Sustainable Sites

SS | WE | EA | MR | EQ | ID

Overview

Development and construction processes are often destructive to local ecology. These activities also encroach on productive agricultural land areas and open space. Stormwater runoff from developed areas can impact water quality in receiving waters, hinder navigation and recreation, and disrupt aquatic life. Fortunately, steps can be taken to reduce impacts on previously undeveloped lands and to improve previously contaminated sites.

Selection of an appropriate project location can reduce the need for private automobile use and reduce urban sprawl. Locating developments on existing brownfield sites, in existing urban infill areas and on other non-greenfield locations may have economic benefits. For example, the infrastructure to service the development may already be in place.

When considering site alternatives, it is important to consider environmental criteria throughout the site selection process.

The major ecological features of the site should be identified, including the site geology, hydrology, vegetation, wildlife and prior site history. Communication with project stakeholders, including building occupants, the general public and site neighbors can be facilitated through public meetings, design charrettes and organized comment processes.

It is also important to minimize project impacts on surrounding areas after construction is complete and the building is occupied. By addressing heat island effects and reducing light pollution on the site, the site can become integrated into its surroundings and serve as a considerate and beneficial neighbor for the lifetime of the building.

Overview of LEED™ Prerequisites and Credits

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

SS Credit 8
Light Pollution Reduction

There are 14 points available in the Sustainable Sites category.

Erosion & Sedimentation Control

SS	WE	EA	MR	EQ	ID
Prerequisite 1					

Required

Intent

Control erosion to reduce negative impacts on water and air quality.

Requirements

Design a sediment and erosion control plan, specific to the site, that conforms to United States Environmental Protection Agency (EPA) Document No. EPA 832/R-92-005 (September 1992), Storm Water Management for Construction Activities, Chapter 3, OR local erosion and sedimentation control standards and codes, whichever is more stringent. The plan shall meet the following objectives:

- Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- Prevent sedimentation of storm sewer or receiving streams.
- Prevent polluting the air with dust and particulate matter.

Submittals

❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring whether the project follows local erosion and sedimentation control standards or the referenced EPA standard. Provide a brief list of the measures implemented. If local standards and codes are followed, describe how they meet or exceed the referenced EPA standard.

Summary of Referenced Standard

Storm Water Management for Construction Activities (USEPA Document No. EPA 832R92005), **Chapter 3**

U.S. Environmental Protection Agency Office of Water, www.epa.gov/OW

Internet download link for Chapter 3 (72 pages): www.epa.gov/npdes/pubs/chap03_conguide.pdf. Download site for all sections: http://yosemite.epa.gov/water/owrccatalog.nsf, search by title index.

Hardcopy or microfiche (entire document, 292 pages): National Technical Information Service (order # PB92-235951), www.ntis.gov, (800) 553-6847

This standard describes two types of measures that can be used to control sedimentation and erosion. Stabilization measures include temporary seeding, permanent seeding and mulching. All of these measures are intended to stabilize the soil to prevent erosion. Structural control measures are implemented to retain sediment after erosion has occurred. Structural control measures include earth dikes, silt fencing, sediment traps and sediment basins. The application of these measures depends on the conditions at the specific site. If local provisions are substantially similar, they can be substituted for this standard if it is demonstrated that local provisions meet or exceed the EPA best management practices.

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Credit Synergies

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

WE Credit 1
Water Efficient Landscaping

Green Building Concerns

Site clearing and earth moving during construction often results in significant erosion problems because adequate environmental protection strategies are not employed. Erosion results from precipitation and wind processes, leading to degradation of property and sedimentation of local water bodies. This affects water quality as well as navigation, fishing and recreation activities. Fortunately, measures can be implemented to minimize site erosion during construction and to avoid erosion once the buildings are occupied.

Environmental Issues

Contaminated water that flows into receiving waters disrupts stream and estuary habitats. Contributors to erosion problems include destruction of vegetation that previously slowed runoff and reconfiguration of natural site grading. Controlling stormwater runoff reduces erosion and contamination of receiving waters.

Economic Issues

Erosion and sedimentation control does not necessarily add cost to a project. Reduction of sedimentation and erosion through landscaping and other measures can in fact reduce the size, complexity and cost of stormwater management measures. While there are additional costs associated with identifying soil conditions at the site, the knowledge gained can help avoid problems over the building lifetime. For instance, soil erosion issues associated with unstable foundations and potential loss of structural integrity can be avoided if soil conditions are documented in advance and used in the building design.

Landscaping activities to prevent soil erosion include augmentation of poor soil and inclusion of specialized plantings in the landscape design to retain soil in place. Excessive landscaping may require maintenance over time, resulting in additional operation costs. Use of native plants reduces both watering and maintenance requirements.

Community Issues

Communities benefit from reduced erosion and sedimentation control through improved water quality in local streams, rivers and lakes. These water bodies are valuable to communities for sustenance, navigation and recreation.

Design Approach

Strategies

As a general approach to achieve this credit: (1) identify the soil composition on the project site, (2) uncover potential site problems, and (3) develop mitigation strategies. Protect erosion-prone areas from construction activities, and implement a soil stabilization plan in susceptible areas. The plan should include stringent erosion control requirements in construction drawings and specifications to control erosion and sedimentation during construction activities. In addition to construction controls, design the project site to minimize erosion and sedimentation processes over the lifetime of the building.

Erosion and sedimentation control measures should be addressed in an Erosion Control Plan. This plan often covers stormwater management in addition to erosion control because these concepts are intimately linked. The document should include the following information:

1. Statement of erosion control and stormwater control objectives

2. Comparison of post-development stormwater runoff conditions with predevelopment conditions

3. Description of all temporary and permanent erosion control and stormwater control measures implemented on the project site

4. Description of the type and frequency of maintenance activities required for the chosen erosion control methods

Consider augmenting the project design team with an expert in sustainable landscape architecture and land planning. The expert should be familiar with local and state legal requirements for erosion control, as well as strategies and technologies to minimize erosion and sedimentation.

Technologies

Table 1 describes technologies for controlling erosion and sedimentation as recommended by the referenced standard.

Synergies and Trade-Offs

Measures for erosion and sedimentation control are dependent on site location and site design. These measures are often integrated with stormwater management plans because stormwater is a large contributor to erosion problems. Landscaping strategies have a significant effect on erosion. The most suitable areas on a site for a building in terms of passive solar gains or environmental quality benefits may be inappropriate due to problematic soil conditions. Conversely, landscaping that is planted for soil erosion mitigation might affect passive solar gains or wind currents used for natural ventilation.

Definitions

Erosion is a combination of processes in which materials of the earth's surface are loosened, dissolved or worn away, and transported from one place to another by natural agents.

Sedimentation is the addition of soils to water bodies by natural and human-related activities. Sedimentation decreases water quality and accelerates the aging process of lakes, rivers and streams.

Table 1: Technologies for Controlling Erosion & Sedimentation

Control Technology	Description
Stabilization	
Temporary Seeding	Plant fast-growing grasses to temporarily stabilize soils.
Permanent Seeding	Plant grass, trees, and shrubs to permanently stabilize soil.
Mulching	Place hay, grass, woodchips, straw, or gravel on the soil surface to cover and hold soils.
Structural Control	
Earth Dike	Construct a mound of stabilized soil to divert surface runoff volumes from disturbed areas or into sediment basins or sediment traps.
Silt Fence	Construct posts with a filter fabric media to remove sediment from stormwater volumes flowing through the fence.
Sediment Trap	Excavate a pond area or construct earthen embankments to allow for settling of sediment from stormwater volumes.
Sediment Basin	Construct a pond with a controlled water release structure to allow for settling of sediment from stormwater volumes.

Case Study

Donald Bren School of Environmental Science and Management
Santa Barbara, California

The University of California at Santa Barbara's Donald Bren School of Environmental Science and Management is a LEED™ Version 1.0 Platinum Pilot Project. The Bren School houses campus facilities including research and teaching laboratories, and offices. An erosion control plan was instituted for the project to prevent contaminated runoff from leaving the site boundary. Construction stormwater controls included temporary silt fencing and straw-bale catch basins. Project specifications and plans included requirements to preserve topsoil and limit site disturbance. During construction, grading activities were scheduled in accordance with weather conditions. Construction materials stored on-site were protected from the elements to prevent contamination of stormwater volumes, and construction workers were informed of the stormwater control program. During building occupancy, stormwater system inspections are scheduled to occur annually, before and after storm events, and weekly to ensure proper operation of stormwater controls.

Courtesy of Zimmer Gunsul Frasca Partnership

Owner
University of California at Santa Barbara

Site Selection

SS | WE | EA | MR | EQ | ID

Credit 1

1 point

Intent

Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

Requirements

Do not develop buildings, roads or parking areas on portions of sites that meet any one of the following criteria:

- Prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5).
- Land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by the Federal Emergency Management Agency (FEMA).
- Land which is specifically identified as habitat for any species on Federal or State threatened or endangered lists.
- Within 100 feet of any water including wetlands as defined by United States Code of Federal Regulations 40 CFR, Parts 230-233 and Part 22, and isolated wetlands or areas of special concern identified by state or local rule, OR greater than distances given in state or local regulations as defined by local or state rule or law, whichever is more stringent.
- Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt).

Submittals

❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring that the project site meets the credit requirements.

Summary of Referenced Standards

U.S. Department of Agriculture Definition of Prime Agricultural Land as stated in United States Code of Federal Regulations Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5) www.access.gpo.gov/nara/ (go to "browse your choice of CFR titles and/or volumes")

This standard states: "Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. In general, prime farmlands have an adequate and dependable water supply from precipitation

or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. Examples of soils that qualify as prime farmland are Palouse silt loam, 0 to 7 percent slopes; Brookston silty clay loam, drained; and Tama silty clay loam, 0 to 5 percent slopes."

Federal Emergency Management Agency (FEMA) 100-Year Flood Definition

Federal Emergency Management Agency, www.fema.gov, (202) 646-4600

This referenced standard addresses flood elevations. FEMA defines a 100-Year Flood as the flood elevation that has a 1% chance of being reached or exceeded each year. It is *not* the most significant flood in a 100-year period. Instead, 100-year floods can occur many times within a 100-year period. See the FEMA Web site for comprehensive information on floods and other natural disasters such as wildfires and hurricanes.

Endangered Species Lists

U.S. Fish and Wildlife Service's List of Threatened and Endangered Species, endangered.fws.gov

This referenced standard addresses threatened and endangered wildlife and plants. The Service also maintains a list of plants and animals native to the United States that are candidates for possible addition to the federal list.

National Marine Fisheries Service's List of Endangered Marine Species, www.nmfs.noaa.gov/endangered.htm

Consult state agencies for state-specific lists of endangered or threatened wildlife and plant species.

Definition of Wetlands in the United States Code of Federal Regulations, 40 CFR, Parts 230-233, and Part 22

www.access.gpo.gov/nara/cfr/index.html, (888) 293-6498

This referenced standard addresses wetlands and discharges of dredged or filled material into waters regulated by states. The definition of wetland areas pertaining to this credit, found in Part 230, is as follows:

"Wetlands consist of areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Green Building Concerns

As non-urban development increases, the importance of prudent site selection increases as well. Prevention of habitat encroachment is an essential element of sustainable site selection. The best strategy for selecting a building site is to choose a previously developed site. Since these sites have already been disturbed, damage to the environment is limited and sensitive land areas can be preserved.

The site surrounding a building defines the character of the building and provides the first impression for occupants and visitors to the building. Creative and careful site designs can integrate the natural surroundings with the building(s), providing a strong connection between the built and natural environments and minimizing adverse impacts on the non-built portions of the site.

Environmental Issues

Habitat preservation is the most effective means to meet the requirements of the Endangered Species Act and to minimize developmental impacts on indigenous wildlife. Not building on inappropriate sites preserves these areas for wildlife, recreation and ecological balance. Building on inappropriate sites such as floodplains can be detrimental to ecosystems.

Economic Issues

Site selection can play an important role in the way in which the public responds to, and is involved with, the proposed development. Channeling development away from sensitive ecological areas in favor of previously disturbed sites can encourage public support for a project and speed public review periods, thus minimizing or preventing obstacles traditionally encountered during project scoping. Economically, this can also save on mitigation costs that a developer would incur if the proposed development were approved within a sensitive area.

Appropriate site selection can reduce the risk of property damage due to natural events such as landslides, floods, sinkholes and soil erosion. Higher first costs may be encountered due to site survey and selection activities. Increased property values can offset these costs in the future.

Proper site selection can also avoid potential loss of property due to potential litigation resulting from harm to endangered species.

Community Issues

Prudent site selection can enhance property values within the community when development is integrated into the surrounding ecosystem. For example, by clustering buildings in a neighborhood, green space can be set aside for parks and community gathering spaces. Thoughtful site selection and planning can also allow the developer to integrate unique neighborhood characteristics during project design.

Design Approach

Strategies

Avoid developing sites that exhibit any of the characteristics listed in the restricted criteria. Consider the proposed use of the building, and set a preference for previously developed sites that complement the use, thereby reducing associated parking needs and vehicular miles traveled. The site selection process might include landscape architects, ecologists, environmental engineers and civil engineers, as well as local professionals who can provide site-specific expertise.

Have a government official, ecologist or other qualified professional perform a site survey to inventory the important environmental characteristics, including wetlands, sloped areas, unique habitat areas and forested areas. Zoning requirements of the local municipality and the community master plan should be integrated to the

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

SS Credit 8
Light Pollution Reduction

MR Credit 1
Building Reuse

EQ Credit 8
Daylight & Views

greatest extent possible. Community coordination and consideration of public comments can help pre-empt negative community reaction. Where feasible, integrate neighboring activities to create a development with shared amenities and spaces.

When designing the building, consider a smaller footprint, and set aside large contiguous areas for natural space on the project site. Build in dense blocks to limit the development footprint and site disturbance to the smallest area possible. Incorporate site features into the design such as natural features that already exist on the site, natural shelter from trees or terrain, natural areas for outdoor activities, and water features for thermal, acoustic and aesthetic benefit.

Synergies and Trade-Offs

Site selection is the basis of site design and affects all aspects of the site, including transportation amenities, natural areas, stormwater management, amount of impervious surfaces, and site lighting requirements. Water supply and management issues, especially landscape irrigation and stormwater reuse, are dependent on project location. Opportunities to increase the building's energy performance can be realized by locating the project in areas where natural ventilation and solar gains can be managed and based on the angles and location of the sun. The local climate and marketplace should influence choices of materials. Natural ventilation and daylight can benefit indoor environmental quality.

Resources

Web Sites

ESRI

www.esri.com/hazards/makemap.html

This software company creates tools for GIS mapping. Its Web site includes an option to make a map of all of the flood areas within a user-defined location.

Natural Resources Defense Council

www.nrdc.org, (212) 727-2700

NRDC uses law, science, and a large membership base for protection of wildlife and wild places to ensure a safe and healthy environment.

Print Media

Constructed Wetlands in the Sustainable Landscape by Craig Campbell and Michael Ogden, John Wiley & Sons, 1999.

Holding Our Ground: Protecting America's Farms and Farmland by Tom Daniels and Deborah Bowers, Island Press, 1997.

Saved By Development: Preserving Environmental Areas, Farmland by Rick Pruetz, Arje Press, 1997.

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping by Ralph W. Tiner, Lewis Publishers, 1999.

Definitions

A **Community** is an interacting population of individuals living in a specific area.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

An **Ecosystem** is a basic unit of nature that includes a community of organisms and their nonliving environment linked by biological, chemical, and physical process.

An **Endangered Species** is an animal or plant species that is in danger of becoming extinct throughout all or a significant portion of its range due to harmful human activities or environmental factors.

A **Threatened Species** is an animal or plant species that is likely to become endangered within the foreseeable future.

Wetland Vegetation consists of plants that require saturated soils to survive as well as certain tree and other plant species that can tolerate prolonged wet soil conditions.

Development Density

SS	WE	EA	MR	EQ	ID
Credit 2					

1 point

Intent

Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

Requirements

Increase localized density to conform to existing or desired density goals by utilizing sites that are located within an existing minimum development density of 60,000 square feet per acre (two story downtown development).

Submittals

- ❑ Provide the LEED Letter Template, signed by the civil engineer, architect or other responsible party, declaring that the project has achieved the required development densities. Provide density for the project and for the surrounding area.
- ❑ Provide an area plan with the project location highlighted.

Summary of Referenced Standard

There is no standard referenced for this credit.

SS | WE | EA | MR | EQ | ID

Credit 2

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

MR Prerequisite 1
Storage & Collection of Recyclables

MR Credit 1
Building Reuse

MR Credit 2
Construction Waste Management

MR Credit 3
Resource Reuse

EQ Prerequisite 1
Minimum IAQ Performance

EQ Credit 2
Increase Ventilation Effectiveness

EQ Credit 8
Daylight & Views

Green Building Concerns

The development of open space away from urban cores and other existing development may reduce a property's first cost, but this development paradigm has far-reaching negative consequences for the environment and the community. Building occupants become increasingly dependent on private automobiles for commuting. As travel distances increase, this results in more air and water pollution. Prime agricultural land is lost and previously developed urban sites fall into disuse and decay. Utility, transportation and community support infrastructure must also be developed to support the people who utilize new buildings. These infrastructure requirements increase the development's impact far beyond the initial project scope. In contrast, urban redevelopment is an effective strategy to curb suburban sprawl, tap into existing infrastructure and conserve rapidly disappearing greenfield space.

Environmental Issues

By maintaining density in cities, agricultural land and greenfield areas are preserved for future generations. Mass transportation in urban areas can be an attractive alternative mode of transportation, reducing impacts associated with automobile use. Building in urban areas reduces the number of vehicle miles traveled and, thus, reduces pollution caused by automobiles. The use of existing utility lines, roadways, parking, landscaping components and other services eliminates the environmental impacts of constructing these features for non-urban developments.

Economic Issues

A significant economic benefit of infill development is the reduction or elimination of new infrastructure, including roads, utility services and other amenities already in place. If mass transit serves the urban site, significant cost reductions are possible by downsizing the project parking capacity. Urban infill development sometimes requires significant additional costs when compared with suburban development due to site constraints, contaminated soils and other issues. Municipal and county incentives for urban infill projects may also be available.

Community Issues

Urban sprawl affects quality of life because commuters must spend increasing amounts of time in their automobiles. In addition, families often need more vehicles to accommodate family needs, resulting in a higher cost of living and less free time. The redevelopment of urban areas helps restore, invigorate and sustain established urban living patterns, creating a more stable and interactive community.

Design Approach

Strategies

The general approach for achieving this credit is to give preference to sites within an existing urban fabric. Work with local jurisdictions and follow the urban development plan to meet or exceed density goals. Consider synergies with neighbors and choose sites based on infrastructure, transportation and quality-of-life considerations. Sites with redevelopment plans that will achieve the required development density by the completion of the project should not be excluded from consideration. This credit can be achieved by choosing to develop a site where a community revitalization is occurring provided the required development density is achieved by the project's completion.

Synergies and Trade-Offs

Urban redevelopment affects all areas of site design including site selection, especially transportation planning, the overall building footprint and stormwater

management. Urban sites often involve the rehabilitation of an existing building, with a reduction of construction waste and new material use. However, these sites may also have limited space available for construction waste management activities and occupant recycling programs. Urban sites may have negative IEQ aspects such as contaminated soils, undesirable air quality or limited daylighting applications.

Calculations

The following calculation methodology is used to support the credit submittals listed on the first page of this credit. To determine the development density of a project, both the project density and the densities of surrounding developments must be calculated. The extent of neighboring areas to include in density calculations varies depending upon the size of the project. Larger projects are required to consider a greater number of neighboring properties than smaller projects. The density calculation process is described in the following steps:

1. Determine the total area of the project site and the total square footage of the building. For projects that are part of a larger property (such as a campus), define the project area as that which is defined in the project's scope. The project area must be defined consistently throughout LEED documentation.

2. Calculate the development density for the project by dividing the total square footage of the building by the total site area in acres. This development density must be equal to or greater than 60,000 square feet per acre (see **Equation 1**).

3. Convert the total site area from acres to square feet and calculate the square root of this number. Then multiply the square root by three to determine the appropriate density radius. (Note: the square root function is used to normalize the calculation by removing effects of site shape.) (see **Equation 2**).

4. Overlay the density radius on a map that includes the project site and surrounding areas, originating from the center of the site. This is the density boundary. Include a scale on the map.

5. For each property within the density boundary and for those properties that intersect the density boundary, create a table with the building square footage and site area of each property. Include all properties in the density calculations except for undeveloped public areas such as parks and water bodies. Do not include public roads and right-of-way areas. Information on neighboring properties can be obtained from your city or county zoning department.

6. Add all the square footage values and site areas. Divide the total square footage by the total site area to obtain the average property density within the density boundary. The average property density of the properties within the density boundary must be equal to or greater than 60,000 square feet per acre.

The following example illustrates the property density calculations: A 30,000-square-foot building is located on a 0.44-

Equation 1:

$$\text{Development Density}\left[\frac{\text{SF}}{\text{acre}}\right] = \frac{\text{Building Square Footage [SF]}}{\text{Property Area [acres]}}$$

Equation 2:

$$\text{Density Radius [LF]} = 3 \times \sqrt{\text{Property Area [acres]} \times 43{,}560\left[\frac{\text{SF}}{\text{acre}}\right]}$$

acre urban site and the calculations are used to determine the building density. The building density is above the minimum density of 60,000 square feet per acre required by the credit (see **Table 1**).

Next, the density radius is calculated. A density radius of 415 feet is calculated (see **Table 2**).

The density radius is applied to an area plan of the project site and surrounding area. The plan identifies all properties that are within or are intersected by the density radius. The plan includes a scale and a north indicator.

Table 3 below summarizes the information about the properties identified on the map. The building space and site area are listed for each property. These values are summed and the average density is calculated by dividing the total building space by the total site area.

For this example, the average building density of the surrounding area is greater than 60,000 square feet per acre, and, thus, the example qualifies for one point under this credit.

Resources

Web Sites

International Union for the Scientific Study of Population

www.iussp.org

IUSSP promotes scientific studies of demography and population-related issues.

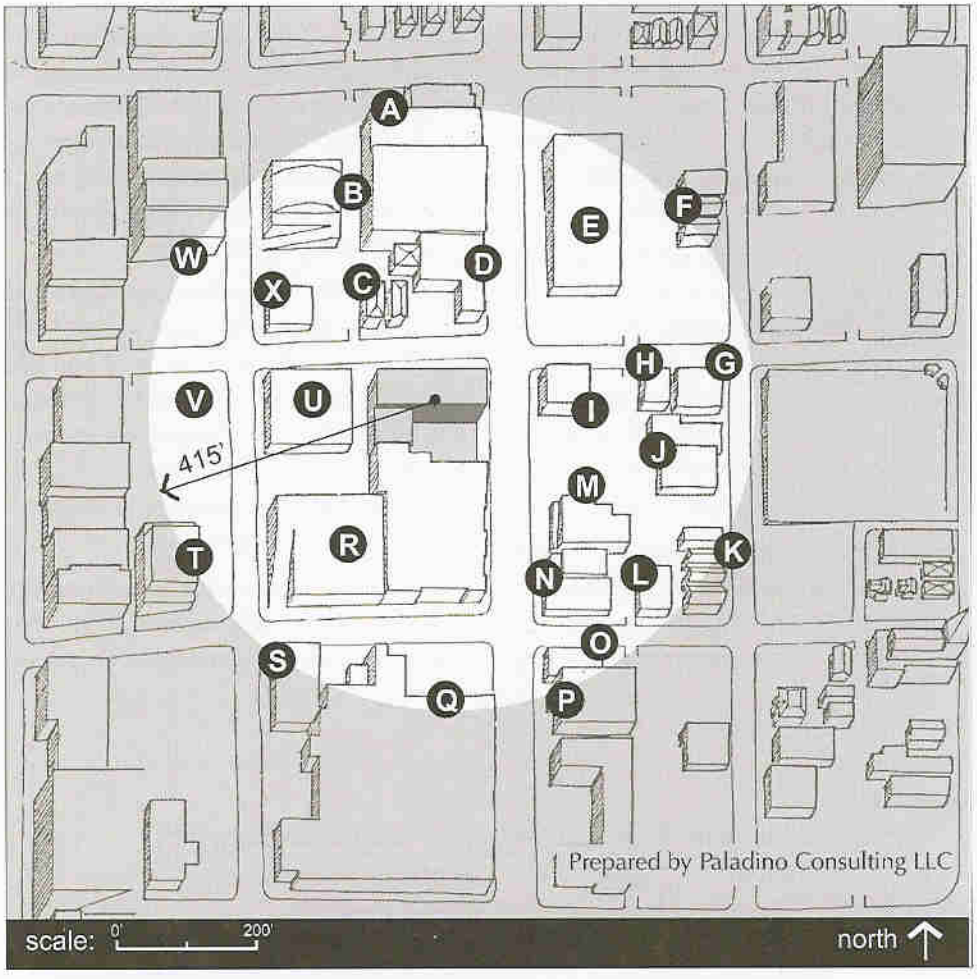


Figure 1: An Illustration of a Sample Area Plan

Table 1: Property Density Calculations

Project Buildings	Building Space [SF]	Site Area [acres]
Project	30,000	0.44
Density [SF/acre]		**68,182**

Table 2: Density Radius Calculation

Density Radius Calculation	
Site Area [acres]	0.44
Density Radius [LF]	415

Urban Land Institute

www.uli.org, (800) 321-5011

The Urban Land Institute is a nonprofit education and research institute that is supported by its members. Its mission is to provide responsible leadership in the use of land in order to enhance the total environment.

Print Media

Changing Places: Rebuilding Community in the Age of Sprawl by Richard Moe and Carter Wilkie, Henry Holt & Company, 1999.

Density by Design: New Directions in Residential Development, Steven Fader, Urban Land Institute, 2000.

Green Development: Integrating Ecology and Real Estate, by Alex Wilson et al., John Wiley & Sons, 1998.

Once There Were Greenfields: How Urban Sprawl Is Undermining America's Environment, Economy, and Social Fabric by F. Kaid Benfield et al., Natural Resources Defense Council, 1999.

Suburban Nation: The Rise of Sprawl and the Decline of the American Dream by Andres Duany et al., North Point Press, 2000.

Table 3: Sample Area Properties

Buildings within Density Radius	Building Space [SF]	Site Area [acres]	Buildings within Density Radius	Building Space [SF]	Site Area [acres]
A	33,425	0.39	N	28,740	0.30
B	87,500	1.58	O	6,690	0.15
C	6,350	0.26	P	39,000	0.39
D	27,560	0.32	Q	348,820	2.54
E	66,440	1.17	R	91,250	1.85
F	14,420	1.36	S	22,425	0.27
G	12,560	0.20	T	33,650	0.51
H	6,240	0.14	U	42,400	0.52
I	14,330	0.22	V	-	0.76
J	29,570	0.41	W	19,200	0.64
K	17,890	0.31	X	6,125	0.26
L	9,700	0.31	Y	5,000	0.30
M	24,080	0.64	Z	4,300	0.24
			Total Building Space [SF]	997,665	
			Total Site Area [acres]		16.04
			AVERAGE DENSITY [SF/acres]		**62,199**

SS | WE | EA | MR | EQ | ID

Credit 2

Definitions

A **Greenfield** is undeveloped land or land that has not been impacted by human activity.

Property Area is the legal property boundary of a project and includes all areas of the site including constructed areas and non-constructed areas.

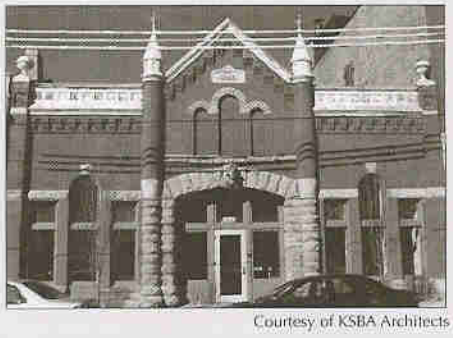
Site Area is defined the same as property area.

The **Square Footage** of a building is the total area in square feet of all rooms including corridors, elevators, stairwells and shaft spaces.

Case Study

KSBA Architects Office Building
Pittsburgh, Pennsylvania

The KSBA Architects office building is a LEED™ Certified Pilot Project located in the Lawrenceville section of Pittsburgh. The building is a rehabilitation project of a building originally constructed in 1888 and is part of a decade-long neighborhood revitalization program involving several local jurisdictions and community planning agencies. The two-story building is located in a neighborhood that includes a variety of businesses and industries, all within close proximity to downtown Pittsburgh. The location benefits the building occupants by providing a neighborhood that is conducive to walking, eating, entertainment, transportation and living.



Courtesy of KSBA Architects

Owner
KSBA Architects

Brownfield Redevelopment

SS	WE	EA	MR	EQ	ID
Credit 3					

1 point

Intent

Rehabilitate damaged sites where development is complicated by real or perceived environmental contamination, reducing pressure on undeveloped land.

Requirements

Develop on a site documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment) OR on a site classified as a brownfield by a local, state or federal government agency. Effectively remediate site contamination.

Submittals

- ❑ Provide a copy of the pertinent sections of the ASTM E1903-97 Phase II Environmental Site Assessment documenting the site contamination OR provide a letter from a local, state or federal regulatory agency confirming that the site is classified as a brownfield by that agency.
- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring the type of damage that existed on the site and describing the remediation performed.

Summary of Referenced Standards

ASTM E1903-97 Phase II Environmental Site Assessment

ASTM International, www.astm.org

This guide covers a framework for employing good commercial and customary practices in conducting a Phase II environmental site assessment of a parcel of commercial property. It covers the potential presence of a range of contaminants that are within the scope of CERCLA, as well as petroleum products.

EPA Brownfields Definition

EPA Sustainable Redevelopment of Brownfields Program, www.epa.gov/brownfields

With certain legal exclusions and additions, the term "brownfield site" means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant (source: Public Law 107-118, H.R. 2869 – "Small Business Liability Relief and Brownfields Revitalization Act"). See the Web site for additional information and resources.

SS | WE | EA | MR | EQ | ID

Credit 3

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

MR Credit 1
Building Reuse

MR Credit 2
Construction Waste Management

MR Credit 3
Resource Reuse

EQ Prerequisite 1
Minimum IAQ Performance

Green Building Concerns

Many potential building sites in urban locations have been abandoned due to real or perceived contamination from previous industrial or municipal activities. These sites can be remediated and redeveloped for reuse. Environmental and economic concerns are key issues when evaluating brownfield redevelopment. Costs incurred to remediate site contamination and land prices can be additive or can offset each other. Perception of the building site by the building owner and future building occupants must also be weighed. Building owners may be wary of cleanup requirements and the potential for liability associated with contaminants migrating off-site and impacting downstream neighbors. Building occupants may worry about health risks from breathing contaminated air or coming into contact with contaminated soil. These concerns must be investigated and resolved before making the final decision to redevelop a brownfield site.

Environmental Issues

Remediation efforts remove hazardous materials from brownfield sites' soil and groundwater. This reduces the exposure of humans and wildlife to health risks as a result of environmental pollution. Redevelopment of brownfield sites provides an alternate option to developing on greenfield sites. Preservation of greenfield sites for future generations decreases the overall environmental impact of development. Brownfields often have existing infrastructure improvements in place including utilities and roads, reducing the need for further environmental impacts due to construction of new infrastructure. In some instances, rather than remediate the contamination, it may be more sensible to leave contaminants in place, choosing instead to stabilize and isolate the contaminants from human exposure.

Economic Issues

Brownfields can offer an attractive location and are often inexpensive when compared to comparable uncontaminated properties. It is essential to weigh the value of the remediated property against cleanup costs to determine if the site is economically viable for redevelopment. Developers have been reluctant to redevelop brownfield sites in the past due to potential liability associated with taking responsibility for the cleanup of others' contamination. In recent years, the EPA and many state and local government agencies have begun to provide incentives for brownfield redevelopment by enacting laws that reduce the liability of developers who choose to remediate contaminated sites. Before embarking on a brownfield development effort, it is important to contact state and local regulators to determine the rules governing these sites and available financial assistance programs. It may also be helpful to contact the regional EPA's Office of Solid Waste and Emergency Response (OSWER), which may provide site characterization and remediation support.

Community Issues

Reclaiming contaminated sites can contribute to social and economic revitalization within neighborhoods by taking a local liability and turning it into an asset. Cleaning up contaminated properties can instill a new sense of pride in local residents, and it can also provide the incentive to improve nearby properties.

Design Approach

Strategies

Gain community support by highlighting the environmental, economic and community-related benefits of brownfield redevelopment. Negotiate with local municipalities and landowners for below-

market purchase prices for brownfield real estate. Also, obtain tax incentives by meeting the locally applicable requirements of EPA brownfield tax credits. The advantages and disadvantages of brownfield redevelopment must be carefully considered during the site selection process.

Utilize remediation experts to develop a master plan for site remediation. Prioritize site remediation activities based on available funds and specific site considerations, and establish time frames for completing remediation activities. Test for toxicity and hazardous levels of pollution on the proposed site. To earn this credit, a site with existing hazardous substances present or potentially present must be selected, and remediation efforts must be performed to identify, contain and mitigate the hazard.

Clean the site using established technologies that have minimal disruption on the natural site features, both above ground and underground. Consider in-situ remediation schemes that treat contaminants in place instead of off-site. Once remediation is complete, continue to monitor the site for the identified contaminants to ensure that contamination problems do not return.

Technologies

Remediation efforts on brownfield sites are sometimes costly and time-intensive due to the potentially extensive effort required to characterize the contamination, evaluate cleanup options and perform cleanup activities. However, substantially lower property costs can offset remediation costs and time delays. The cost of remediation strategies varies by site and region. Several remediation strategies should be considered in order to identify the strategy with the greatest benefit and lowest cost to the property owner.

The appropriate technology for a specific site depends on the contaminants present, hydrogeologic conditions and other factors. Traditional remediation efforts for contaminated groundwater are termed "pump-and-treat." Pump-and-treat technologies involve pumping contaminated groundwater to the surface and treating the water using physical or chemical processes. Contaminated soils can be remediated in a variety of ways. Advanced technologies such as bioreactors and in-situ applications are sometimes more cost-effective than hauling large quantities of contaminated soil to an approved disposal facility. Innovative remediation efforts such as solar detoxification technologies are currently being developed and are expected to reduce remediation costs in the future. It is important to consider the environmental implications of all remediation strategies being investigated for your project to ensure the solution does not cause problems elsewhere.

Synergies and Trade-Offs

Brownfield redevelopment has an impact on all aspects of the site design and often works in concert with urban redevelopment efforts. Existing infrastructure can lower development costs and take advantage of connections with neighboring sites. Some brownfield sites include existing buildings that can be rehabilitated. However, it is always prudent to investigate potential contamination problems and their effect on indoor air quality and occupant health before selecting a remediation strategy.

Resources

Web Sites

Brownfields Non-Profits Network

www.brownfieldsnet.org,
(717) 230-9700

A collection of nonprofit organizations that provide information on brownfield redevelopment.

Brownfields Technology Support Center

www.brownfieldstsc.org

A public cooperative effort that provides technical support to federal, state and local officials on items related to site investigation and cleanup.

EPA Sustainable Redevelopment of Brownfields Program

www.epa.gov/brownfields

A comprehensive site on brownfields that includes projects, initiatives, tools, tax incentives and other resources to address brownfield remediation and redevelopment. For information by phone, contact your regional EPA office.

Print Media

ASTM Standard Practice E1739-95: Risk-Based Corrective Action Applied at Petroleum Release Sites, American Society for Testing & Materials, (610) 832-9585, www.astm.org

This document is a guide for risk-based corrective action (RBCA), a decision-making process that is specific to cleaning up petroleum releases at contaminated sites. It presents a tiered approach to site assessment and remedial actions. It also includes a comprehensive appendix with risk calculations and sample applications.

EPA OSWER Directive 9610.17: Use of Risk-Based Decision-Making in UST Correction Action Programs, U.S. Environmental Protection Agency, Office of Underground Storage Tanks, www.epa.gov/swerust1/directiv/od961017.htm, (703) 603-7149

This document addresses the application of risk-based decision-making techniques to properties where leaking underground storage tanks (USTs) have created risks to human health and the environment. Guidelines are included to assist in making decisions in a manner consistent with federal law, specifically CERCLA and RCRA programs. Risk-based decision-making is a method that utilizes risk and exposure assessment methodology to determine the extent and urgency of cleanup actions. The goal is to protect human health and the environment. This standard includes several examples of state programs that use risk-based decision-making in leaking UST legislation.

Definitions

Bioremediation involves the use of microorganisms and vegetation to remove contaminants from water and soils. Bioremediation is generally a form of in-situ remediation, and can be a viable alternative to landfilling or incineration.

CERCLA refers to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. CERCLA addresses abandoned or historical waste sites and contamination. It was enacted in 1980 to create a tax on the chemical and petroleum industries and provided federal authority to respond to releases of hazardous substances.

Ex-Situ Remediation involves the removal of contaminated soil and groundwater. Treatment of the contaminated media occurs in another location, typically a treatment facility. A traditional method of ex-situ remediation is pump-and-treat technology that uses carbon filters and incineration. More advanced methods of ex-situ remediation include chemical treatment or biological reactors.

In-Situ Remediation involves treatment of contaminants in place using technologies such as injection wells or reactive trenches. These methods utilize the natural hydraulic gradient of groundwater and usually require only minimal disturbance of the site.

RCRA refers to the Resource Conservation and Recovery Act. RCRA focuses on active and future facilities. It was enacted in 1976 to give the EPA authority

to control hazardous wastes from cradle to grave, including generation, transportation, treatment, storage and disposal. Some non-hazardous wastes are also covered under RCRA.

Remediation is the process of cleaning up a contaminated site by physical, chemical or biological means. Remediation processes are typically applied to contaminated soil and groundwater.

Risk Assessment is a methodology used to analyze for potential health effects caused by contaminants in the environment. Information from the risk assessment is used to determine cleanup levels.

A **Site Assessment** is an evaluation of above-ground (including facilities) and subsurface characteristics, including the geology and hydrology of the site, to determine if a release has occurred, as well as the extent and concentration of the release. Information generated during a site assessment is used to support remedial action decisions.

SS | WE | EA | MR | EQ | ID

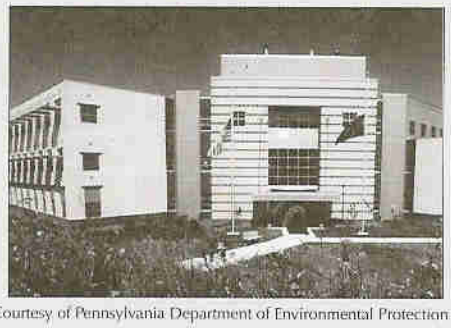
Credit 3

Case Study

Pennsylvania Department of Environmental Protection's South Central Regional Office Building

Harrisburg, Pennsylvania

The Pennsylvania Department of Environmental Protection's South Central Regional Office Building is a LEED™ Bronze Pilot Project that uses environmentally friendly technologies to significantly reduce energy consumption while creating a productive office atmosphere. The building is located on a site formerly used for various industrial and municipal activities. In the 1950s, the 13.5-acre site was quarried for shale. The site was converted into a municipal waste disposal facility in the 1960s and 1970s before being abandoned until the late 1990s. The Pennsylvania Department of Environmental Protection chose to redevelop the site to take advantage of the urban location and the depressed property cost. Remediation efforts included capping the entire site and installing methane and leachate collection systems to manage contaminant volumes leaving the site.



Courtesy of Pennsylvania Department of Environmental Protection

Owner
909 Partners

Alternative Transportation

SS | WE | EA | MR | EQ | ID

Credit 4.1

Public Transportation Access

1 point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Locate project within 1/2 mile of a commuter rail, light rail or subway station or 1/4 mile of two or more public or campus bus lines usable by building occupants.

Submittals

- ❑ Provide the LEED Letter Template, signed by an appropriate party, declaring that the project building(s) are located within required proximity to mass transit.

- ❑ Provide an area drawing or transit map highlighting the building location and the fixed rail stations and bus lines, and indicate the distances between them. Include a scale bar for distance measurement.

Alternative Transportation

Bicycle Storage and Changing Rooms

1 point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

For commercial or institutional buildings, provide secure bicycle storage with convenient changing/shower facilities (within 200 yards of the building) for 5% or more of regular building occupants. For residential buildings, provide covered storage facilities for securing bicycles for 15% or more of building occupants in lieu of changing/shower facilities.

Submittals

- ❑ For commercial projects: provide the LEED Letter Template, signed by the Architect or responsible party, declaring the distance to bicycle storage and showers from the building entrance and demonstrating that these facilities can accommodate at least 5% of building occupants.

OR

- ❑ For residential projects: provide the LEED Letter Template, signed by the architect or responsible party, declaring the design occupancy for the buildings, number of covered bicycle storage facilities for securing bicycles, and demonstrating that these facilities can accommodate at least 15% of building occupants.

Alternative Transportation

SS | WE | EA | MR | EQ | ID

Credit 4.3

Alternative Fuel Vehicles

1 point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Provide alternative fuel vehicles for 3% of building occupants AND provide preferred parking for these vehicles, OR install alternative-fuel refueling stations for 3% of the total vehicle parking capacity of the site. Liquid or gaseous fueling facilities must be separately ventilated or located outdoors.

Submittals

- ❑ Provide the LEED Letter Template and proof of ownership of, or 2 year lease agreement for, alternative fuel vehicles and calculations indicating that alternative fuel vehicles will serve 3% of building occupants. Provide site drawings or parking plan highlighting preferred parking for alternative fuel vehicles.

OR

- ❑ Provide the LEED Letter Template with specifications and site drawings highlighting alternative-fuel refueling stations. Provide calculations demonstrating that these facilities accommodate 3% or more of the total vehicle parking capacity.

SS | WE | EA | MR | EQ | ID

Credit 4.4

Alternative Transportation

1 point

Parking Capacity

Intent

Reduce pollution and land development impacts from single occupancy vehicle use.

Requirements

Size parking capacity to meet, but not exceed, minimum local zoning requirements AND provide preferred parking for carpools or vanpools capable of serving 5% of the building occupants; OR add no new parking for rehabilitation projects AND provide preferred parking for carpools or vanpools capable of serving 5% of the building occupants.

Submittals

- ❑ For new projects: provide the LEED Letter Template, signed by the civil engineer or responsible party, stating any relevant minimum zoning requirements and declaring that parking capacity is sized to meet, but not exceed them. State the number of preferred parking spaces for carpools.

OR

- ❑ For rehabilitation projects: provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring that no new parking capacity has been added.State the number of preferred parking spaces for carpools.

Summary of Referenced Standard

There is no standard referenced for this credit.

Green Building Concerns

As of the late 1990s, an estimated 200 million of the 520 million cars worldwide were located in the United States. The infrastructure (roadways and parking lots) used by automobiles dissects open expanses that wildlife relies on for migration and foraging. This impervious infrastructure also contributes to the erosion and pollution of receiving waters. The exhaust from automobiles pollutes the air and contributes to acid rain. Environmental impacts occur during extracting, refining and transporting crude oil for gasoline production. Reducing private automobile use saves energy and reduces associated environmental problems.

Fortunately, alternatives to conventional transportation methods exist. A surprisingly large number of people are willing to use alternative means of transportation such as bicycles, mass transit and carpools if they are convenient and facilities are provided to encourage their use. Alternative fuel vehicles lessen environmental impacts associated with automobiles. These vehicles use non-gasoline-based fuels such as electricity, natural gas and hydrogen-powered fuel cells. As a result, they require special refueling facilities to be viable alternatives to conventional vehicles.

Parking facilities for automobiles also have negative impacts on the environment because asphalt surfaces increase stormwater runoff and contribute to urban heat island effects. By restricting the size of parking lots and promoting carpooling activities, building occupants can benefit from increased green space.

Environmental Issues

Reduction of private automobile use reduces fuel consumption and the associated release of air and water pollutants in vehicle exhaust. Alternative fuel vehicles offer the possibility of reducing air pollutants from conventional gasoline-powered vehicles as well as reducing the environmental effects of producing gasoline. It is important to remember that vehicles using fuels such as natural gas and electricity still cause pollution at the tailpipe or power plant and are not otherwise environmentally benign. The use of electric vehicles eliminates tailpipe exhaust and centralizes the source of emissions at power plants, where emissions can be better controlled. According to the U.S. DOE, compressed natural gas vehicle emissions are 80% less than those from gasoline-powered vehicles.

Parking lots produce stormwater runoff and contribute to the urban heat island effect. They also diminish green space on the project site. Minimizing parking lot size reduces the development footprint and sets aside more space for natural areas or greater development densities.

Economic Issues

Reducing the size of parking areas based on anticipated use of bicycles, carpools and public transit by building occupants may lower initial project costs. If local utilities charge for stormwater runoff based on impervious surface area, minimization of these areas can result in lower stormwater charges.

The initial cost to design and construct a project in proximity to mass transit varies widely. During the site selection process, project owners should compare the cost of building sites in different areas to determine if a reduction in automobile use is possible and economical. Many occupants view proximity to mass transit as a benefit and this can influence the value and marketability of the building. Parking infrastructure and transportation requirements, disturbance of existing habitats, resource consumption, and future fuel costs should also be assessed.

SS | WE | EA | MR | EQ | ID

Credit 4

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

SS Credit 8
Light Pollution Reduction

WE Credit 2
Innovative Wastewater Treatment

EA Prerequisite 1
Fundamental Building Systems Commissioning

EA Credit 1
Optimize Energy Performance

EA Credit 3
Additional Commissioning

EA Credit 5
Measurement & Verification

MR Credit 1
Building Reuse

EQ Prerequisite 1
Minimum IAQ Performance

The initial project cost increase for bike storage areas and changing facilities is nominal relative to the overall project cost. Initial costs for alternative vehicles are higher than for conventional vehicles and this may delay their purchase, decreasing the necessity for refueling stations. Different alternative fuel vehicles need different refueling stations, and the costs associated with these stations vary.

Community Issues

Building occupants can realize health benefits through bicycle and walking commuting strategies. Bicycling and walking also expose people to the community, encouraging interaction among neighbors and allowing for enjoyment of the area in ways unavailable to automobile passengers.

Electric vehicle engines do not contribute to noise pollution relative to internal combustion engines. Alternative fuel vehicles have low, or no, tailpipe emissions. Aside from health benefits, lower emissions can help cities meet federal regulations and qualify for transportation funding.

Design Approach

Strategies

Survey potential building occupants and determine if the available mass transportation options meet their needs. Use existing transportation networks to minimize the need for new transportation lines. Provide attractive, functional and direct sidewalks, paths and walkways to existing mass transit stops. Provide incentives such as transit passes to encourage occupants to use mass transit. Encourage employees to work from home if practical and design the building to account for the needs of telecommuting.

Design and construct safe bicycle pathways and secure bicycle storage areas for cyclists. Provide shower and changing areas for cyclists that are easily accessible from bicycle storage areas. For multifamily residential buildings, provide safe, easily accessible and adequately sized bicycle racks. Encourage carpooling through initiatives such as preferred parking areas for high-occupancy vehicles (HOV) and the elimination of parking subsidies for non-carpool vehicles. Explore the possibility of sharing facilities with other groups for parking, shuttles and bike paths. Install an adequate number of easy-to-use refueling stations for alternative fuel vehicles. For residential buildings, consider establishing carsharing programs.

Technologies

A variety of bicycle rack and locker products are currently available. The appropriate type and number of bicycle facilities depends on the number of bicyclists and the climate of the region.

The U.S. DOE defines alternative fuels as those that are substantially non-petroleum and yield energy security and environmental benefits. DOE recognizes the following as alternative fuels: methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70% of the alcohol fuel), natural gas (compressed or liquefied), liquefied petroleum gas, hydrogen, fuels derived from biological materials, and electricity (including solar energy). Efficient gas-electric hybrid vehicles are included in this group for LEED purposes.

Electric vehicles (EVs) require a receptacle specifically designed for this purpose, usually 240 volts. EVs with conventional lead-acid batteries require recharging after 50 miles. Refueling stations for natural gas vehicles have compressors and dispensers that deliver compressed natural gas (CNG) at about 3,000 psi.

Synergies and Trade-Offs

Transportation planning is affected by site selection and has a significant impact on site design. A building site near transit lines may have negative characteristics, such as site contamination, poor air quality, unsafe conditions or problematic drainage. Real estate costs may also be higher in areas close to transit lines.

Provisions for carpooling and the use of bicycles as a viable transportation mode for building occupants reduce the need for more parking spaces, thus reducing the need for impervious surfaces and potential water runoff problems. A reduction in hard surface parking areas could also increase the amount of open space on the site while reducing heat island effects and stormwater runoff volumes.

Shower and changing facilities can add to the building's footprint or decrease other usable building space. These facilities also increase water and material usage. While alternative fuel vehicles have lower impacts on the environment than conventional vehicles, they require energy and materials to produce, as well as land area for storage and mobility. Alternative fuel refueling stations require energy for operation as well as commissioning and measurement and verification attention.

Space allocation and installation of refueling stations may not be cost-effective without enough vehicles that require refueling at such stations. Building space may come at a premium, especially in projects rehabilitating existing buildings. Investigate the possibility of sharing facilities with other partners and businesses.

Calculations

The following calculation methodology is used to support the credit submittals.

Mass Transit

Use an area drawing to indicate mass transit stops within 1/2 mile of the project. Remember that the project is required to be within 1/2 mile of a commuter rail, light rail or subway station or within 1/4 mile of two or more bus lines. **Figure 1** shows two bus lines within 1/4 mile of the project location. The map includes a scale bar and a north indicator.

If private shuttle buses will be used to meet the requirements, they must connect to public transit and operate at least during the most frequent commuting hours.

Bicycle-Securing Apparatus and Changing/Showering Facilities

To determine the number of secure bicycle spaces and changing/showering facilities required for the building, follow the calculation methodology as follows:

1. Identify the total number of full-time and part-time building occupants.

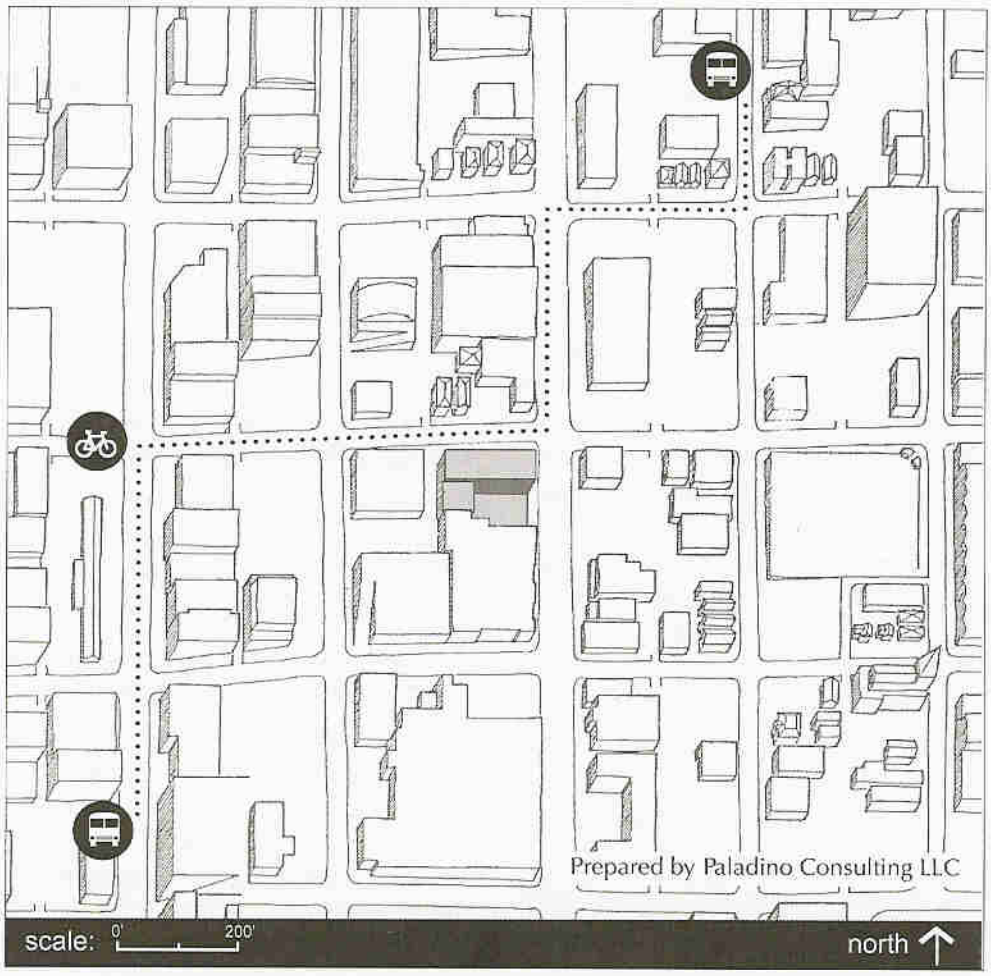
2. Calculate the Full-Time Equivalent (FTE) building occupants based on a standard eight-hour workday. A full-time worker has an FTE value of 1.0 while a half-time worker has a FTE value of 0.5 (see **Equation 1**).

3. Total the FTE values for each shift to obtain the total number of FTE building occupants. In buildings that house companies utilizing multiple shifts, select the shift with the greatest number of FTE building occupants.

4. The minimum number of **secure bicycle spaces** required is equal to 5% of the FTE building occupants during the maximum shift (see **Equation 2**). Secure bicycle spaces include bicycle racks, lockers and storage rooms. These spaces must be easily accessible by building occupants during all periods of the year, and free of charge.

5. The required number of **changing** and **showering facilities** for non-residential buildings is based on the number of bicycling occupants. A minimum of one shower for every eight bicycling occupants

Figure 1: Sample Area Drawing



is required to earn this point. (This number is based on recommended showering facilities for institutional spaces). Showering facilities can be unit showers or group showering facilities (see **Equation 3**). This calculation is not necessary for residential buildings.

For example, a building houses a company with two shifts. The first shift includes 240 full-time workers and 90 half-time workers. The second shift includes 110 full-time workers and 60 part-time workers. Calculations to determine the total FTE building occupants for each shift are included in **Table 1**.

The first shift is used for determining the number of bicycling occupants because it has the greatest FTE building occupant total. Based on a total of 285 FTE building occupants, the estimated number of bicycling occupants is 15. Thus, 15 secure bicycle spaces are required for this example. The required number of changing and showering facilities is one facility for every eight bicycling occupants. Thus, total number of required showering facilities in this example is two. More showers may be necessary for the building based on the number of actual bicycling occupants.

Equation 1:

$$\text{FTE} = \frac{\text{Worker Hours [hours]}}{8\ \text{[hours]}}$$

Table 1: Sample FTE Calculation

Shift	Full-Time Occupants		Part-Time Occupants		Full-Time Equivalent (FTE) Occupants
	Occupants	[hr]	Occupants	[hr]	Occupants
First Shift	240	8	90	4	285
Second Shift	110	8	60	4	140

Alternative Fuel Refueling Stations

To calculate the number of vehicles required to be serviced by alternative fuel refueling stations, multiply the total number of vehicle parking spaces by 3% (see **Equation 4**).

In the example above, the building has a parking area with 250 parking spaces. Therefore, alternative fuel refueling stations are required to service 3% of the 250 parking spaces, or eight vehicles. The required number of refueling stations depends on the number of vehicles (eight, in this case) and the service limits of the station (the time necessary for each complete refueling multiplied by the number of AFVs defined by **Equation 4**) in combination with the station's operating hours (i.e., if all vehicles are refueled within a short timeframe, or an eight-hour day, or nonstop).

Carpool Spaces

To calculate the number of carpool spaces required, multiply the number of FTE building occupants during the maximum shift (see the bicycle calculations above) by 5% and divide by two occupants per vehicle (see **Equation 5**). In the example above, a total of 285 FTE building occupants requires a minimum of eight carpool spaces.

Resources

Web Sites

Advanced Transportation Technology Institute

www.etvi.org, (423) 622-3884

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Equation 2:

$$\text{Secure Bicycle Spaces (non-residential buildings)} = \text{FTE Building Occupants} \times 5\%$$

$$\text{Secure Bicycle Spaces (residential buildings)} = \text{FTE Building Occupants} \times 15\%$$

Equation 3:

$$\text{Showering Facilities (non-residential buildings)} = \frac{\text{Bicyling Spaces}}{8}$$

Equation 4:

$$\text{Minimum Vehicle Refueling Capacity} = \text{Total Parking Spaces} \times 3\%$$

Equation 5:

$$\text{Required Number of Carpool Spaces} = \frac{\text{FTE Building Occupants} \times 5\%}{2}$$

Alternative Fuels Data Center

www.afdc.doe.gov, (800) 423-1363

A section of the DOE Office of Transportation Technologies that has information on alternative fuels and alternative fuel vehicles, a locator for alternative refueling stations, and other related information.

Electric Auto Association

www.eaaev.org

A nonprofit education organization that promotes the advancement and widespread adoption of electric vehicles.

Electric Vehicle Association of the Americas

www.evaa.org, (202) 508-5924

An industry association that promotes electric vehicles through policy, information and market development initiatives.

EV World

www.evworld.com

A Web site with current events, product reviews and other information related to electric vehicles.

Natural Gas Vehicle Association

www.ngvc.org, (202) 824-7360

An organization consisting of natural gas companies, vehicle and equipment manufacturers, service providers, environmental groups, and government organizations to promote the use of natural gas for transportation.

Print Media

Alternative Fuels: Technology & Developments, Society of Automotive Engineers, 1997.

Definitions

Alternative Fuel Vehicles are vehicles that use low-polluting, non-gasoline fuels such as electricity, hydrogen, propane or compressed natural gas, liquid natural gas, methanol, and ethanol. Efficient gas-electric hybrid vehicles are included in this group for LEED purposes.

A **Carpool** is an arrangement in which two or more people share a vehicle for transportation.

Mass Transit includes transportation facilities designed to transport large groups of persons in a single vehicle such as buses or trains.

Public Transportation is bus, rail or other transportation service for the general public on a regular, continual basis that is publicly or privately owned.

Case Study

PNC Firstside Center
Pittsburgh, Pennsylvania

The PNC Firstside Center is a LEED™ Silver Project that functions as a banking facility. To assess transportation planning issues, the project team polled future building occupants to determine the percentage of occupants who would use personal vehicles, carpools, mass transportation, and other forms of transportation such as bicycles and walking. The owner used data from the poll to influence the local transit authority to construct a future mass transit stop adjacent to the building. Until the transit stop is in operation, building occupants are utilizing 11 bus routes located within _ mile of the building. The site is located adjacent to a city bikeway and the building has bicycle racks to accommodate 60 bicycles, as well as showering and changing facilities. Eight electric vehicle recharging stations have been installed for building occupants using personal vehicles. Finally, the owner reached agreement with the local parking authority to share a portion of a public 1200-space multilevel parking facility located across the street.

Courtesy of Paladino Consulting LLC

Owner
PNC Bank

Reduced Site Disturbance

SS | WE | EA | MR | EQ | ID

Credit 5.1

Protect or Restore Open Space

1 point

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

On greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways and main utility branch trenches, and 25 feet beyond constructed areas with permeable surfaces (such as pervious paving areas, stormwater detention facilities and playing fields) that require additional staging areas in order to limit compaction in the constructed area; OR, on previously developed sites, restore a minimum of 50% of the site area (excluding the building footprint) by replacing impervious surfaces with native or adapted vegetation.

Submittals

❑ For greenfield sites: provide the LEED Letter Template, signed by the civil engineer or responsible party, demonstrating and declaring that site disturbance (including earthwork and clearing of vegetation) has been limited to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walk ways and main utility branch trenches, and 25 feet beyond constructed areas with permeable surfaces. Provide site drawings and specifications highlighting limits of construction disturbance.

OR

❑ For previously developed sites: provide a LEED Letter Template, signed by the civil engineer or responsible party, declaring and describing restoration of degraded habitat areas. Include highlighted site drawings with area calculations demonstrating that 50% of the site area that does not fall within the building footprint has been restored.

SS | WE | EA | MR | EQ | ID

Credit 5.2

Reduced Site Disturbance

Development Footprint

1 point

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

Reduce the development footprint (defined as entire building footprint, access roads and parking) to exceed the local zoning's open space requirement for the site by 25%. For areas with no local zoning requirements (e.g., some university campuses and military bases), designate open space area adjacent to the building that is equal to the development footprint.

Submittals

❑ Provide a copy of the local zoning requirements highlighting the criteria for open space. Provide the LEED Letter Template, signed by the civil engineer or responsible party, demonstrating and declaring that the open space exceeds the local zoning open space requirement for the site by 25%.

OR

❑ For areas with no local zoning requirements (e.g., some university campuses and military bases), designate open space area adjacent to the building that is equal to the development footprint. Provide a letter from the property owner stating that the open space will be conserved for the life of the building.

Summary of Referenced Standard

There is no standard referenced for this credit.

Green Building Concerns

Development of greenfield or undeveloped areas disturbs and destroys wildlife and plant habitat as well as wildlife corridors that allow animal migration. As animals are pushed out of existing habitat, they become increasingly crowded into smaller spaces. Eventually, their population exceeds the carrying capacity of these spaces and they begin to invade surrounding developments or perish due to overpopulation. Overall biodiversity, as well as individual plant and animal species, may be threatened by reduction of habitat areas. Minimizing site disturbance reduces habitat destruction.

Environmental Issues

The construction process is often damaging to site ecology, indigenous plants and regional animal populations. Ecological site damage can be avoided or minimized by limiting the extent of construction activities to certain areas on the site and by restricting the development footprint to the greatest extent possible. Protection of open space and sensitive areas through the use of strict boundaries reduces damage to the site ecology, resulting in preservation of wildlife corridors and habitat.

Economic Issues

Preserving topsoil, plants and trees on the site can reduce landscaping costs for the building and increase property values. Indigenous plantings often require less maintenance than exotic plantings and minimize inputs of fertilizers, pesticides, and water, reducing maintenance costs over the building lifetime. In some cases, trees and vegetation developed as specimens off-site are costly to purchase and may not survive transplanting. Purchasing and installing new plants can add to project cost. Saving existing site vegetation to replant after construction is complete may be a more cost-effective strategy.

Reducing the footprint of a structure on a given site can have varying economic impacts. Building a vertical structure with the same square footage as a horizontal structure may add a small percentage to first costs depending on building size and use. A structure with a smaller footprint is generally more resource-efficient, resulting in reduced material and energy costs. A more compact building with coordinated infrastructure can reduce initial project costs, as well as operations and maintenance costs. Reduced earthwork, shorter utility lines, and reduced surface parking and paved areas all can reduce initial project costs. Compact paving areas and buildings reduce operations and maintenance costs.

Design Approach

Strategies

Design a master plan for the project area, survey existing ecosystems and identify soil types on the site. Document existing water elements, soil conditions, ecosystems, wildlife corridors, trees and other vegetation, and map all potential natural hazards. Consider the impacts of the proposed development on existing natural and built systems and propose strategies to mitigate negative impacts.

Choose a building footprint and location that minimize disturbance to the existing ecosystem. Consider issues such as building orientation, daylighting, heat island effects, stormwater generation, significant vegetation and other sustainable building issues. Once the site and building location have been determined, design and construct a compact parking, road and building footprint layout in order to preserve open land. Reduce footprints by tightening program needs and stacking floor plans.

Encourage preservation, conservation and restoration of existing natural site amenities. Where appropriate, build on parts

SS | WE | EA | MR | EQ | ID

Credit 5

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 6
Stormwater Management

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

SS Credit 8
Light Pollution Reduction

WE Credit 1
Water Efficient Landscaping

WE Credit 2
Innovative Wastewater Treatment

WE Credit 3
Water Use Reduction

EA Credit 2
Renewable Energy

MR Prerequisite 1
Storage & Collection of Recyclables

MR Credit 1
Building Reuse

MR Credit 2
Construction Waste Management

EQ Credit 8
Daylight & Views

of the site that are already degraded so as not to degrade undisturbed areas. Restore the native landscape of the site by preserving and planting native species to reestablish predevelopment site conditions. Restoration efforts will vary depending on the particular project site.

Volunteer efforts can reduce the cost of saving existing trees and plants. For example, a volunteer "plant rescue" effort was organized on the site of the new EPA complex in Research Triangle Park, North Carolina. Assisted by the neighboring National Institutes for Environmental Health Sciences and the North Carolina Botanical Gardens at Chapel Hill, this effort saved more than 2,000 plants that were transplanted elsewhere on the site or sent to other locations. A variety of local plant amnesty organizations exist that can help with plant and tree preservation and relocation.

During the construction process, establish clearly marked construction and disturbance boundaries and note these site protection requirements in construction documents. Delineate lay down, recycling and disposal areas, and use paved areas for staging activities. Erect construction fencing around the drip line of existing trees to protect them from damage and soil compaction by construction vehicles. Establish contractual penalties if destruction of protected areas outside of the construction boundaries occurs. Coordinate infrastructure construction to minimize the disruption of the site and work with existing topography to limit cut-and-fill efforts for the project.

For achievement of Credit 5.2 in areas with no established zoning requirements for open space, a project must show that an open space area equal to the building footprint has been established adjacent to the building.

Synergies and Trade-Offs

Balancing the verticality of a structure with open space requirements can be a challenging exercise. For instance, shading from tall structures may change the environmental character of the open space, and these structures may be intimidating and unwelcoming to building occupants. Furthermore, large expanses of open space may be a barrier to public transportation access. Conversely, retaining a high proportion of open space vegetation reduces stormwater runoff volumes and natural features may be available for wastewater or stormwater treatment. Preservation of certain trees may reduce passive solar gains. Check the siting of the structure to optimize solar opportunities and to preserve the most significant trees. Additional vegetation can assist with cooling breezes and noise reduction, and enhance the site air quality.

The site location and site design have a significant effect on open space and reduced habitat disturbance. Heat island effects, stormwater generation, and light pollution should all be considered when determining the site design. The landscape design and irrigation scheme is intimately tied with the site design and open space allotted. In addition, water reuse and on-site wastewater treatment strategies have an effect on non-building spaces.

Renewable energy technologies such as wind turbines and biomass generation require site space. Rehabilitation of existing buildings may dictate the amount of open space available. Construction waste management schemes may encroach on natural areas for storage of building wastes earmarked for recycling.

Resources

Web Sites

North American Native Plant Society

www.nanps.org, (416) 631-4438

A nonprofit association dedicated to the study, conservation, cultivation and restoration of native plants. Contains links to state/provincial associations.

Soil and Water Conservation Society

www.swcs.org, (515) 289-2331

An organization focused on fostering the science and art of sustainable soil, water and related natural resource management.

Print Media

Beyond Preservation: Restoring and Inventing Landscapes by A. Dwight Baldwin et al., University of Minnesota Press, 1994.

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources by John Tillman Lyle and Joan Woodward, Milldale Press, 1999.

Landscape Restoration Handbook by Donald Harker, Lewis Publishers, 1999.

Definitions

The **Building Footprint** is the area on a project site that is used by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

A **Greenfield** is defined as undeveloped land or land that has not been impacted by human activity.

Local Zoning Requirements are local government regulations imposed to promote orderly development of private lands and to prevent land use conflicts.

Native/Adapted Plants are those that are indigenous to a locality or have adapted to the local climate and are not invasive. Such plants do not require irrigation or fertilization once root systems are established in the soil.

Open Space Area is the property area minus the development footprint. Open space must be vegetated and pervious, thus providing habitat and other ecological services.

Case Study

Kandalama Hotel
Colombo, Sri Lanka

The Kandalama Hotel, a LEED™ Bronze Pilot Project, is a 162-bedroom resort hotel located on a picturesque site with dense vegetation. The project site is an excellent example of how a sensitive natural site can be thoughtfully developed to protect the existing natural attributes. The design team chose to capitalize on the natural amenities of the site by minimizing construction extents and the overall building footprint. As a result, the total built area is only 10% of the total 55-acre site. Special efforts were made during construction to retain native vegetation and nestle the hotel into the existing lush trees and plants to provide shading for the guest rooms, restaurants and garden areas. A survey of the density and distribution of flora was used to document the existing site characteristics and the building design was altered to preserve existing trees and the natural topography of the site. Stilts and columns were used to elevate the buildings above existing natural features such as boulders and to reduce cut-and-fill needs.

Courtesy of Green Technologies, Inc.

Owner
Kandalama Hotels Ltd.

Stormwater Management

SS | WE | EA | MR | EQ | ID

Credit 6.1

Rate and Quantity

1 point

Intent

Limit disruption and pollution of natural water flows by managing stormwater runoff.

Requirements

If existing imperviousness is less than or equal to 50%, implement a stormwater management plan that prevents the post-development 1.5 year, 24 hour peak discharge rate from exceeding the pre-development 1.5 year, 24 hour peak discharge rate.

OR

If existing imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff.

Submittals

- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring that the post-development 1.5 year, 24 hour peak discharge rate does not exceed the pre-development 1.5 year 24 hour peak discharge rate. Include calculations demonstrating that existing site imperviousness is less than or equal to 50%.

OR

- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring and demonstrating that the stormwater management strategies result in at least a 25% decrease in the rate and quantity of stormwater runoff. Include calculations demonstrating that existing site imperviousness exceeds 50%.

Stormwater Management

1 point

Treatment

Intent

Limit disruption of natural water flows by eliminating stormwater runoff, increasing on-site infiltration and eliminating contaminants.

Requirements

Construct site stormwater treatment systems designed to remove 80% of the average annual post-development total suspended solids (TSS) and 40% of the average annual post-development total phosphorous (TP) based on the average annual loadings from all storms less than or equal to the 2-year/24-hour storm. Do so by implementing Best Management Practices (BMPs) outlined in Chapter 4, Part 2 (Urban Runoff), of the United States Environmental Protection Agency's (EPA's) *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, January 1993 (Document No. EPA-840-B-92-002) or the local government's BMP document (whichever is more stringent).

Submittals

- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring that the design complies with or exceeds EPA or local government Best Management Practices (whichever set is more stringent) for removal of total suspended solids and total phosphorous.

Summary of Referenced Standard

Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters, January 1993 (Document No. EPA 840B92002)

Internet location: www.epa.gov/owow/nps/MMGI

Hardcopy or microfiche (entire document, 836 pages): National Technical Information Service (order # PB93-234672), www.ntis.gov, (800) 553-6847

U.S. Environmental Protection Agency Office of Water, www.epa.gov/OW

This document discusses a variety of management practices that can be incorporated to remove pollutants from stormwater volumes. Chapter 4, Part II addresses urban runoff and suggests a variety of strategies for treating and infiltrating stormwater volumes after construction is completed. See the Resources section later in this credit for a summary of best management practices listed in the EPA document.

Green Building Concerns

The volume of stormwater generated from a site depends on the impervious surface area. In natural settings, the majority of precipitation infiltrates into the ground while a small portion runs off on the surface and into receiving waters. This surface runoff water is classified as stormwater runoff. As areas are constructed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff volumes that are transported via urban infrastructure (e.g., gutters, pipes and sewers) to receiving waters. These stormwater volumes contain sediment and other contaminants that have a negative impact on water quality, navigation and recreation. Furthermore, conveyance and treatment of stormwater volumes requires significant municipal infrastructure and maintenance.

Reducing the generation of stormwater volumes maintains the natural aquifer recharge cycle. In addition, stormwater volumes do not have to be conveyed to receiving waters by the municipality, and receiving waters are not impacted.

Environmental Issues

Reduction and treatment of runoff volumes decrease or eliminate contaminants that pollute receiving water bodies. For instance, parking areas contribute to stormwater runoff that is contaminated with oil, fuel, lubricants, combustion byproducts, material from tire wear, and deicing salts. Minimizing the need for stormwater infrastructure also reduces construction impacts and the overall ecological "footprint" of the building. Finally, infiltration of stormwater on-site can recharge local aquifers, mimicking the natural water cycle.

Economic Issues

If natural drainage systems are designed and implemented at the beginning of site planning, they can be integrated economically into the overall development. Water detention and retention features require cost for design, installation and maintenance. However, these features can also add significant value as site amenities if planned early in the design. Water features may pose safety and liability problems, especially in locations where young children are playing outdoors. The use of infiltration devices such as pervious paving may reduce water runoff collection system costs.

Community Issues

Stormwater volume reduction leads to improved watershed quality that benefits the community through improved water quality, navigation and recreation activities. Reduced stormwater collection and treatment systems lessen the burden on municipalities for maintenance and repair, resulting in a more affordable and stable tax base.

Design Approach

Strategies

The most effective method to minimize stormwater runoff volume is to reduce the amount of impervious area. By reducing impervious area, stormwater infrastructure can be minimized or deleted from the project. To minimize impervious surfaces and to encourage the natural processes of evaporation and infiltration, consider such methods as designing a smaller building footprint, installing green roofs and paving with pervious materials.

Capture stormwater from impervious areas to reuse within the building. Stormwater harvesting from roofs and hardscapes can be used for non-potable

SS | WE | EA | MR | EQ | ID

Credit 6

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 3
Brownfield Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

WE Credit 1
Water Efficient Landscaping

WE Credit 2
Innovative Wastewater Treatment

WE Credit 3
Water Use Reduction

MR Credit 1
Building Reuse

uses such as sewage conveyance, fire suppression and industrial applications.

For stormwater volumes that must be conveyed from the site to a receiving water body, design treatment practices to match the needs of the location and the specific drainage area. Design stormwater facilities to remove contaminants and release the volumes to local water bodies. Utilize biologically based and innovative stormwater management features for pollutant load reduction such as constructed wetlands, stormwater filtering systems, bioswales, bioretention basins, and vegetated filter strips. Use vegetated buffers around parking lots to remove runoff pollutants such as oil and grit. Specify and install water quality structures for pretreatment of runoff from surface parking areas. Do not disturb existing wetlands or riparian buffers when constructing ponds at the lowest elevations of a site. Design stormwater runoff to flow into vegetated swales rather than into structured pipes for conveyance to water quality ponds. Swales provide filtration for stormwater volumes and require less maintenance than constructed stormwater features. Install sequences of ponds whenever possible for more complete water treatment.

In some cases, such as heavily wooded sites where larger ponds are not feasible, distribute smaller bioretention areas that use subsurface compost and plantings to accelerate the filtering of contaminants around the site, instead of using one large pool. To moderate water runoff along drainage paths, construct water ponds to temporarily store stormwater flows. These ponds also improve water quality through settling and biodegradation of pollutants.

Technologies

Clustering or concentrating developments to reduce the amount of paved surfaces such as roads, parking lots and sidewalks minimizes impervious surfaces. Widths and lengths of roads, parking lots and sidewalks can also be minimized. For instance, turning lanes in roads can be removed to minimize the width of the paved surface. This requires the sharing of traveling and turning lanes.

Garden roofs or green roofs are vegetated surfaces that capture rainwater and return a portion of it back to the atmosphere via evapotranspiration. They consist of a layer of plants and soil, a cup layer for collection and temporary storage of stormwater, and a synthetic liner to protect the top of the building from stormwater infiltration. Garden roofs also provide insulating benefits and aesthetic appeal. Some garden roofs require plant maintenance and are considered active gardens while other garden roofs have

Table 1: Typical Runoff Coefficients

Surface Type	Runoff Coefficient	Surface Type	Runoff Coefficient
Pavement, Asphalt	0.95	Turf, Flat (0 - 1% slope)	0.25
Pavement, Concrete	0.95	Turf, Average (1 - 3% slope)	0.35
Pavement, Brick	0.85	Turf, Hilly (3 - 10% slope)	0.40
Pavement, Gravel	0.75	Turf, Steep (> 10% slope)	0.45
Roofs, Conventional	0.95	Vegetation, Flat (0 - 1% slope)	0.10
Roof, Garden Roof (< 4 in)	0.50	Vegetation, Average (1 - 3% slope)	0.20
Roof, Garden Roof (4 - 8 in)	0.30	Vegetation, Hilly (3 - 10% slope)	0.25
Roof, Garden Roof (9 - 20 in)	0.20	Vegetation, Steep (> 10% slope)	0.30
Roof, Garden Roof (> 20 in)	0.10		

grasses and plants that require no maintenance or watering. All types of garden roofs require semiannual inspection but are estimated to have a longer lifetime and require less maintenance than conventional roofs.

Pervious paving systems reduce stormwater runoff by allowing precipitation to infiltrate the undersurface through voids in the paving material. These systems can be applied to pedestrian traffic surfaces as well as low-vehicle traffic areas such as parking spaces, fire lanes, and maintenance roads. Use pervious paving materials such as poured asphalt or concrete with incorporated air spaces or use concrete unit paving systems with large voids that allow grass or other vegetation to grow between the voids.

Pervious paving has several options, including systems that use grass and a plastic grid system (90% pervious), concrete grids with grass (40% pervious), and concrete grids with gravel (10% pervious). Pervious paving requires different maintenance procedures than impervious pavement. With some systems, vacuum sweeping is necessary to prevent the voids from clogging with sediment, dirt and mud. Systems that use vegetation, such as grass planted in a plastic matrix over gravel, may require mowing like conventional lawns. Snow removal from pervious paving requires more care than from conventional paving. Check existing codes relating to the use of pervious surfaces for roadways.

To earn the second portion of this credit, stormwater volumes leaving the site must pass through a stormwater treatment system that removes total suspended solids and phosphorous to the required levels.

Packaged stormwater treatment systems can also be installed to treat stormwater volumes. These systems use filters to remove contaminants and can be sized for various stormwater volumes.

Synergies and Trade-Offs

Stormwater runoff is affected significantly by site selection and site design, especially transportation amenity design. It may be possible to reuse stormwater for nonpotable water purposes such as flushing urinals and toilets, custodial applications, and building equipment uses. Rehabilitation of an existing building may affect stormwater reduction efforts if large impervious surfaces already exist.

It is helpful to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes can also be reduced by designing the building with underground parking, a strategy that also reduces heat island effects. Pervious paving systems usually have a limit on transportation loads and may pose problems for wheelchair accessibility and stroller mobility. If stormwater volumes are treated on site, additional site area may need to be disturbed to construct treatment ponds or underground facilities. Application of garden roofs reduces stormwater volumes that may be intended for collection and reuse for non-potable applications.

Calculations for Credit 6.1

The following calculation methodology is used to support the credit submittals listed on the first page of this credit. Stormwater runoff volumes are affected by surface characteristics on the site as well as rainfall intensity over a specified time period. To simplify stormwater calculations, consider only the surface characteristics of the project site. Stormwater volumes generated are directly related to the net imperviousness of the project site. By reducing the amount of impervious surface on the site, stormwater volumes are reduced.

The calculation methodology to estimate the imperviousness of the project site is as follows:

1. Identify the different surface types on the site: roof areas, paved areas (e.g., roads and sidewalks), landscaped areas, and other areas.

2. Calculate the total area for each of these surface types using site drawings. Use **Table 1** to assign a runoff coefficient to each surface type. If a surface type is not included in the table, use a "best estimate" or manufacturer information. For instance, if pervious paving is used, consult the manufacturer to determine the imperviousness or percentage of the surface that does not allow infiltration.

3. Create a spreadsheet to summarize the area and runoff coefficient for each surface type. Multiply the runoff coefficient by the area to obtain an impervious area for each surface type. This figure represents the square footage of each surface area that is 100% impervious (see **Equation 1**).

4. Add the impervious areas for each surface type to obtain a total impervious area for the site.

5. Divide the total impervious area by the total site area to obtain the imperviousness of the site (see **Equation 2**).

Credit requirements state that for sites with imperviousness less than or equal to 50%, imperviousness must not increase from predevelopment to post-development conditions. For previously developed sites with imperviousness greater than 50%, imperviousness must be reduced by 25% from predevelopment to post-development conditions.

The following example describes the calculation method for site imperviousness. The example project is an office renovation and site improvements to an existing concrete parking lot of average slope. Surface types include sidewalks, parking areas, landscaping and the roof. The roof

Table 2: Design Case Imperviousness

Surface Type	Runoff Coefficient	Area [SF]	Impervious Area [SF]
Pavement, Asphalt	0.95	5,075	4,821
Pavement, Pervious	0.60	1,345	807
Roof, Garden Roof (4 - 8 in)	0.30	8,240	2,472
Vegetation, Average (1 -3% slope)	0.20	4,506	901
	TOTAL AREA	**14,660**	
	TOTAL IMPERVIOUS AREA		**8,100**
	IMPERVIOUSNESS		**55%**

Table 3: Baseline Case Imperviousness

Surface Type	Runoff Coefficient	Area [SF]	Impervious Area [SF]
Pavement, Concrete	0.95	19,166	18,208
	TOTAL AREA	**19,166**	
	TOTAL IMPERVIOUS AREA		**18,208**
	IMPERVIOUSNESS		**95%**

Equation 1:

$$\text{Impervious Area [SF]} = \text{Surface Area [SF]} \times \text{Runoff Coefficient}$$

Equation 2:

$$\text{Imperviousness [\%]} = \frac{\text{Total Pervious Area [SF]}}{\text{Total Site Area [SF]}}$$

area is assumed to be equal to the building footprint as determined from site drawings. **Table 2** shows calculations for the design case.

To reduce imperviousness, concrete sidewalks and asphalt parking lots can be substituted with pervious paving and vegetation in some areas. The building footprint is reduced and garden roofs are applied to reduce roof runoff.

Next, calculations are done for the baseline case or the existing site conditions (see **Table 3**). The original use of the site was for parking and, thus, the entire site was paved with concrete pavement.

The calculations demonstrate that the design case has an imperviousness of 47% and the baseline case has an imperviousness of 95%—a 50% reduction that exceeds the 25% required, thus earning one point.

Calculations for Credit 6.2

In most cases where projects choose to utilize standard EPA or local BMPs, no calculations are required to demonstrate compliance with the requirements of Credit 6.2. In instances where designs far different than accepted BMPs have been developed and implemented, the LEED Letter Template along with detailed engineering calculations may be required to demonstrate the TSS and phosphorus reductions that will be achieved.

Resources for Credit 6.2

Below is a summary of stormwater best management practices from the **EPA's Guidance Specifying Management Measures for Sources of Non-point Pollution in Coastal Waters**. For more information about this document, see Summary of Referenced Standard earlier in this credit.

Infiltration Basins and **Trenches** are devices used to encourage subsurface infiltration of runoff volumes through temporary surface storage. Basins are ponds that can store large volumes of stormwater. They need to drain within 72 hours to maintain aerobic conditions and to be available for the next storm event. Trenches are similar to infiltration basins except that they are shallower and function as a subsurface reservoir for stormwater volumes. Pretreatment to remove sediment and oil may be necessary to avoid clogging of infiltration devices. Infiltration trenches are more common in areas where infiltration basins are not possible.

Porous Pavement and **Permeable Surfaces** are used to create permeable surfaces that allow runoff to infiltrate into the subsurface. These surfaces are typically maintained with a vacuuming regime to avoid potential clogging and failure problems.

Vegetated Filter Strips and **Grassed Swales** utilize vegetation to filter sediment and pollutants from stormwater. Strips are appropriate for treating low-velocity surface sheet flows in areas where runoff

is not concentrated. They are often used as pretreatment for other stormwater measures such as infiltration basins and trenches. Swales consist of a trench or ditch with vegetation and require occasional mowing. They also encourage subsurface infiltration, similar to infiltration basins and trenches.

Filtration Basins remove sediment and pollutants from stormwater runoff using a filter media such as sand or gravel. A sediment trap is usually included to remove sediment from stormwater before filtering to avoid clogging.

Constructed Wetlands are engineered systems that are designed to mimic natural wetland treatment properties. Advanced designs incorporate a wide variety of wetland trees, shrubs, and plants while basic systems only include a limited number of vegetation types.

Detention Ponds capture stormwater runoff and allow pollutants to drop out before release to a stormwater or water body. A variety of detention pond designs are available, with some utilizing only gravity while others use mechanical equipment such as pipes and pumps to facilitate transport. Some ponds are dry except during storm events; others permanently store water volumes.

Table 4 highlights the advantages, disadvantages and removal efficiency rates for the above stormwater control practices.

Table 4: EPA Best Management Practices

Practice	Advantages	Disadvantages	Removal Efficiency [%]	
			TSS (req. 80%)	TP (req. 40%)
Infiltration Basins & Infiltration Trenches	Provides groundwater recharge, high removal efficiency, provides habitat	Requires permeable soils, high potential for failure, requires maintenance	50 to 100	50 to 100
Porous Pavement	Provides groundwater recharge, no space requirement, high removal efficiency	Requires permeable soils, not suitable for high-traffic areas, high potential for failure, requires maintenance	60 to 90	60 to 90
Vegetated Filter Strips	Low maintenance, good for low-velocity flows, provides habitat, economical	Not appropriate for high-velocity flows, requires periodic repair and reconstruction	40 to 90	30 to 80
Grassy Swales	Small land requirements, can replace curb and gutter infrastructure, economical	Low removal efficiency	20 to 40	20 to 40
Filtration Basins	Provides groundwater recharge, peak volume control	Requires pretreatment to avoid clogging	60 to 90	0 to 80
Constructed Wetlands	Good for large developments, peak volume control, high removal efficiency, aesthetic value	Not economical for small developments, requires maintenance, significant space requirements	50 to 90	0 to 80
Dry Ponds	Peak flow control, less space and cost vs. wet pond	Space, maintenance, limited soil groups	70 to 90	10 to 60
Wet Ponds	Peak flow control, prevents scour and resuspension	Space, cost, maintenance, limited soil groups	50 to 90	20 to 90

Source: EPA840B92002 Tables 4-5 and 4-7

Other technologies may also satisfy the credit's performance requirements.

Definitions

A **Constructed Wetland** is an engineered system designed to simulate natural wetland functions for water purification. Constructed wetlands are essentially treatment systems that remove contaminants from wastewaters.

Impervious Surfaces promote runoff of precipitation volumes instead of infiltration into the subsurface. The imperviousness or degree of runoff potential can be estimated for different surface materials.

Stormwater Runoff consists of water volumes that are created during precipitation events and flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater runoff volumes.

Total Phosphorous (TP) consists of organically bound phosphates, poly-phosphates and orthophosphates in stormwater, the majority of which originates from fertilizer application. Chemical precipitation is the typical removal mechanism for phosphorous.

Total Suspended Solids (TSS) are particles or flocs that are too small or light to be removed from stormwater via gravity settling. Suspended solid concentrations are typically removed via filtration.

Case Study

Philips Eco-Enterprise Center
Minneapolis, Minnesota

The Phillips Eco-Enterprise Center is a mixed-use building that houses environmental and energy efficiency organizations, consultants and manufacturers. The landscape on the project site was designed using xeriscape principles and requires no irrigation volumes. The native prairie grasses and wildflowers survive solely on precipitation. Stormwater that is not used by the plants or infiltrated into the subsurface is treated in a restored wetland and enhanced bio-filtration system. The system removes oil and sediment from stormwater and diverts 1.5 million gallons of runoff from entering the municipal stormwater system annually. Finally, a 4,000-square-foot section of the roof was designed as a garden roof to reduce stormwater runoff, provide superior insulation, and create a natural area that building occupants may enjoy.

Courtesy of Paladino Consulting LLC

Owner
The Green Institute

Heat Island Effect

SS | WE | EA | MR | EQ | ID

Credit 7.1

Non-Roof

1 point

Intent

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

Requirements

Provide shade (within 5 years) and/or use light-colored/high-albedo materials (reflectance of at least 0.3) and/or open grid pavement for at least 30% of the site's non-roof impervious surfaces, including parking lots, walkways, plazas, etc.; OR place a minimum of 50% of parking spaces underground or covered by structured parking; OR use an open-grid pavement system (less than 50% impervious) for a minimum of 50% of the parking lot area.

Submittals

- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, referencing the site plan to demonstrate areas of paving, landscaping (list species) and building footprint, and declaring that:
  - ❑ A minimum of 30% of non-roof impervious surfaces areas are constructed with high-albedo materials and/or open grid pavement and/or will be shaded within five years
  - ❑ OR a minimum of 50% of parking spaces have been placed underground or are covered by structured parking
  - ❑ OR an open-grid pavement system (less than 50% impervious) has been used for a minimum of 50% of the parking lot area.

Heat Island Effect

Roof

1 point

Intent

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

Requirements

Use ENERGY STAR® compliant (highly reflective) 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.

Submittals

❑ Provide the LEED Letter Template, signed by the architect, civil engineer or responsible party, referencing the building plan and declaring that the roofing materials comply with the ENERGY STAR® Label requirements and have a minimum emissivity of 0.9. Demonstrate that high-albedo and vegetated roof areas combined constitute at least 75% of the total roof area.

OR

❑ Provide the LEED Letter Template, signed by the architect, civil engineer or responsible party, referencing the building plan and demonstrating that vegetated roof areas constitute at least 50% of the total roof area.

Summary of Referenced Standards

ASTM E408-71(1996)e1—Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques, www.astm.org, (610) 832-9585

This standard describes how to measure total normal emittance of surfaces using a portable inspection-meter instrument. The test methods are intended for large surfaces where non-destructive testing is required. See the standard for testing steps and a discussion of thermal emittance theory.

ASTM E903-96—Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres, www.astm.org, (610) 832-9585

Referenced in the ENERGY STAR roofing standard, this test method uses spectrophotometers and need only be applied for initial reflectance measurement. Methods of computing solar-weighted properties from the measured spectral values are specified. This test method is applicableto materials having both specular and diffuse optical properties.Except for transmitting sheet materials that are inhomogeneous, patterned, or corrugated, this test method is preferred over Test Method E1084.

The ENERGY STAR roofing standard also allows the use of reflectometers to measure solar reflectance of roofing materials. See the roofing standard for more details.

EPA Energy Star Roofing Guidelines

U.S. Environmental Protection Agency ENERGY STAR® Program, www.energystar.gov, (888) 782-7937

The EPA's ENERGY STAR program allows for voluntary partnerships between the U.S. Department of Energy, the U.S. Environmental Protection Agency, product manufacturers, local utilities, and retailers. ENERGY STAR is dedicated to promoting energy efficiency, reducing air pollution, and saving money for businesses and residences through decreased energy use. In addition to several other building product categories, the ENERGY STAR program identifies roofing products that reduce the amount of air-conditioning needed in buildings, and can reduce energy bills by up to 50% (source: EPA). Roofing products with the ENERGY STAR logo meet the EPA criteria for reflectivity and reliability. Roof solar reflectance requirements for ENERGY STAR roofing products are summarized in **Table 1**.

See the ENERGY STAR Roofing Web site for technical criteria, a list of qualifying products and additional information.

Table 1: EPA Energy Star Roof Criteria

Roof Type	Slope	Initial Solar Reflectance	3-Year Solar Reflectance
Low-Slope Roof	≤ 2:12	0.65	0.50
Steep-Slope Roof	> 2:12	0.25	0.15

Credit Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 2
Urban Redevelopment

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

WE Credit 1
Water Efficient Landscaping

EA Credit 1
Optimize Energy Performance

MR Credit 1
Building Reuse

EQ Credit 7
Thermal Comfort

Green Building Concerns

As the built environment grows and replaces natural settings, it also relinquishes associated ecological services. Vegetation cools the area surrounding it via shade and evapotranspiration. The use of dark, non-reflective surfaces for parking, roofs, walkways and other surfaces contributes to heat island effects created when heat from the sun is absorbed and radiated back to surrounding areas. As a result of heat island effects, ambient temperatures in urban areas can be artificially elevated by more than 10°F when compared with surrounding suburban and undeveloped areas. This results in increased cooling loads in the summer, requiring larger HVAC equipment and energy for building operations. Heat island effects can be mitigated through the application of shading and the use of materials that reflect the sun's heat instead of absorbing it.

Figure 1 illustrates heat island effects in various cities throughout the United States. The greater amount of cooling degree-days in urban locations means that air-conditioning systems must work harder and use more energy to maintain thermal comfort in buildings.

Environmental Issues

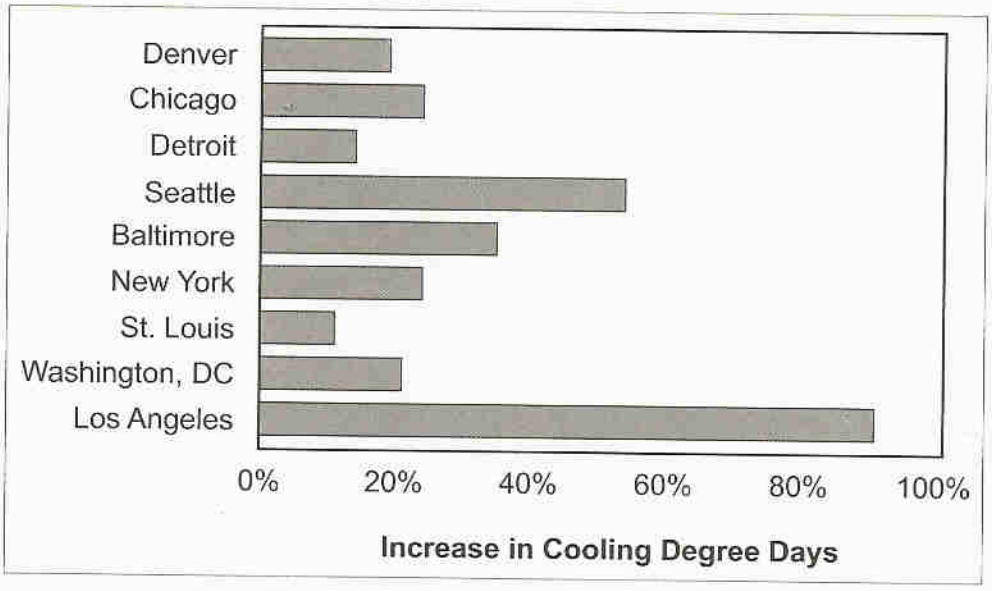
Heat island effects are detrimental to site habitat, wildlife and migration corridors. Plants and animals are sensitive to higher temperatures and may not thrive in areas that are unnaturally hot. Reduction of heat island effect minimizes disturbance of local microclimates. This can reduce summer cooling loads that in turn reduce energy use and infrastructure requirements.

Economic Issues

According to the EPA, about $40 billion is spent annually in the United States to air-condition buildings—one-sixth of all electricity generated in a year. Reduction in heat islands lowers the cost of cooling and HVAC equipment needs. Energy to cool buildings is a substantial cost over a building's lifetime.

Higher initial costs may result from installation of additional trees and architectural shading devices. However, these items have an acceptable payback when integrated into a whole systems approach that maximizes energy savings.

Figure 1: Percentage Increase in Cooling Degree Days for Select Cities



Design Approach

Strategies

Shade constructed surfaces (e.g. roof, roads and sidewalks) on the site with landscape features and minimize the overall building footprint. Consider replacing constructed surfaces with vegetated and/or permeable surfaces such as garden roofs and open grid paving or specify high-albedo materials to reduce heat absorption.

Technologies: Non-Roof

Paving Materials generally exhibit low reflectance. Asphalt's reflectance ranges from 0.05 to 0.10 when new and 0.10 to 0.15 when weathered. Standard gray-cement concrete reflectance is 0.35 to 0.40 when new and 0.20 to 0.30 when weathered. White-cement concrete reflectance is 0.70 to 0.80 when new and 0.40 to 0.60 when weathered. Note that the stated reflectance values are for pavements created in a laboratory. Concrete made with white cement may cost up to twice as much as that made with gray cement. Some blended cements (e.g., slag cements) are very light in color and cost the same as gray cement (Source: "Albedo: A Measure of Pavement Surface Reflectance," R&T Update #3.05, June 2002, American Concrete Pavement Association, www.pavement.com/techserv/RT3.05.pdf). Because pavement is ubiquitous, even a small improvement in albedo can make an impact. A simulation by Lawrence Berkeley National Laboratory predicted that increasing the reflectivity of 1250 km of pavement in Los Angeles by 0.25 would result in $15 million worth of energy savings and reduce smog-related medical and lost-work expenses by $76 million per year.

Coatings and integral colorants can be used in parking surfaces to improve solar reflectance. If reflective coatings, light concrete or gravel cannot be used, consider an open-grid paving system that increases perviousness by at least 50%, which remains cooler because of evaporation.

Vegetation can shade buildings and pavements from solar radiation and cool the air through evapotranspiration. Provide shade using native or climate-tolerant trees, large shrubs and non-invasive vines. Trellises and other exterior structures can support vegetation to shade on parking lots, walkways and plazas. Deciduous trees allow buildings to benefit from solar heat gain during the winter months. On site locations where tree planting is not possible, use architectural shading devices to block direct sunlight radiance.

Technologies: Roof

To maximize energy savings and minimize heat island effects, materials must exhibit a high solar reflectance and a high thermal emittance over the life of the product. Read the manufacturer's data when selecting a product based on a material's reflective properties. Not all manufacturers conduct solar reflectance and thermal emittance testing as a matter of course, although research on urban heat islands has helped to expose the problem and encourage such testing. Far more often, manufacturers measure visible reflectance.

Visible reflectance correlates to solar reflectance, but the two quantities are not equal because solar gain covers a wider range of wavelengths than visible light. A material that exhibits a high visible reflectance usually has a slightly lower solar reflectance. For example, a good white coating with a visible reflectance of 0.8 typically has a solar reflectance of 0.7. Therefore, it is necessary to measure the solar reflectance of the material even if the visible reflectance is known.

Visit the ENERGY STAR® Web site to look for compliant roofing products and cross-reference with the emissitance data on the Lawrence Berkeley National Laboratory's Cool Roofing Materials Database

(eetd.lbl.gov/CoolRoofs) and the Cool Roof Rating Council Web site (www.coolroofs.org).

Table 2 provides example values to give a general idea of initial solar reflectance and infrared emittance for common roofing materials. Typically, white roofing products exhibit higher performance characteristics than nonwhite products. Performance varies by roofing material as well as brand.

The information below is a summary of relevant information from the Lawrence Berkeley National Laboratory's Cool Roofing Materials Database.

Asphalt Roofing exhibits rather low reflectance. Premium white shingles are only about 30% reflective, and other colors reflect less. Thermal emittance is generally high. Thus, white asphalt roofing might achieve credit requirements for a steep-slope application.

Coatings contain transparent polymeric materials and a white pigment to make them opaque and reflective. White coatings typically reflect 65% or more of the sun's energy and protect the polymer material and/or substrate underneath from UV damage. Coatings are applied in thicknesses of at least 20 mils (for maximum reflectance), and up to 50 mils (for greater durability). Reflectivity performance will benefit from occasional cleaning. Tinted (colored) coatings cost more and reflect less sunlight.

Garden Roofs minimize heat island effects and have aesthetic value. Garden roofs or green roofs are vegetated surfaces that capture rainwater and return a portion of it back to the atmosphere through evapotranspiration, which cools trees and the surrounding air. Vegetation experiences lower peak temperatures—60 to 100 degrees Fahrenheit compared to 190 degrees on traditional rooftops—because it contains moisture. Garden roofs can potentially save energy used for heating and cooling. Some garden roofs require plant maintenance and are considered active gardens, while other garden roofs have grasses and plants that require no maintenance or watering. All types of garden roofs require periodic inspection but are expected to have longer lifetimes than conventional roofs because the underlying waterproof membrane is shielded from the effects of ultraviolet radiation and weather.

Membrane Roofing is fabricated from strong, flexible, waterproof materials. There are four types of cool roofing membranes: EPDM, CSPE, PVC and TPO. These membranes typically exhibit solar reflectance of 0.75. When a dark membrane (or other roofing such as modified bitumen) is surfaced with roofing granules such as gravel, the roof has the solar reflectance of asphalt shingles, which is quite low.

Metal Roofing is typically steel or aluminum based, although there is still a small amount of copper and tin roofing used today. Bare and coated metal roofing products typically have a solar reflectance of 60% to 80%, and a low thermal emittance.

Table 2: Cool Roofing Materials

Roofing Material	Initial Solar Reflectance	Infrared Emittance
Coating, White	0.75	0.80 – 0.90
Membrane, White	0.75	0.80 – 0.90
Concrete Tile, White	0.73	0.80 – 0.90

Source: LBNL Cool Roofing Materials Database: eetd.lbl.gov/CoolRoofs
Note: This table shows common or possible values. Values vary per specific brand and product.

Synergies and Trade-Offs

Site selection and site planning have a significant effect on urban heat islands. Shading from evergreen trees and architectural shading devices may interfere with possible solar benefits. Deciduous trees will allow for solar heat gain during the winter months. Shading strategies should be integrated with solar strategies such as daylighting, solar heating and photovoltaic cells.

Garden roofs reduce stormwater volumes that may be collected for non-potable purposes. If water reuse and garden roof strategies are applied together, it is necessary to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes from garden roofs depend on the local climate, depth of soil, type of plants used and other variables. However, all garden roofs decrease stormwater volumes substantially.

Light-colored pavements may create glare from reflection, posing a hazard to vehicle traffic and annoyance for building occupants. Buildings in very cold climates may not experience year-round energy benefits from reflective roofing and other surfaces, due to the inverse impact that lower heat absorptivity and higher emittance have on heating energy needs. Increasing the reflectance of a roof reduces annual cooling energy use in almost all climates.

Calculations

The following calculation methodology is used to support the credit submittals listed on the first page of this credit.

Shading of Non-Roof Impervious Surfaces

1. Identify all non-roof impervious surfaces on the project site and sum the total area.

2. Identify all trees that contribute shade to non-roof impervious surfaces. Calculate the shade coverage provided by these trees after five years on the non-roof impervious surfaces on June 21 at noon solar time to determine the maximum shading effect. Add the total area of shade provided for non-roof impervious surfaces.

3. Shade must be provided for at least 30% of non-roof impervious surfaces to earn this point (see **Equation 1**).

Impervious Surface Calculations

1. Calculate the total parking lot area of the project. Parking lots include parking spaces and driving lanes. Exclude parking spaces that do not receive direct sun (e.g., underground parking and stacked parking spaces), sidewalks, roadways and other impervious surfaces that cannot support vehicle loads.

2. Calculate the parking area that is designed with pervious paving materials.

3. A minimum of 50% of the total parking area must be comprised of paving materials that exhibit less than 50% imperviousness (see **Equation 2**).

Equation 1:

$$\text{Shade [\%]} = \frac{\text{Shaded Impervious Area [SF]}}{\text{Total Impervious Area [SF]}}$$

Equation 2:

$$\text{Pervious Portion [\%]} = \frac{\text{Pervious Parking Area [SF]}}{\text{Total Parking Area [SF]}}$$

Equation 3:

$$\text{Vegetated Roof [\%]} = \frac{\text{Vegetated Roof Area [SF]}}{\text{Total Roof Area [SF]}}$$

Vegetated Roof Calculations

1. Calculate the total roof area of the project. Deduct areas with equipment and other appurtenances.

2. Calculate the area of roof that is surfaced with a vegetated roof system.

3. Calculate the percentage of the total roof area that is covered with a green vegetated roof system (see **Equation 3**).

Resources

Web Sites

American Concrete Pavement Association

www.pavement.com, 847-966-2272

See R&T Update #3.05, June 2002, "Albedo: A Measure of Pavement Surface Reflectance," www.pavement.com/techserv/RT3.05.pdf, for reflectance data and related information.

Cool Roof Rating Council

www.coolroofs.org, (866) 465-2523

Created in 1998 to develop accurate and credible methods for evaluating and labeling the solar reflectance and thermal emittance (radiative properties) of roofing products and to disseminate the information to all interested parties.

ENERGY STAR® Roofing Products

www.energystar.gov, (888) 782-7937

Provides solar reflectance levels required to meet U.S. EPA ENERGY STAR labeling requirements, a list of compliant products (by manufacturer) for low-slope and steep-slope roofs, and additional information.

Greenroofs.com

www.greenroofs.com

An independent clearinghouse for information about vegetated roofs.

Lawrence Berkeley National Laboratory Heat Island Group

eetd.lbl.gov/HeatIsland/graphic, 510-486-7437

Presents research on the effects of heat islands and provides specific information and data on roofing materials. For reflectance and emissivity data, see eetd.lbl.gov/CoolRoofs.

Sacramento Cool Community Program

www.energy.ca.gov/coolcommunity/strategy/coolpave.html

A program of the Sacramento Tree Foundation that promotes the use of vegetation strategies, cool roofing and cool pavements to reduce the city's heat island. Sacramento's parking lot shading ordinance is provided, as well as other resources helpful for local governments.

Definitions

Albedo is synonymous with solar reflectance (see below).

Heat Island Effects occur when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces that contribute to the heat island effect include streets, sidewalks, parking lots and buildings.

Infrared or Thermal Emittance is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 3 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Open-Grid Pavement is defined for LEED purposes as pavement that is less than 50% impervious.

Solar Reflectance (albedo) is the ratio of the reflected solar energy to the incoming solar energy over wavelengths of approximately 0.3 to 2.5 micrometers. A reflectance of 100% means that all of the energy striking a reflecting surface is reflected back into the atmosphere and none of the energy is absorbed by the surface. The best standard technique for its determination uses spectro-photometric measurements with an integrating sphere to determine the reflectance at each different wavelength. An averaging process using a standard solar spectrum then determines the average reflectance (see ASTM Standard E903).

Underground Parking is a "tuck-under" or stacked parking structure that reduces the exposed parking surface area.

Light Pollution Reduction

SS | WE | EA | MR | EQ | ID
Credit 8

1 point

Intent

Eliminate light trespass from the building and site, improve night sky access and reduce development impact on nocturnal environments.

Requirements

Meet or provide lower light levels and uniformity ratios than those recommended by the Illuminating Engineering Society of North America (IESNA) *Recommended Practice Manual: Lighting for Exterior Environments* (RP-33-99). 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. Any luminaire within a distance of 2.5 times its mounting height from the property boundary shall have shielding such that no light from that luminaire crosses the property boundary.

Submittals

❑ Provide the LEED Letter Template, signed by a lighting designer or an appropriate party, declaring that the credit requirements have been met.

Summary of Referenced Standard

IESNA Recommended Practice Manual: Lighting for Exterior Environments (IESNA RP-33-99)

Illuminating Engineering Society of North America, www.iesna.org, (212) 248-5000

This standard provides general exterior lighting design guidance and acts as a link to other IESNA outdoor lighting Recommended Practices (RPs). IESNA RP documents address the lighting of different types of environments. RP-33 was developed to augment other RPs with subjects not otherwise covered and is especially helpful in the establishment of community lighting themes and in defining appropriate light trespass limitations based on environmental area classifications. RP-33 addresses visual issues such as glare, luminance, visual acuity and illuminance. Also covered are exterior lighting design issues including community-responsive design, lighting ordinances, luminaire classification, structure lighting, and hardscape and softscape lighting. Light level recommendations in RP-33 are lower than in many other RPs, since RP-33 was written to address environmentally sensitive lighting.

Another useful Recommended Practice is RP-20-98, "Lighting for Parking Facilities." RP-20 discusses lighting design issues and makes light level recommendations for open and covered parking facilities. Not all the light level recommendations in the RP-20, or in any of the RPs, are appropriate for lighting in environmentally sensitive areas, so it is important to try to use the lowest recommended values. It is also important to recognize that, as a whole, different IESNA RP documents are not in agreement on all lighting issues and many of the RPs will be revised to include

recommendations based on environmental zones. The designer must interpret related documents to find a recommendation that uses the lowest light levels while still addressing specific project issues. **Table 1** provides suggested light trespass limitations based on different types of environmental zones. Illuminance values are measured at the eye on a plane perpendicular to the line-of-sight.

Table 1: Light Trespass Limitations

Environmental Zone	Description	Recommended Maximum Illuminance Levels [fc]
E1: Intrinsically Dark	Parks and residential areas where controlling light pollution is a high priority	0.1
E2: Low Ambient Brightness	Outer urban and rural residential areas	0.1
E3: Medium Ambient Brightness	Urban residential areas	0.2
E4: High Ambient Brightness	Urban areas having both residential and commercial use and experiencing high levels of nighttime activity	0.6

Note: Table 1 has been adapted from IESNA RP-33-99. "Post Curfew" recommendations have been used for all values to ensure that light trespass is minimized for each environmental zone. It is recognized that in situations where the property line is very close to the area of development (commonly referred to as "zero property line"), and where lighting is required for emergency egress purposes, it may not be possible to meet the Table 1 recommendations. These situations should be carefully explained and documented.

Green Building Concerns

Outdoor lighting is necessary for illuminating connections between buildings and support facilities such as sidewalks, parking lots, roadways and community gathering places. However, light trespass from poorly designed outdoor lighting systems can affect the nocturnal ecosystem on the site, and light pollution limits night sky access. Through thoughtful design and careful maintenance, outdoor lighting can address night sky visibility issues and site illumination requirements, while minimizing the negative impact on the environment.

Environmental Benefits

Sensitively designed outdoor lighting can extend access and use of many areas into the nighttime hours. We can gain a unique appreciation for a place at night because of sensitively and creatively designed lighting systems. But any time lighting is added to an exterior environment, light pollution and the potential for light trespass increase. Even with the best full cutoff luminaires and the lowest wattage lamp packages, the added light will be reflected off surfaces and into the atmosphere. Using the minimum amount of lighting equipment, limiting or eliminating all landscape lighting, and avoiding light pollution and trespass through the careful selection of lighting equipment and controls allow nocturnal life to thrive while still providing for nighttime activity.

Economic Benefits

Carefully designed exterior lighting solutions can reduce infrastructure costs and energy use when compared to common practice solutions. Energy and maintenance savings over the lifetime of the project can be substantial.

Community Benefits

Minimizing light pollution and trespass allows for night sky access by the surrounding community. Another key benefit is better visual comfort and improved visibility. Sensitively designed lighting systems that minimize glare and provide more uniform light at lower levels will help create aesthetically pleasing environments that are safer and more secure. A carefully designed and maintained outdoor lighting system can help a project be a non-intrusive member of the community.

Design Approach

Strategies

Eliminate all unshielded fixtures (floodlights) on the project site. Interpret between existing standards and design for the lowest possible light levels while addressing safety, security, access, way finding, identification and aesthetics. Use IESNA designation "full cutoff" luminaires for lamp packages with more than 3500 initial lumens and provide shielding for luminaires with lamps having more than 1000 initial lumens. The shielding of low brightness luminaires can vary depending on the ambient brightness of the surrounding environment and on the type of environmental zone (as described in IESNA RP-33-99) that best describes the project. For example, in sites where there is low ambient brightness and there is a great potential for glare and light trespass, even sources with very low lumen output may need to be fully shielded to maintain the highest levels of visual comfort. In these situations, a luminaire with IESNA full cutoff designation might be appropriate. In high ambient brightness areas where less shielding is required, a luminaire with IESNA semi-cutoff or non-cutoff designations may be appropriate. The designer should take care in making the decision on how much shielding is required.

Minimize or eliminate lighting of architectural and landscape features. Where lighting is required for safety, security,

Credit Synergies

SS Credit 1
Site Selection

SS Credit 4
Alternative Transportation

SS Credit 5
Reduced Site Disturbance

SS Credit 7
Landscape & Exterior Design to Reduce Heat Islands

EA Prerequisite 1
Fundamental Building Systems Commissioning

EA Credit 1
Optimize Energy Performance

EA Credit 3
Additional Commissioning

EA Credit 5
Measurement & Verification

egress or identification, utilize downlighting techniques rather than uplighting. For example, in environments that are intrinsically dark, no landscape features should be lighted, and architectural lighting should be designed only as a last resort when other strategies have failed to provide the minimum amount of required lighting. In areas of high ambient brightness, some low level (subtle) lighting of features, facades or landscape areas may be appropriate in pedestrian environments or for identification and way finding in other areas where light trespass is not likely to be an issue. However, even in areas of high ambient brightness, all non-essential lighting, including landscape and architectural lighting, should be minimized or turned off after hours. If shielded, low brightness sources are used to selectively light features, they should be properly aimed so that light from the luminaires cannot be measured across project boundaries. In all cases, controls should be used wherever possible to turn off lighting after normal operating hours or in post-curfew periods. Consider at least the following strategies when designing the exterior lighted environment:

1. Employ a lighting professional to assess the project's lighting needs and provide recommendations based specifically on lighting for a sustainable design environment.

2. Carefully review and respond to any local or regional lighting ordinances or bylaws that might impact the lighting design for the project site.

3. Consult IESNA RP-33 and determine the type of environmental zone that the project falls under from Intrinsically Dark (Zone E1) to High Ambient Brightness (Zone E4). Understand the design implications of the environmental zone that best fits the project and study neighboring areas to identify potential light trespass problems.

4. Use the least amount of lighting equipment possible to achieve the goals of the project, but balance the quantity of equipment used with the need to provide for glare control and uniform lighting. In most cases, it is better to have two luminaires with lower light output and good glare control than one higher output luminaire.

5. Select all lighting equipment carefully. Any type of luminaire, whether it is full cutoff, semi-cutoff or non-cutoff, can produce excessive brightness in the form of glare. For example, horizontal lamp positions in full cutoff luminaires tend to produce much less glare than vertical lamps. Selecting high-performance equipment of good quality is not only essential in maintaining visual quality, but also will quickly pay for itself in reduced maintenance costs.

6. Design exterior lighting to produce minimal upward illumination from direct or reflected light sources. Select luminaire locations carefully to control glare and contain light within the design area. Pay special attention to luminaires that are located near the property line to ensure that no measurable light from these luminaires crosses the project boundary.

7. Use the minimum amount of light necessary and only light areas that require it. Design and develop a control scheme to minimize or turn lighting off after hours or during post-curfew periods.

8. Create a computer model of the proposed electric lighting design and simulate system performance. Use this tool to provide point by point horizontal illuminance information or an isofootcandle contour map demonstrating that illuminance values are zero (or near zero) at the project boundary. Where luminaires are within 2.5 times their mounting height from the project boundary and the light levels are not zero at the boundary, light trespass is more likely to be a problem. In

this case a simple calculation can be performed to show that the "line of sight" illuminance limits for light trespass listed in **Table 1** have been met. A procedure for evaluating light trespass is outlined in the calculations section.

9. After the lighting system is constructed, it should be commissioned to ensure that it is installed and operating properly. Maintenance should be performed on the system on a regular basis to ensure that it continues to operate correctly, and that light pollution and trespass are minimized.

Technologies

Design site lighting and select lighting equipment and technologies to have minimal impact off-site and minimal contribution to sky glow (light pollution). Employ luminaires with the proper optics and shielding. Use low-reflectance ground covers and minimize the use of highly reflective and specular surfaces that may be a source of reflected glare. When surfaces are used to reflect light, use lower wattage light sources to reduce light levels and overall brightness. Even low brightness luminaires should be aimed carefully to eliminate glare and light trespass. Aiming angles greater than 45 degrees above vertical should be avoided. Luminaires with lockable aiming should be used in instances where glare control is very important or where special aiming must be maintained. Use motion sensors, photocells, stepped dimming, automatic switching and time clocks to control exterior lighting during pre- and post-curfew periods. Exterior signs that must be lighted should be made as small as possible and internally lighted signs should have letters and images on a dark background. Externally lighted signs should be downlighted from the top whenever possible, and the luminaires used should be full cutoff with additional shielding as necessary to control stray light that does not illuminate the sign.

Synergies and Trade-Offs

Exterior lighting strategies are affected by the transportation program, as well by as the total area of developed space on the project site. In addition to energy efficiency, the exterior lighting system requires commissioning and measurement & verification. ASHRAE 90.1–1999 (see EA Credit 1) includes provisions for exterior facade lighting and addresses automatic lighting controls, control devices, minimum lamp efficacy and lighting power limits. The standard requires separate calculations for interior and exterior lighting loads and, thus, trade-offs between interior and exterior loads are not permitted. See the standard for more information.

Education is one of the most important aspects of sustainable lighting design. Some people believe incorrectly that lower levels of outdoor lighting will create safety or security problems. However, it can be easily demonstrated that the quality of the lighting design has a much greater impact on safety and the perception of security than does light level. Low light level environments with good uniformity of light and controlled glare are often environments that provide good visibility. Environments with good visibility are usually safer and more secure. These environments also use less energy, and they cause less light pollution and trespass. It is not only acceptable, but also sometimes preferred not to light an environment.

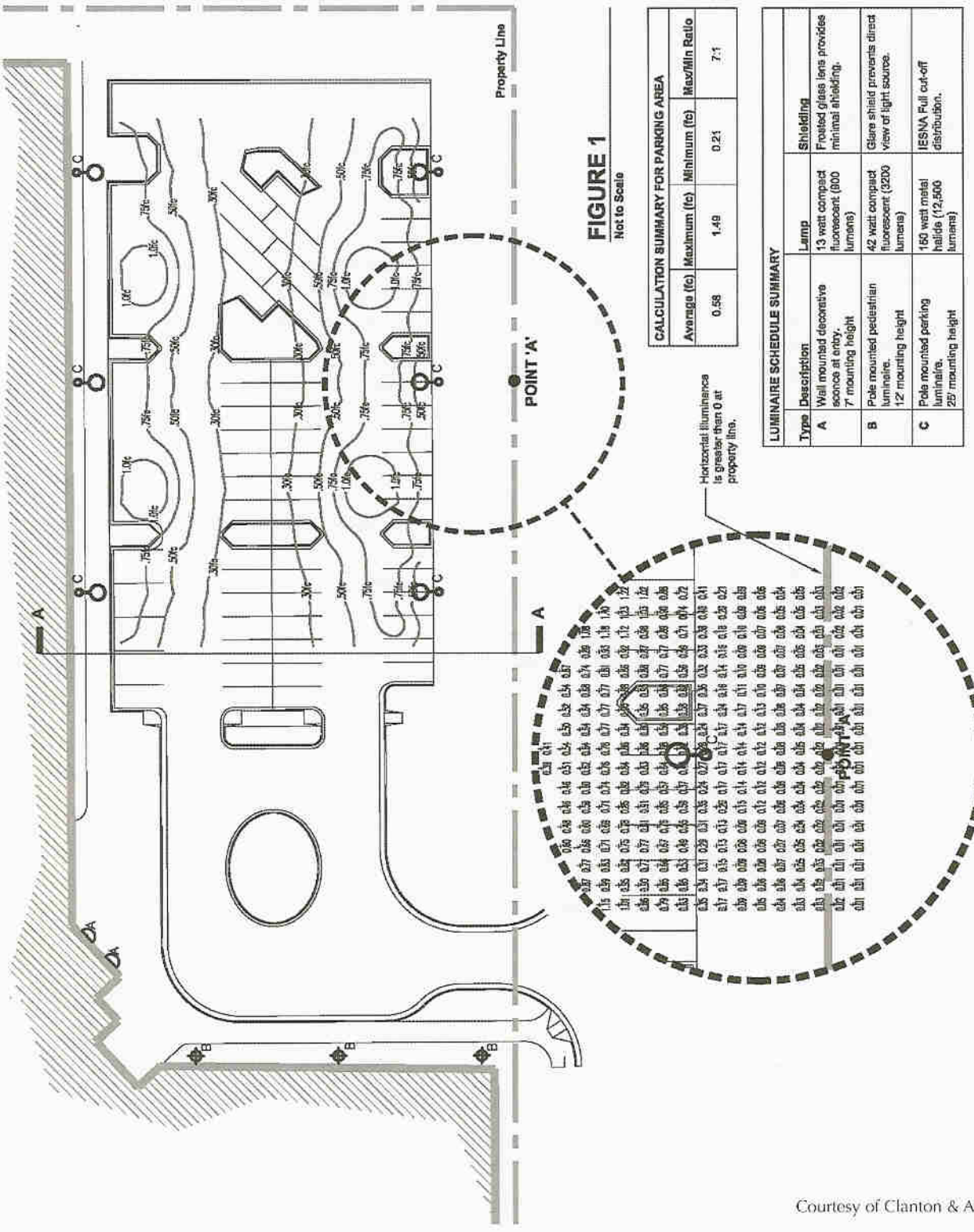
Calculations

The following materials are recommended to support the credit:

1. Provide an exterior site plan showing:

- All buildings, parking and pedestrian areas, trees and landscape features
- A luminaire schedule showing the type, style, location, height, orientation, shielding and aim-

Figure 1: Example of a Site Lighting Plan



Courtesy of Clanton & Associates

ing of all light sources and all lighting control devices

- A computer-generated lighting calculation indicating horizontal illuminance on a 10'x10' minimum grid and a minimum of 10 feet beyond the lot or property boundary for areas that are representative of each design condition (Isofootcandle contours are also acceptable for showing light levels). Include maximum to minimum uniformities for each specific type or area of use, and any associated light loss factors (LLF) used in the procedure. RP-33 references appropriate RPs for various design conditions. Consult these RPs for recommended criteria.

2. Provide a calculation for "line of sight illuminance" (light trespass) for luminaires near the property line where the calculated light levels did not reach zero. See **Table 1** for light trespass limits. To calculate line of site illuminance (E_{line}): multiply the horizontal illuminance (E_{horz}) (at ground level for LEED calculation purposes) on the property line by one over the sine of the angle ($1/\sin\theta$), where the angle is between the ground plane at the point of measurement and a line drawn from that point to the light source.

3. Catalog cut sheets for all exterior luminaires with more that 3500 lumen lamps, demonstrating that they meet the Full Cutoff IESNA Classification, and indicating lamp type, distribution type and any additional shielding.

4. Catalog cut sheets for all exterior luminaires with more than 1000 lumen lamps, demonstrating that they are appropriately shielded for the project's Environmental Zone.

5. Provide interior lighting design drawings for the building's perimeter areas demonstrating that the maximum candela value of interior lighting falls within the building and not out through the windows.

The site lighting plan illustrated in **Figure 1** includes a parking lot and office building in an area of low ambient brightness (Environmental Zone 2). The luminaire schedule describes the light source used in each luminaire and the shielding classification provided to meet the credit requirements. Note that a summary is used in this example for illustration purposes. A complete schedule is required.

The site lighting plan indicates major site features, luminaire layout and calculated point-by-point illuminance values at ground level on a grid that is less than 10'x10', or indicated by isofootcandle lines. The maximum to minimum uniformity ratio is 7:1, which meets the criteria in IESNA RP-20, which RP-33 references for parking facilities.

The lighting point-by-point calculation plan shows that the illuminance value at the property line does not reach 0 at Point A (E_{horz} at Point A is 0.01fc). Therefore, the "line of site illuminance" must be calculated for the adjacent luminaire. The calculation $E_{line}=(1/\sin 33°)(0.01fc)$ yields a result of 0.018fc. Since this value is less than the 0.1fc limitation given by IESNA RP-33-99, the LEED requirement has been met for Point A.

The angle of the maximum candela value for interior luminaires is determined from the luminaire photometry. It is then diagramed on the building section. The site and building sections in **Figure 2** illustrates that the maximum candela values for luminaire types "X" and "Y" fall within the building.

Courtesy of Clanton & Associates

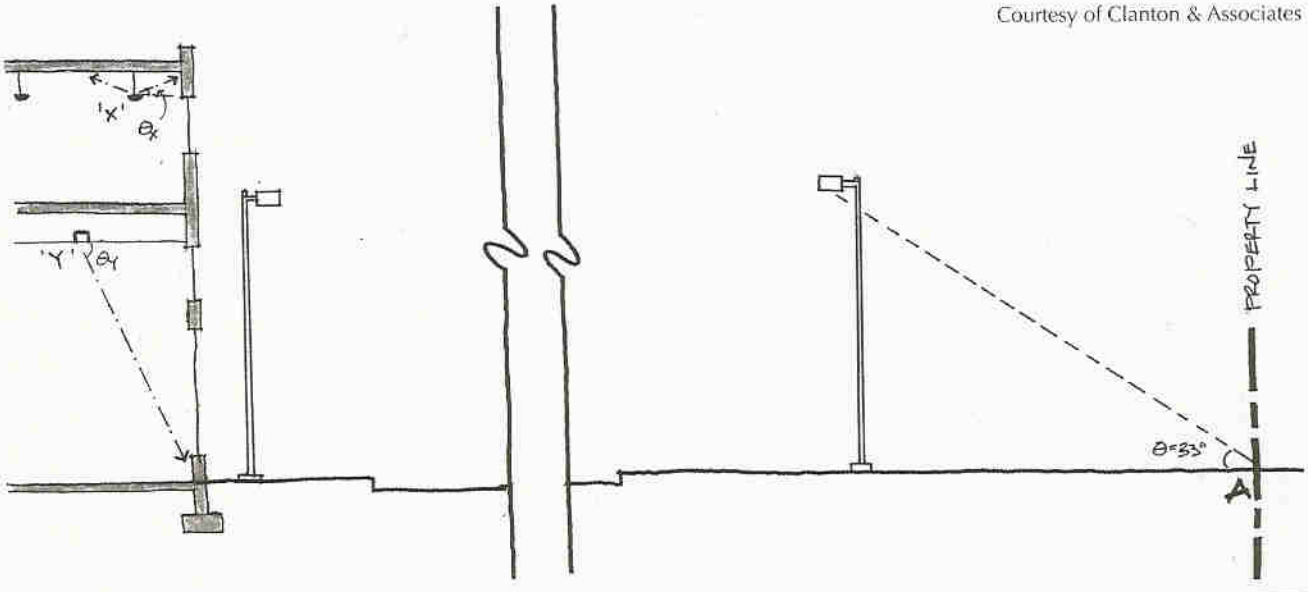


Figure 2: Building and Site Sections

Resources

Web Sites

Illuminating Engineering Society of North America

www.iesna.org, (212) 248-5000

The most comprehensive source for lighting information.

International Dark Sky Association

www.darksky.org, (520) 293-3198

A nonprofit organization dedicated to providing education and solutions for light pollution and light trespass.

Lighting Research Center

www.lrc.rpi.edu

A leading university-based research center devoted to providing objective information about lighting technologies, applications and products to aid facility managers, utilities, lighting designers, engineers and electrical contractors. The Web site includes the National Lighting Product Information Program (NLPIP), which provides free publications about lighting topics (such as light pollution) and products.

New England Light Pollution Advisory Group (NELPAG)

cfa-www.harvard.edu/cfa/ps/nelpag.html

A volunteer group that educates professionals and the public on the virtues of efficient, appropriately sited glare-free outdoor night lighting by addressing safety, right to privacy, light trespass, night sky vision and energy issues.

Print Media

Outdoor Lighting Manual for Vermont Municipalities, PTI Publications Center, (301) 490-2188, Order No. DG/95-308.

Definitions

Curfew Hours are locally determined times when greater lighting restrictions are imposed.

Cutoff Angle is the angle between the vertical axis of a luminaire and the first line of sight (of a luminaire) at which the light source is no longer visible.

Illuminance is the amount of light falling on a surface, measured in units of footcandles (fc) or lux (lx).

A **Footcandle** (fc) is a measure of light falling on a given surface. One footcandle is equal to the quantity of light falling on a one-square-foot area from a one candela light source at a distance of one foot. Footcandles can be measured both horizontally and vertically by a footcandle or "light meter."

A **Full Cutoff** luminaire has zero candela intensity at an angle of 90 degrees above the vertical axis (nadir) and at all angles greater than 90 degrees from nadir. Additionally, the candela per 1000 lamp lumens does not numerically exceed 100 (10 %) at an angle of 80 degrees above nadir. This applies to all lateral angles around the luminaire.

Glare is the sensation produced by luminance within the visual field that is significantly greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort or loss in visual performance and visibility

Light Pollution is caused by stray light from unshielded light sources and light reflecting off surfaces that enters the atmosphere where it illuminates and reflects off dust, debris and water vapor to cause an effect know as "sky glow." Light pollution can substantially limit visual access to the night sky, compromise astronomical research, and adversely affect nocturnal environments. Stray light that enters the atmosphere does not increase nighttime safety or security and needlessly consumes energy and natural resources.

Light Trespass is commonly thought of as "the light shining in my window." It is defined as obtrusive light that is unwanted, because of quantitative, directional or spectral attributes. Light trespass causes annoyance, discomfort, distraction or a loss of visibility

Luminance is what we commonly call brightness or the light coming from a surface or light source. Luminance is composed of the intensity of light striking an object or surface and the amount of that light reflected back toward the eye. Luminance is measured in footlamberts (fl) or candela per square meter (cd/m2).

Shielding is a non-technical term that describes devices or techniques that are used as part of a luminaire or lamp to limit glare, light trespass and light pollution.

Case Study

The Aspen Skiing Company Sundeck Restaurant
Aspen, Colorado

The Aspen Skiing Company Sundeck Restaurant is a LEED™ Version 1.0 Bronze Pilot Project located atop Aspen Mountain. Interior and exterior lighting plans were designed to minimize impacts on the surrounding natural areas. Blackout curtains were installed for interior service areas where unshielded fixtures are located to block light from spilling out of windows. Lighting fixtures were chosen carefully to eliminate direct glare from light sources and indirect glare from expected viewing angles. Reflectance of interior surfaces that can be viewed from off-site is limited to 40%. Exterior lighting is limited to code requirements and outdoor fixtures are baffled to reduce light trespass. All exterior lighting is automatically shut off at 11 pm. Reflective surfaces on the project site were minimized and snow is removed from below windows to reduce the potential for light reflection.

Courtesy of The Aspen Skiing Company

Owner
The Aspen Skiing Company