure that the strategies and precautions outlined under IPM Pre-Construction Preventive Measures (above) are being completed satisfactorily.
   3. Indicate required inspections of all areas where service pipes, etc. enter the building and waste pipes exit the building to confirm tightness of seals at points of entry and exit.
   4. Indicate required inspections of all wet locations (rest rooms, janitors' closets, kitchens, pantries, maintenance and service areas, etc) to confirm tightness of pipe-fittings and all holes, voids, cracks or similar are properly stopped.
   5. The Plan will include visual inspections of vulnerable pipes and locations where water leaks could occur inside the building.
   6. Indicate that spills and standing water or puddles must be cleaned or mopped-up promptly.
   7. Indicate that drains and open pipes are required to be covered with grilles.
   8. Note that temporary or loose cabling, or wires on the exterior of the building that can act as a means for rodents etc. to gain access to higher entry points will not be permitted.
   9. The Plan will allocate space for stock-piling materials. Stacking materials against the building where they can act to conceal the presence of rodents and vermin, potentially allowing them access to the building from concealed locations, will not be permitted.

C. IPM Plan -- On-Going Monitoring:
   1. A schedule of inspections of all potential points of entry for rodents will be included.
   2. Outline approaches for the monitoring of pest populations on a continuous basis.

3. Outline an occupant-response plan to immediately address complaints concerning the presence of pests (occupants are usually the first to notice cockroaches, mice and rats).
4. Indicate an action threshold point at which pest control action must occur.
5. Outline a set of guidelines which establish good sanitation rules so that absolutely no foodstuffs are left exposed in kitchens, pantries and storerooms.
6. Outline a set of 'good house-keeping' standards that require the removal of areas of standing water and immediate clean up of spills, leaks, etc. that could be a source of water for vermin.

IV. Targets

The overall objective of this plan is to prevent pest colonies from establishing themselves and thriving in the World Trade Center buildings. However, in New York City, especially near the Hudson River and the port, it is almost impossible to totally eliminate vermin. The effort is therefore focused on severely limiting the presence of rats, mice, cockroaches and other vermin in the World Trade Center buildings. The greatest potential to achieving this goal is to create a completely inhospitable environment that does not support the basic requirements necessary for the livelihood of these vermin. By removing all casual food and water sources, large rat and mice populations will be unable to thrive, and insects such as cockroaches, will also be controlled. In order to achieve this goal, food service personnel, as well as building occupants, will need to be instructed in the specific handling of food and biodegradable waste.

The second target is to use a vermin control plan that is effective while avoiding the use of chemicals such as pesticides and rat poison, which are harmful to building occupants and domestic animals. Along with denying food and water sources to vermin, minimizing easy access and immediately addressing 'first signs' of their presence, via non-toxic means, will also contribute greatly to the effectiveness of these strategies and to reducing numbers. Careful implementation and follow through on the IPM plan will achieve this goal.

V. Evaluation

Complete a report at the end of construction that describes strategies established to minimize pest access to the building. Indicate where the plan has been established successfully and where there are vulnerabilities such as at the loading dock, which may need specific, vigilant observation during the on-going implementation of the IPM plan. Indicate measures established to educate and inform food service personnel and building occupants on the proper handling of food waste to reduce the potential for pests in the building.

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Pest Control

IEQ-9-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:**
A copy of an Integrated Pest Management Plan based on USEPA Best Management Practices to promote physical controls and non-pesticide measures over pesticide application, is attached.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Personal Control

IEQ-10

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide building occupants with a high level of thermal, ventilation, and lighting system control to promote productivity, comfort and well-being.

Action: Provide building occupants with individual controls over airflow, temperature and lighting systems. Provide operable windows where practicable and feasible.

Introduction/Context

The World Trade Center Redevelopment will include a rail station, hotels, performing arts center and other entertainment venues, as well as office towers, underground malls, street level shops, restaurants and cafes. With 10 million square feet of office space and 880,000 square feet of retail space, it will be a workplace for tens of thousands of people. The concept of design excellence envisions a community that is structurally, economically, and politically sound, providing a user-friendly and attractive atmosphere for workers, residents, visitors and tourists.

With a focus on the workplace, the principle is an environment that connects at a very human level to the workers, individually and in work teams that power business success. The human story of the World Trade Center is compelling, like no other. It is grand and terrifying and basic. It is about a workplace functioning in both normal and emergency modes, and the astonishing heights determination, grit and city pride can engender out of the despair that characterized this site, and its people, just a few years ago.

How buildings and their systems help people perform their normal tasks and achieve their objectives is a basic element of design excellence. Enabling building occupants to control their local environment has been shown to contribute to high levels of productivity and to a sense of well-being. The provision of individual access to local controls for lighting, temperature and ventilation is not always an easy task. But, the potential payback in workplace productivity of only a few percentage points dominates all other sources of green building savings and certainly supports full investigation of the opportunity.

While Executive Order 111 does not directly cite local control, there are several related issues raised in NYSBGTC 638.7 (d) Indoor Air Quality. The IAQ Profile requires a record of occupant thermal comfort complaints and procedures for responding to, and mitigating, the cause. In the NYSGBTC, Section 638.8 (e) Commissioning Design Intent and Basis, a narrative describing the level of occupant control over HVAC is required to be provided. The support documentation cited for this guideline is intended to be an integral component of the Design Intent and Basis narrative. LEED NC v 2.1 EQ Credit 6 requires further calculation related to floor area, location, and provision of lighting, temperature and ventilation control and operable windows.

Relevant Issues

Ecological

Personal control can contribute to environmental impact in two ways; on one hand enhancing value; and on another, lowering environmental impact of the World Trade Center Redevelopment. Personal control of workplace environment has been associated with productivity improvement. For a nominal increase in the expenditure of natural resources, significantly greater value is created by the business enterprise that provides its workers with a more productive work environment. That enterprise may be a better investment of natural and human capital.

Personal control allows the individual or local team to adjust their work environment to meet the specific needs of their current task. The nature of their work, their sense of comfort and well-being, as well as local conditions, change over the work day. If enabled by local controls for lighting, ventilation and temperature, individuals can adjust their environment to suit their current need rather than accept a code-level standard delivered under all conditions, which may be designed in part to manage and lower energy use. Of course, if accumulated choices are intended to result in lower energy use, building occupants need to be empowered with this knowledge of the impact of their decisions in order to be active participants in improving management's goals. Typically, the incremental increase in energy use associated with providing employees with the means to control their comfort level, is quickly off-set by acknowledged satisfaction with the workspace, and resulting increases in productivity.

Economic

As formulated for a balanced scorecard approach to building performance, measures of workplace performance include elements of cost reduction and value creation, such as: profitability, capacity for innovation, quality of work life, employee retention, operational efficiency and others. While all of these elements can be measured, metrics are not often readily available and the causal link to those conditions that contribute to them is difficult to establish.

The basic principle is that people will work better individually and in teams if they are empowered to adjust the environmental parameters. The research to-date seems to confirm that principle. One attempt to place specific numbers on the gains in productivity realized has the average measured workforce productivity gains of 7.1% with lighting control, 1.8% with ventilation control, and 1.2% with thermal control. Taken across the operations of a business, the potential economic gain associated with these improvements is very attractive (Overall Productivity and Health Benefits of Green Buildings were estimated at $36.90 to $55.30 per square foot). Their application requires assessment of the specific business and its operations *(Kats 2003).*

Neighborhood

Underlying the goals and objectives for the WTC Redevelopment is the success of business enterprises located there. As a center of economic activity, the quality of its workplaces and its productive work environments will support business success and promote further development of Lower Manhattan. Further, a workplace known for its

contribution to individual and team success will support a strong sense of community in building occupants. That feeling of well-being can easily transfer to customers and members of the surrounding community, generating benefits well beyond the confines of the office or workplace.

Methodology

Design Strategies

- Embed personal control of local work environments in a whole-building approach to indoor environmental quality, particularly as related to lighting, ventilation and temperature.
- Identify control opportunities that can be effectively implemented in individual workspace areas and those available in team workspaces, e.g. multi-occupant offices, conference rooms, classrooms, or open team area.

Means and Methods

Personal Control of the local environment is about work performance as it is affected by both local environmental conditions that can be adjusted to meet personnel needs and worker motivation derived from being in control of local conditions. Appropriate applications for consideration of Personal Control devices include both individual and team or multi-occupant workspaces. Spaces for which the benefits of Personal Control do not apply include those that are not regularly occupied for work-related purposes, such as corridors, lobbies, storage rooms, rest rooms, local copy rooms, local kitchen areas and the like.

Personal Control has value only related to its impact on the workforce. A direct measure of its implementation is the percent of the total workforce empowered with Personal Control at their workstation, coupled with the percent of other team workspaces enabled for local control. LEED NC v2.1 EQ Credit 6, Systems Control, includes a calculation related to floor area as a means to quantify the extent of implementation of Personal Control. It provides an indirect indication of the percent of the total workforce that is empowered with Personal Control. When this LEED credit is sought, design teams should run the calculation to determine compliance.

Leveraging the synergies of 'best practice green building design' is especially critical to the cost-effective implementation of Personal Control. The typical workspace is integrated into the whole building design, where this approach is appropriate in considering localized control of lighting, temperature and ventilation. Related Guides include: IEQ – 12 Lighting Quality, IEQ – 8 Thermal Comfort, IEQ – 4 Ventilation Air Quality, and EEQ – 3 Optimize Energy Performance. Personal Control may present opportunities to lower energy use or possibly generate an increase in energy use. An integrated approach is required that includes enabling the occupant to perform their role in maintaining good indoor air quality by educating them to use their personal control options for their personal comfort.

Lighting

A quality lighting environment is the result of an integrated approach incorporating day-lighting and electrical lighting, ambient lighting appropriate to space use, task lighting per specific task needs, and other lighting quality parameters. Guideline IEQ – 12 Lighting Quality describes the whole building approach to design of a quality lighting environment. The strategy here is to embed Personal Control into that design.

People have differing preferences for illuminance, the nature of tasks they perform varies in the course of a work day, and the location in which they perform them may change. Personal Control of lighting can be as simple as an on/off control of a local task light that could be moved to suit the individual's need or an on/off control of a bank of lights in a team room to suit the current team task. Dimming control has been found to be particularly effective when applied to task lighting or overhead fixtures with direct and indirect lighting components. In teaming or multi-occupant workspaces, provision of local adjustment of lighting enables modifications to a number of desired lighting condition to be made.

Temperature & Ventilation

A quality thermal and ventilation environment is also the result of an integrated approach to building structure and building systems design. The strategy is again, to embed Personal Control into these components of building design.

'Ventilation' as applied here to Personal Control requires further explanation. Ventilation for acceptable indoor air quality per ASHRAE Standard 62 – 2001 is defined as "the process of supplying air to, or removing air from, a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space." As related to Personal Control, ventilation may indeed involve supplying or removing air from the local space, but the purpose is to allow the occupant to adjust comfort conditions to suit their personal or team needs. The amount of outdoor air introduced to control contaminant levels or humidity is a separate issue, however, temperature too, is a factor of comfort. In the case of naturally ventilated spaces through operable windows, ventilation and thermal comfort control are the same.

The primary factors affecting thermal comfort (ASHRAE Standard 55 – 2004) are:

- Metabolic rate: occupant activity level
- Clothing insulation: what the occupant is wearing
- Air temperature: temperature of the air around the occupant
- Radiant temperature: temperature of the surfaces around the occupant
- Air speed: regardless of direction the rate of air flow across the occupant
- Humidity: moisture content of the air around the occupant.

The first two of these are determined by the occupant and the schedule of activities. Personal Control typically enables the occupant to adjust the remaining four conditions over some limited, but effective range: air temperature, some component of radiant temperature, or the amount, speed, or direction of air flow in their local area.

Thermal comfort is a subjective feeling. People respond differently to thermal conditions, their activities may change throughout the work day, and clothing may be seasonal. Personal Control of one or more of the thermal factors affecting comfort enables the individual or team in a multi-occupant space to adapt their environment to better suit their individual preferences as they change over time. The regimen of Personal Control is an integral component of the comfort criteria (see IEQ – 8) for the related workspace and its design should reflect the overall intent used in developing the comfort criteria.

Mechanical Systems
Personal Control as implemented in mechanically conditioned and ventilated spaces may take a variety of forms. It may be local temperature control provided in an enclosed office, small laboratory, conference room, or classroom. Or, it could be local control of air flow, including, speed, amount, or direction of air flow delivered to an individual workstation from an under floor distribution system. Radiant panels also provide a means for local adjustment of the thermal environment that could be integrated into the overall thermal comfort design.

Operable Windows
Operable windows employed as a component for natural ventilation have a specific definition in ASHRAE 62 – 2001. The window opening is required to be a minimum of 4% of the net occupiable floor area of the naturally ventilated space, and that space must be permanently open to and within 25 feet of the window. It has been found that with operable windows, people feel comfortable over a broader range of temperatures that varies with the mean monthly outdoor air temperature (refer to ASHRAE Standard 55 – 2004).

Personal Control through the use of operable windows in a naturally ventilated space has a more limited range of applications in New York City than it might in San Francisco or Seattle. However, the seasonal variation in New York City presents those days when natural ventilation would be a delight. Knowing that, in the case of a noxious spill or other air quality accident, natural ventilation is at hand is a great personal reassurance and value.

Case Studies
West Bend Mutual Insurance, West Bend, WI
When the West Bend Mutual Insurance Company had their new headquarters designed and built in 1991, one major goal was to create a working environment that would provide superior comfort for employees while also being energy and cost efficient. In order to give occupants the ability to adjust their work area to suit their own varying thermal comfort needs the design team decided to use Environmentally Responsive Workstations (ERW's) produced by Johnson Controls Systems. Even in an open office plan, these desk-top integrated units allow individual employees to control the temperature and flow rate of their own personal desktop air register. To further enhance thermal comfort control, a radiant heating panel is located under the desk to warm the lower body. Employees can also control their own level of task lighting and use a white-noise generating device to block-out distractions. The effectiveness of this system was evaluated by an independent worker productivity study conducted by the Center for Architectural Research at Rensselaer Polytechnic Institute. The results of this research showed a 16% productivity increase in West

Bend's employees after they moved from their previous offices to the new building. By partially disabling the ERW's and noting a 13% decrease in productivity, it was determined that the enhanced personal control afforded to the workers was responsible for a 2.8% increase in their production. According to West Bend Mutual, that translated to an annual projected annual savings of $364,000 on a 13 million dollar payroll. (Kroner 1992)

Reference

Definitions

Individual Workspaces are those regularly occupied work areas that support a single worker such as an office cubicle in an open office plan, a single person office, or special work station supporting a single person such as a call center service provider, lab technician, or receptionist.

Team Workspaces or Multi-occupant Workspaces are those regularly used work areas that support a more than one worker such as a multi-occupant office, conference room, classroom, or open team area in which control of the local environment is a shared action that supports local team development.

Personal Control is the ability to manipulate environmental systems to adjust for local needs. It may be switched or variable control of quantity or direction of the controlled parameter e.g. on/off or dimming control of task lighting, adjustment of air temperature, local quantity delivered, or direction of air flow.

Naturally conditioned spaces, occupant controlled are those spaces where the thermal conditions of the space are regulated primarily by the opening and closing of windows by the occupants.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

Standards

IESNA 9th Edition Handbook, Chapter 10 Quality of the Visual Environment

ASHRAE Standard 62-2001 Ventilation for Acceptable Indoor Air Quality

ASHRAE Standard 55 2004 Thermal Environmental Conditions for Human Occupancy

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Personal Control

IEQ-10-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	○	○

☐ **Required Component:**
A narrative is attached describing the level of occupant control over their local workspace environment, including individual workspace and shared multi-occupant spaces such as conference rooms, classrooms, or open retail areas. Environmental parameters to be considered include lighting, and temperature and ventilation control via mechanical systems or, temperature and ventilation control via operable windows where operable windows may present a feasible alternative.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 6.1: Controllability of Systems – Perimeter Spaces.)*
This certifies that regularly occupied perimeter spaces of the building have at least one operable window as defined by ASHRAE 62-2001 and one lighting control zone for every 200 square feet (on average).

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 6.2: Controllability of Systems – Non-Perimeter Spaces.)*
This certifies that a minimum of 50% of building occupants in regularly occupied, non-perimeter areas have been provided with control over individual airflow, temperature, and lighting.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Acoustics IEQ-11

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Minimize vibration and noise levels in indoor spaces and at exterior environments to achieve appropriate physical comfort and sound isolation for tasks and speech intelligibility, while contributing to human well-being and productivity.

Action: Where practical, program locations of mechanical equipment and other sources of noise away from areas of building and exterior spaces designed for use by building tenants and the public. Design separations to minimize transfer of noise. Consider strategies to reduce the transmission of exterior ambient noise. Comply with the recommendations of ASHRAE Applications Chapter 47 Design Guidelines to reduce potential noise and vibration from mechanical equipment, and the Architectural Graphic Standards 8th Edition: Sound Isolation Criteria Table, page 44, to address acoustic criteria for enclosed office space such as offices, meeting rooms and other occupied areas.

Related Guidelines: SEQ-5

Introduction/Context

In 2003 alone, New York City received over 11,000 noise complaints. Many of these complaints were focused on street noise, including demolition and construction work, street reconstruction and resurfacing, vehicular traffic, car horns, etc. Other complaints relate to building mechanical systems, which are too loud or lack noise control features.

Many office and residential environments are noisy as a result of poor planning and design, intrusive noise from nearby mechanical equipment, lack of absorptive materials and insufficient speech privacy or sound isolation.

Aggravating noise levels, either because of excessive decibel levels or because of their repetitiveness or annoying character, are known to adversely affect human health and well-being. People require periods of calm and quiet each day in order to function at their optimum levels. It is well documented that prolonged exposure to noise over 85 dB causes permanent hearing disabilities, and can result in the development of serious medical conditions, including hypertension and heart disease. Intrusive noises, even at low decibel levels, can impair performance, interfere with concentration and reduce attentiveness, memory skills and the ability to focus.

In the city, with its many sound reflecting surfaces, large amount of vehicular traffic, on-going demolition, construction and road-building and all of the associated mechanical and transportation equipment, ambient street noise is frequently raised to uncomfortable and sometimes unhealthy levels. For this reason, indoor environment noise management is essential.

Building design needs to take into consideration potential noise pollution and build-in strategies to reduce, manage and prevent conditions that may lead to the excessive transfer of sound, both within and from outside the building.

Relevant Issues

Ecological
Excess or disruptive noise levels create health concerns for people. Prolonged noise exposure is known to contribute to stress-related ailments, while sudden, loud sounds can both frighten and distract people, reducing concentration and productivity and occasionally, causing accidents. Outdoors, excessive noise is disruptive to natural ecosystems, adversely affecting wildlife, such as songbirds.

Economic
Work environments with low levels of distraction encourage concentration and are central to the success of productive workplaces. Employees are distracted in quiet environments where occupant or exterior activity is intrusive, resulting in broken concentration and less productivity. Pleasant workplaces, which are designed with appropriate level of sound absorbing materials, suitable sound blocking construction techniques, and speech privacy systems (also referred to as 'sound masking or 'white noise') help to reduce the intrusiveness of non-associated activity noise and in turn, increase employee satisfaction. This has been related to a reduction in absenteeism and higher worker performance. Prospective tenants are likely to be positively influenced by a space that is isolated from exterior noise, and to rent spaces where ambient noise is not a distracting or potentially disruptive factor.

Neighborhood
From time to time, all city neighborhoods are subjected to an uncomfortable level of noise – during the demolition and/or construction of nearby buildings, road repair and from the frequent noise of loud vehicles. The objective is to minimize the resulting disturbances so that periods of disruption are brief, and the noise is muffled to some degree so it is not perceived as on-going. Impact noise levels from vertically stacked spaces can be minimized through the selection and incorporation of sound and impact isolating floor/ceiling constructions. Importance is also placed on providing residences where sleep disturbance from interior and exterior activity is minimized. Neighborhoods that offer peaceful, quiet environments are more attractive than consistently 'loud' areas, and tend to be more beneficial psychologically, physically, socially and environmentally to their constituents. Noise pollution discourages community interaction, ultimately driving people away from a neighborhood.

Office buildings that are well designed can minimize the noise and vibration associated with mechanical equipment and exterior activities. Indoor environments can support speech privacy, while reducing reverberation through the use of sound absorbing materials.

Methodology

Design Strategies - Room Acoustics
A room with good acoustics enhances speech intelligibility and minimizes the build up of noise. For good speech intelligibility a Rapid Assessment Speech Transmission Index (RASTI) of 0.60 or higher is recommended (0.60 to 0.75 - "GOOD"; 0.75 and above - "EXCELLENT").

To control the build up of noise for spaces that require good speech intelligibility, the following reverberation times are recommended:

Room Volume (cu.ft.)	Reverberation Time (sec.)
less than 2,000	0.5
2,000 to 4,000	0.6
4,000 to 8,000	0.7
8,000 to 16,000	0.8
16,000 to 32,000	0.9
32,000 and greater	1.0 *

* Auditoria for music performance should be designed for reverberation times that are consistent with the type of music intended. An acoustical expert should be consulted for this goal.

For atria, which are used as locations for lectures, functions or gatherings, the design should incorporate sufficient sound absorbing materials to achieve an average sound absorption coefficient of all surfaces of 0.18 or greater.

Design Strategies - Speech Privacy and Sound & Impact Isolation
Spaces designed with good speech privacy and appropriate sound isolation can provide freedom from distraction for workers, minimize the transmission of confidential speech, limit the transfer of sound across demising constructions and reduce the intrusiveness of exterior noise.

For spaces that are enclosed with solid partions, the sound isolating performance of the construction should be consistent with the program of the space. Select construction materials that have a sound isolation performance level consistent with the minimum levels noted in the Sound Isolation Criteria table in the latest edition of the Architectural Graphic Standards (page 61 of the 9th Ed.). This is important for spaces such as offices, meeting rooms, residences, mechanical rooms, and spaces with noise sensitive programs.

For vertically stacked residential and office spaces, the floor/ceiling construction should be selected to be consistent with local code requirements, and with a floor/ceiling assembly resistance to the transmission of impact noise of no less than an impact isolation class of fifty (IIC 50) for occupied spaces. Vertically stacked residences that are intended for above market rates shall have constructions with IIC ratings of 60 or higher.

For open plan office spaces, the design shall include elements that provide suitable levels of sound privacy for the workers. The tenant shall select performance goals according to the following levels of privacy:

Desired Privacy Level	Articulation Index
Confidential (audible but non intelligible)	0.05 or lower
Normal (audible and partially intelligible)	0.05 to 0.20
Transitional (audible and mostly intelligible)	0.20 to 0.40

Design Strategies - Background Noise and Exterior Noise Emissions
Mechanical system should be designed to minimize operational noise impacts to occupied spaces.

For intrusive exterior noise, select exterior wall construction to reduce intrusive exterior sounds to achieve average background noise levels for the type of use for the space, in accordance with the *HVAC-Related Background Sound In Rooms,* as described in the current version of the ASHRAE Applications Handbook (Table 34 in Chapter 47 of the 2003 edition).

Design the mechanical systems to achieve background noise levels for the type of use for the space according to the *HVAC-Related Background Sound In Rooms,* as described in the current version of the ASHRAE Applications Handbook (Table 34 in Chapter 47 of the 2003 edition).

For noise emissions from building systems to the community, all World Trade Center projects must comply with the New York City Noise Control Code.

New York City's Noise Control Code

Ambient noise quality zone	Day-time standards (7am - 10pm)	Night-time standards (10pm - 7am)
Noise quality zone N-1 (Low density residential RL; land-use zones R-1 to R-3	Leq=60 dB(A) measured for any one hour	Leq=50 dB(A) measured for any one hour
Noise quality zone N-2 (High density residential RH; land-use zones R-4 to R-10)	Leq=65 dB(A) measured for any one hour	Leq=55 dB(A) measured for any one hour
Noise quality zone N-3 (All Commercial and manufacturing land-use zones)	Leq=70 dB(A) measured for any one hour	Leq=70 dB(A) measured for any one hour

Means and Methods

1. Room Acoustics
Incorporate sound absorbing finishes to absorb excess sound energy and minimize the build up of noise.

For spaces where the presentation of speech is important, provide sound reflecting surfaces to enhance the propagation of sound from the podium/stage to the audience.

Where possible, provide sound absorbing materials on the ceilings of lobbies and corridors to minimize the build up and transmission of conversations and activity noise.

2. Speech Privacy and Sound & Impact Isolation

Plan the layout of spaces so that spaces with louder activities or programs are not adjacent to spaces that are sensitive to intrusive noise. Incorporate storage spaces, closets, or corridors between louder spaces and noise sensitive spaces.

Orient the building or locate noise sensitive interior spaces so that they have minimal exposure to intrusive exterior noise sources.

For enclosed spaces, select construction approaches that include specially designed acoustically damping partitions, double or staggered studs (without bracing, such as UL Design No. 493), multiple layers of drywall, resilient elements, and stud cavity insulation.

Seal the edges of construction materials, especially where they come in contact with structural elements, such as structural ceilings, floors, and columns, using non hardening sealants. Generally, these sealants consist of silicone, acrylic, or latex and should comply with the VOC requirements of LEED for sealants. This is particularly important where partitions meet the underside of composite metal decks.

Minimize penetrations that may weaken the sound isolating performance of the construction. Where penetrations are necessary, seal effectively with non-hardening caulk or a flexible fire-stopping product. Avoid back-to-back outlets in demising walls; where necessary seal the rear of the outlet box to be airtight.

For open office spaces, use sound absorbing ceilings with high performance (NRC 0.85 or higher), partial height barriers with sound absorbing surfaces, and speech privacy systems that provide a uniform coverage of background noise at 45 to 48 dBA.

For noise sensitive spaces that are exposed to intrusive exterior noise, specify insulating glazing with an interior pane of laminated glass or panes with two different thicknesses. For spaces that desire very low noise levels, or for conditions with excessive exterior noise exposure, incorporate an interior storm panel that captures an airspace of 2 inches or more from the primary insulating glazing unit.

Use carpeting, resilient floor underlayments, or resiliently suspended ceiling constructions to minimize the transfer of impact noise to sensitive spaces below.

3. Background Noise and Exterior Noise Emissions

Plan the placement of mechanical and electrical transformer equipment to be remote from noise sensitive spaces. Include buffer spaces, such as corridors or storage rooms to provide isolation.

Select quiet mechanical systems, such as underfloor plenum air distribution, and slightly oversized ductwork to minimize the generation of mechanical noise.

Use variable speed controllers to reduce the operating capacity of equipment when demand is low, as this will often also reduce noise levels from this equipment. This strategy also contributes to efficient use of energy.

Incorporate noise and vibration control specific for the equipment, such as sound attenuators, mufflers, or vibration isolators.

Design and layout ducted air distribution systems for low pressure air delivery. For noise sensitive spaces, design airflow velocities to be consistent with those listed in table 4 in Chapter 47 of the 2003 ASHRAE Applications Handbook.

4. General
To enhance indoor environmental quality, select noise control insulation materials that encapsulate any fibrous media with protective liner facings. The most effective materials are referred to as "hospital-grade". Minimize the use of internal duct lining by using appropriate and sensible applications of flexible ductwork. Where duct liner must be installed, i.e. in fan discharge and inlet plenums, limited sections of duct risers and mains, and in variable air volume boxes, use protective liner facings, with perforated double wall construction and mylar or equal facings inside the liner, in accordance with the requirements of the NYSGBTC. (External insulation and closed cell foams are not acceptable acoustical substitutes for internal glass fiber lining.)

Project teams are encouraged to consider use of acoustical products that contain recycled content (mineral fiber and glass fiber ceiling tiles, resilient underlayments, cellulose or cotton fiber insulation), are locally produced (sound attenuators, acoustical ceiling tiles, sound absorbing panels), consist of rapidly renewable materials (cork underlayments, cotton fiber batt insulation), or use certified wood (sound transparent wood slat ceilings).

Case Studies
ASID Sound Solutions - Integrating Office Productivity through Integrated Acoustic Planning and Noise Reduction Strategies, 1996
This report studied the productivity benefits of good acoustic planning and design for office workers in an open plan work environment. The research concluded that high performance sound absorbing ceilings, partial height sound absorbing barriers, and a uniform coverage of background noise can increase worker productivity and satisfaction.

Herman Miller MarketPlace, Zeeland, MI
The goal of the client was to create an office prototype to support progressive business practices within a sustainable environment. The intent was that this speculative office building would be an exemplar – an ideal place to work -- while also illustrating the benefits of sustainable design principles to other potential developers. Specific measures were taken to ensure that the building would be both a pleasant and productive workplace. One area of special concern was occupant acoustic comfort. Acoustically absorbent materials were specified to mitigate the reflection of internal sounds and keep noise from becoming disruptive. A fountain in the building's atrium was used to create 'natural' white-noise to help keep other sounds from becoming a distraction to building occupants.

Reference

Definitions

Impact Insulation Class (IIC) is the rating of impact isolation for a floor/ceiling construction. The IIC of floor/ceiling construction is a measure of the sound pressure level in the lower space as the result of a standardized tapping machine operating on the floor above. The values of this rating are measured in accordance with ASTM E492 and determined by ASTM E989. Higher IIC ratings indicate better performance. Most building codes require a minimum IIC rating of 50; IIC ratings of 60+ are recommended for more sensitive spaces, such as luxury residences..

IIC Strength: Helps to rate structure-borne noise such as footfall, a chair dragging on the floor, or other realistic sounds in a single number.

Noise is essentially sound that is unwanted, disturbing, or distracting.

Noise Reduction Coefficient (NRC) is the fraction of sound energy that a material absorbs. This value represents the average of the octave band frequencies between 250 Hz and 2,000 Hz. The values for this rating are measured according to ASTM C423. The range of possible NRC values is from 0.00 to 1.00. Most sound reflecting materials, such as drywall, wood, glass, and concrete, have NRC ratings of 0.05 to 0.10. High performance sound absorbing materials have NRC values of 0.70 or higher.

Sound Transmission Class (STC) is the rating of airborne sound transmission. The STC of floor/ceiling (or wall) structure is a weighted measure of the decibel difference between the airborne sound energy striking one side of the structure and the sound energy radiated into a receiving room on the other side. The weighting of this rating system assesses speech and television type sounds most appropriately. Sounds with significant low frequency (music with bass, mechanical noise, and transportation noise) are not as effectively rated using this system. ASTM E90 is the test standard used for measuring this rating. Higher STC ratings indicate high sound isolation. Most codes require STC 50 or greater constructions; very sensitive or very loud spaces may require constructions with STC ratings of 60+.

Speech Privacy Systems are electronic systems that provide a broadband background noise source with uniform coverage and an adjustable level of sound, which is tuned to coincide with, and cover, speech frequencies. The constant presence of this sound renders other random sounds less noticeable. It is also referred to as sound masking or white noise systems.

White-Noise is random noise consisting of equal energy per frequency band. It sounds similar to static on a radio or the airflow noise from a fan.

Standards

ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method (most recent revision in 2002)

ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements (most recent revision in 2004)

ASTM E492 - Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine (most recent revision in 2004)

ASTM E989 Standard Classification for Determination of Impact Insulation Class (IIC) (most recent revision in 1989)

ASTM E1374 - Standard Guide for Open Office Acoustics and Applicable ASTM Standards (most recent revision in 2002)

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Acoustics

IEQ-11-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	○	○

☐ **Required Component:**
Mechanical equipment and other sources of noise have been located away from areas of the building and exterior spaces designed for use by building tenants and the public. Separations between these spaces have been designed to minimize the transfer of noise.

☐ **Required Component:**
Strategies to reduce the transmission of exterior ambient noise into the building have been considered and employed.

☐ **Required Component:**
Compliance with the recommendations of ASHRAE Applications Chapter 46 Design Guidelines has been met to reduce vibration from mechanical equipment.

☐ **Required Component:**
Compliance with the recommendations of Architectural Graphic Standards 8th Edition: Sound Isolation Criteria Table, page 44 has been achieved to address acoustic criteria for enclosed office spaces, meeting rooms and other occupied areas.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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Lighting Quality IEQ-12

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Employ advanced lighting design to maximize comfort and productivity of building occupants and enhance the quality and efficiency of electric lighting. Fully coordinate ambient electrical lighting design with daylighting strategies.

Action: Design an ambient electrical lighting system that is coordinated with daylighting strategies to provide flexible illumination. Endeavor to meet the recommendations of the Illuminating Engineering Society of North America's (IESNA) 9th Edition Handbook, Chapter 10 Quality of the Visual Environment, and the Lighting Design Guide. Provide high frequency electronic ballasts, recyclable lamps and low mercury/low lead lamps as defined by the US Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP) testing procedure. Supplement ambient lighting system with multi-level task lighting to maintain a minimum of 35 foot-candles (in typical office area) at desk level throughout hours of occupancy.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-6, IEQ-2, IEQ-10

Introduction/Context

Much has been said and written about the importance of high quality, energy efficient lighting in the business environment; nonetheless, the subject remains curiously elusive. Lighting quality is not addressed in any of the LEED Green Building Rating Systems. Indoor lighting in US commercial buildings consumes more than 30% of building energy. Reducing this figure must be a central component of any high-performance building program. One of the keys to a successful sustainable design strategy lies in achieving significant reductions in lighting energy consumption, while also enhancing the quality of lighting in a wide variety of spaces within the building.

In a sustainable approach to design, significant attention is focused on human well-being considerations, which are known to contribute to increased job satisfaction and higher productivity. While there are several factors influencing these goals, including indoor air quality (IAQ) and thermal comfort, lighting quality, in this context, is a major consideration. Providing building occupants with individual and/or group lighting controls allows them to manage light levels for personal comfort. Tailoring lighting strategies to reflect the different requirements of a variety of spaces, will add to flexibility and result in a more responsive lighting strategy.

A well designed lighting strategy includes energy conservation, the integration of electrical lighting and daylighting strategies, maximum visual comfort, the design of flexible lighting plans for specific tasks and designing for computer environments, which requires careful control of glare. According to Judith Heerwagon,"Interior ambient quality can affect work performance. The key factors associated with differential performance are the thermal environment, especially temperature, humidity level, and ventilation, air quality, *and lighting.*"

Relevant Issues

Ecological

The circadian rhythm, or twenty four hour biological clock, establishes the daily cycles of most living creatures, including human beings and plants, and is influenced by the rising and setting of the sun. Scientists confirm that animals and plants become disoriented when subjected to constant and unchanging light levels over a period of twenty four hours. Dim lighting levels are perceived as being restful, while brighter levels enhance the ability to focus and become energized. Building lighting that is designed to be flexible, accommodating changing and different needs will increase human comfort and well-being, and has the potential to contribute to increased productivity.

Reducing lighting power densities and loads, without reducing the quality of the light, will reduce the pollution associated with electrical utilities which must generate power to run the lights and the air conditioning to remove heat generated by the lights.

Economic

A sustainable approach to lighting design can save as much as 50% to 60% in energy costs over a typical lighting installation. Using the latest methodologies for efficiency, while considering lighting quality and appropriateness of light levels, this number can still be achieved, even with the recently upgraded and more rigorous ASHRAE Standards. At 50% savings, this translates into a 15% reduction in total building energy costs, not an insignificant saving.

The latest generations of high performance lighting solutions, which integrate several technologies into a single system, are fairly expensive (adding to 'first cost'). However, according to BC Hydro in British Columbia, the installation of an 'intelligent system' capable of delivering superior lighting quality, which is both easy to control and easy to use, can pay back the incremental cost over a typical, good quality baseline system, in less than 1.8 years. The payback in New York City should be quicker, as utility rates are significantly higher in the North East of the U.S.

A task/ambient system is the most appropriate lighting strategy for office buildings. Pendant direct/indirect lighting fixtures, which may be used as part of such a system, as a preferred sustainable approach to achieve high lighting quality, have a cost premium over recessed fixtures. However, the productivity increase that results from a well-lit space with comfortable ambient lighting and minimized glare achievable with these fixtures quickly offsets the incremental first cost impact.

Consideration of avoided health impacts through the minimization of power plant generated air pollution is another economic factor. A reduction in the amount of CO and CO_2 gasses, as well as NOx, SO_2 and mercury vapor, a byproduct of power generation, means that there will be less air pollution overall, and less acid rain components and mercury to affect the water quality up-state and in New England, providing healthier conditions for people and cleaner habitat for wildlife, especially fish. Generation of less particulate matter means there will also be a reduction in

ground-level smog near the site, reducing the potential for asthma in sensitive people.

Neighborhood

Interior lighting quality primarily affects those who work within the building, and building occupants are found to be more satisfied with their work and learning environments when provided with a flexible, well balanced and glare-free lighting environment. An attractive, varied lighting scheme that reflects and reinforces day-light during the late afternoon and winter working hours adds a dimension of quality to the interior environment for workers and for visitors alike.

An integrated lighting approach which combines day-lighting with high-quality, responsive supplemental electric lighting reduces energy demand, and therefore reduces pollution from the generation of power for lighting energy. This contributes to cleaner air and benefits the neighborhood. A subtly-lit building that glows in the evening hours without causing light pollution is welcoming, and can be an attractive asset to the area.

Methodology

Design Strategies

There are some broad strategies that can guide the development and implementation of an advanced, energy efficient lighting installation, closely allied with superior lighting quality:

Integrate Electric Lighting Strategies with Daylighting:

Maximum use of daylight – a free resource -- reduces energy needs and provides a connection to the outdoors, which in turn contributes to human well-being and productivity gains. Daylighting here in the North East, can provide much of the lighting requirement in an office building with a relatively narrow footplate, except in the late afternoons and darkest days of winter. However, day-lighting needs to be integrated with supplemental lighting for the greatest gains. In such a strategy, a constant foot candle level can be pre-set and maintained at desktop, either via natural light or by supplemental light, which 'kicks in' to support the fading daylight.

This strategy is achieved through the use of photometric light sensors, or photo-cells, and can be fine tuned via the use of a computer model designed to optimize energy use in the building. Energy conservation can be further enhanced through the use of occupancy sensors.

Deep Daylighting

Deep daylighting strategies increase the penetration and distribution of daylight, which in turn reduces the need for supplemental lighting. Day-lit spaces or continuous access to daylight are considered to be assets and are pleasing to most people, thereby contributing to occupant satisfaction and increased productivity.

Place Light where it is Needed

A task/ambient lighting system with pendant light fixtures is an excellent approach to providing overall (ambient) light, with individual task lighting providing essential, focused light for specific activities.

Visual Comfort

Computers now dominate most office interiors, so integrated lighting schemes must be designed for visual comfort and to minimize glare by keeping potential reflected light from screens. This can be achieved in a number of ways, including the careful coordination of space plan layouts with the lighting plan layouts (integrated design) in the design phases.

Enhanced lighting quality, with flexible controls, multiple levels of light-output or luminance, and reduced glare improves the environmental quality of the work space. The building community enjoys well-lit spaces that achieve a balance between daylighting and artificial light. Levels of luminance are designed to support specific tasks and activities, not to flood all areas with equal levels of bright light. Larger spaces are enlivened by a thoughtful approach to lighting quality that is designed to eliminate a dark and gloomy atmosphere at the back wall, furthest from the windows. Minimizing glare removes the potential for eye-strain, while keying light levels to the softer, lower levels that the human eye is historically accustomed to accommodate, tends to create a more restful ambiance than the typical, over-lit office space.

Means and Methods

Integrated, high quality lighting is most effective when planned early in the design phases. The fenestration of the building, depth of window reveals, type of permanent shading devices and choice of glazing, all have an impact on lighting quality and control strategies. It is preferable to avoid the use of tinted or reflective glazing which reduces the amount of daylight able to enter the interior and conflicts with strategies to enhance the quality of the space and reduce energy consumption by optimizing daylighting.

Integrating Electric Lighting Strategies with Daylighting:

Daylight integrated task/ambient lighting systems with pendant light fixtures often link the first two or three rows of pendant fixtures closest to the window wall to a photo cell, which will dim lighting levels based on measured available daylight and a pre-set foot-candle level at the desktop. These systems contribute to energy conservation by responding to available daylight levels, minimizing the need for electric light on bright days and allowing the supplemental system to increase its out-put on dull days, or at any time when daylighting is insufficient to maintain the pre-set foot-candle level. Photo-sensors synchronize fluorescent lamp light out-put with available daylight, allowing lamps to dim or brighten in accordance with changing weather patterns and time of day or month. Task lights are occupant-controlled and need to have flexible levels of luminance in order to adequately accommodate different tasks and variations in occupant needs – for instance, given a choice, an older person will generally choose a brighter level of task lighting than a young person.

To optimize daylight dimming or photo-cell efficiency, lay out fixtures in rows that run parallel to window walls. Where rooms are large or run to a depth of 15'-0" or more, and which are designed to take advantage of as much daylighting as possible, balance the lighting levels by providing vertical illumination at walls furthest from windows or skylights. This strategy can be achieved via wall washers or pendant fixtures placed within two to three feet of the back wall.

A number of energy efficient, integrated lighting systems have been introduced in recent years to the marketplace. These are the new 'intelligent' systems that integrate an entire suite of technologies into a single system that is easy to manage, while providing great flexibility and control. One such system integrates network controls, occupancy sensors, daylight photo-cells, and personal dimming systems, and provides monthly reports detailing energy usage on a system-wide basis. These systems have been demonstrated to reduce lighting power density to 0.5 watts per square foot, and to achieve conservation of more than 80% over typical baseline models.

Deep Daylighting

Deep daylighting is enhanced by ceilings designed to slop upward from the window wall towards the building core or center, and by louvers or light shelves set inside window frames, which bounce the light onto the ceiling and deep into the space. Shading devices can be used to control low western sun in the afternoon, and help to manage thermal comfort, especially in buildings which do not have the advantage of smart glazing technologies.

Locations of interior office or room partitions and high workstation panels must also be considered. To the extent possible, both full height permanent and moveable partitions, including workstation partitions, should be run perpendicular to the window wall. This will allow for maximum interface and efficiency to occur between daylighting and electrical lighting controls. Use of glazed or translucent interior walls, high level clere-stories and low partitions all assist in maximizing the lighting quality of the interior space. Bright, light colors on walls help to optimize lighting quality, and white ceilings with high reflectance characteristics assist daylight penetration, contributing to the cheerfulness of the space in almost all cases. Medium to light architectural finishes, such as carpeting, and bright, light colored furniture and furnishings, such as workstation partitions and desktops, will further enhance this deep-daylighting strategy.

Place Light where it is Needed

Pendant ambient lighting systems require ceiling heights of 8'-6" minimum, and higher if possible. They eliminate the 'glaring headlights' syndrome, where flush, recessed fixtures appear uncomfortably bright against a shadowed background, even with a white ceiling. Ideally, for good light distribution, pendant fixtures with an up-lighting component should hang no less that 1'-6" from the ceiling. The up-light component will provide a sense of a bright, overhead canopy, allowing the down-light component(s) to provide low-level ambient lighting, sufficient to move comfortably around the space and undertake non-critical visual tasks. Ambient illumination levels should be lower than task lighting levels by approximately one third, in order to accommodate the human eye and prevent eyestrain.

Visual Comfort

Consider the Visual Comfort Probability (VCP) in the design approach. To minimize glare, ambient lighting should have a VCP of 80% for computer heavy spaces and 70% for other areas. The VCP addresses recessed ceiling fixtures and the direct portion of pendant fixtures only, and is defined as 'the percentage of people who find the lighting free from discomfort glare.' This is a little difficult to calculate in the abstract – on large projects, the design team might consider building a full-scale lighting mock-up to ensure that the proposed lighting plan achieves the desired high VCP score.

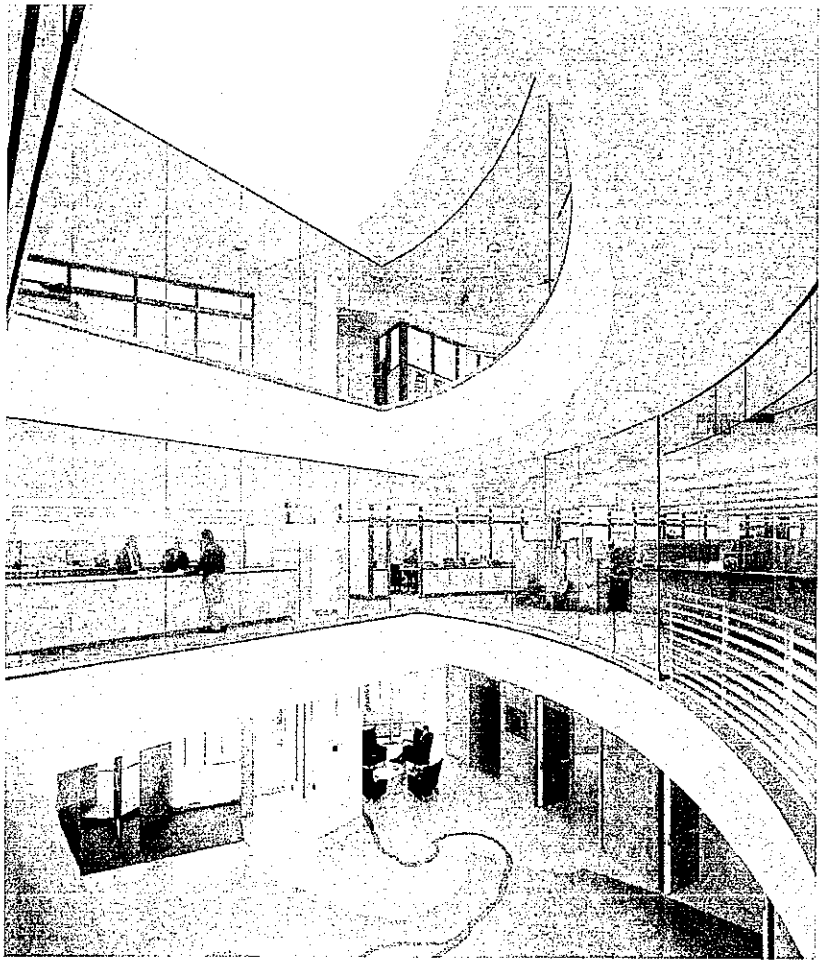
Glare on computer screens can be controlled by an all-up-light (indirect) pendant installation. This creates a rather bright ambient atmosphere, and can cause bright ceiling and fixture reflections to appear in the screens, so computer locations must be flexible to optimize the system. This becomes increasingly easier with the new, compact, flat computer screens, which do not have to be installed in corner locations. Both indirect and direct/indirect pendant fixture, ambient lighting schemes are preferred over recessed or flush-mounted fixtures or downlights. Ceiling luminance designed to enhance conditions for computer tasks in both of these options is recommended to have a ratio across the ceiling of 4 to 1. The luminance levels at ceiling and wall surfaces should not exceed 850 candelas per square meter at any angle, averaged over a 2 by 2 square foot area.

In computer heavy facilities, ambient light levels should be maintained at less than 30 foot-candles, which is comfortable for the work area. Low ambient light levels need to be supplemented by flexible task lighting at each occupant desk or work station, with variable light level settings, up to a maximum high of 50 foot-candles. (See the IES RP-1 Guidelines).

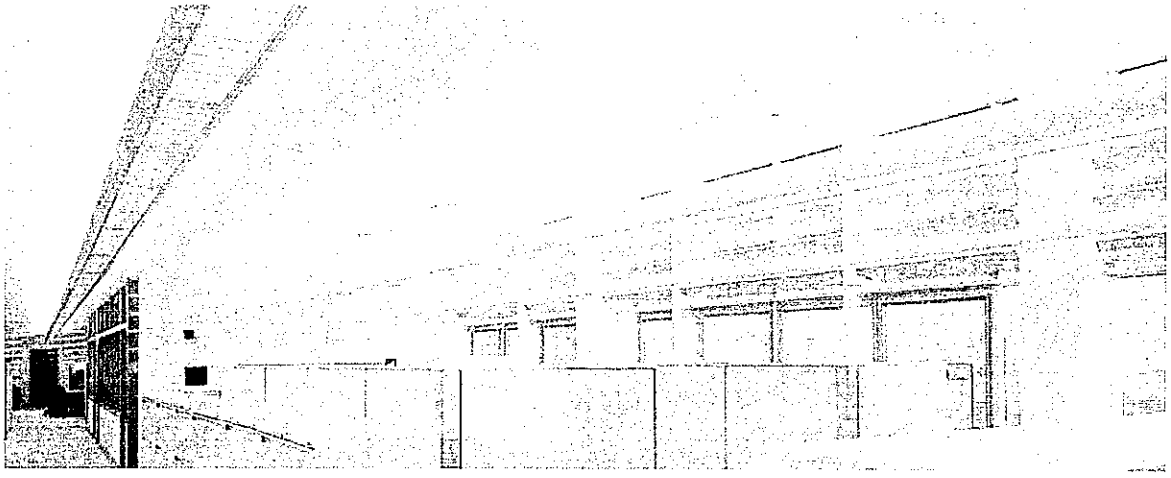
Case Studies

The Chattanooga Development Resource Center, Chattanooga, Tennessee
This building consolidates the majority of city/county governmental agencies and divisions related to the built environment for the City of Chattanooga and Hamilton County. The building embodies many important principles of sustainability and environmental quality in a highly productive 'transparent' and flexible workplace for the officials and planners charged with bringing Chattanooga into the 21st century. High quality lighting is achieved throughout the building via the integration of day-lighting and supplemental electric lighting. Sloped ceilings and perimeter louvers bounce light from exterior openings into occupied spaces, while photo-sensors optimize energy conservation through the continuous coordinated dimming of electric light. Customized day-lighting from high impact/direct beam traversing light in circulation areas to low impact/diffuse light in office areas.

In post-occupancy interviews employees have expressed personal satisfaction with the quality of lighting and the integrated electric lighting and day-lighting strategies in the building, which they feel, contribute to an enhanced daily work experience.



Chattanooga Development Resource Center – Main Lobby with Skylight: Photograph by Timothy Hursley



Chattanooga Development Resource Center – West Sunset Effect. Photograph by Timothy Hursley

Reference

Definitions

Circadian Rhythm Biological cycle lasting approximately 24 hours: In human beings, the circadian rhythm is controlled by a biological clock, called the suprachiasmic nucleus, found in the hypothalamus Its perturbation can bring about illnesses and sleep disorders. The circadian rhythms are astonishing in that, although they last about 25 hours, they are capable of constantly synchronizing to the 24-hour day-night alternation.

Standards

Standards have not been included for this Guideline.

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Lighting Quality

IEQ-12-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: _____

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	Ⓔ	○	○

☐ **Required Component:**
The ambient electrical lighting system for the project has been designed to coordinate with daylighting strategies.

☐ **Required Component:**
Effort has been made toward meeting the recommendations of the Illuminating Engineering Society of North America's (IESNA) 9th Edition Handbook, Chapter 10 Quality of the Visual Environment, and the Lighting Design Guide. A brief description of strategies employed to provide a high quality lighting environment is attached.

☐ **Required Component:**
High frequency electronic ballasts and recyclable lamps have been provided. Lamps are low mercury/low lead as determined by the US Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP) testing process.

☐ **Required Component:**
The ambient lighting system has been supplemented with multi-level task lighting to maintain a minimum of 35 footcandles (in typical office area) at desk level throughout hours of occupancy.

Name _____ Signature _____

Company _____ Role in Project _____

Date _____

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