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DEVELOPMENT OF A FRAMEWORK TO ASSIST OWNERS
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PRACTICES FOR INSTITUTIONAL BUILDINGS

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DEVELOPMENT OF A FRAMEWORK TO ASSIST OWNERS IN DECIDING TO USE SUSTAINABLE SITE DESIGN PRACTICES FOR INSTITUTIONAL BUILDINGS

By

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ABSTRACT

DEVELOPMENT OF A FRAMEWORK TO ASSIST OWNERS IN DECIDING TO USE SUSTAINABLE SITE DESIGN PRACTICES FOR INSTITUTIONAL BUILDINGS

By

Niti Gautam Khosla

This research incorporated the AHP Multi-Attribute Model developed by Herkert et al to Pearce et al's Sustainability Decision Support System Conceptual Framework in order to develop a new decision-making framework for aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites (SS) and Water Efficiency (WE) credits for their projects.

The researcher has conducted literature review to identify existing decision-making frameworks for sustainable development as well as recent studies addressing environmental, community and economic issues of U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) credits with emphasis on SS and WE credits. The researcher identified decision-making attributes, which influence a decision whether or not to use specific LEED SS and WE credits, through existing data collected at a collaborative work session of design professionals, held at Michigan State University, and interviews of four case study projects, to address use of SS and WE credits of LEED. The researcher identified and presented these attributes, relevant to each credit, and finally, a new framework based on Herkert and Pearce's work was developed for institutional owners for helping them to decide whether or not to pursue individual LEED SS and WE credits for their projects.

Dedicated to my husband, Gautam for his love, support and his absolute confidence in me.

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ABBREVIATIONS

AHP	Analytical Hierarchy Process
GSA	United States General Services Administration
LAP	LEED Accredited Professionals
LEED	Leadership in Energy and Environmental Design
LEED-NC	LEED for New Construction
MSU	Michigan State University
SS	Sustainable Sites
US	United States (of America)
USGBC	United States Green Building Council
WE	Water Efficiency

CHAPTER 1

INTRODUCTION

1.1 Introduction

This thesis develops a new decision-making framework for aiding institutional owners as they consider use of specific LEED-NC (Leadership in Energy and Environmental Design – New Construction) Version 2.2 Sustainable Sites (SS) and Water Efficiency (WE) credits for their projects. Many organizations are considering sustainable construction and LEED for their projects. A decision-making framework can aid them as they pursue sustainable design.

'Sustainable Construction' is defined in ASTM E 2114, Terminology for Sustainability Relative to the Performance of Buildings, as "the maintenance of ecosystem components and functions for future generations" [ASTM 2004]. Toward a goal of sustainability, the United States Green Building Council (USGBC) developed the LEED Green Building Rating System to support healthy and sustainable design concepts. Using LEED helps design teams and owners determine green project goals, identify green design strategies, measure and monitor progress, and document success [USGBC-1].

There are two factors that motivate owners to pursue sustainable buildings: intangible benefits such as competitive differentiation or social responsibility, and tangible benefits such as reduced costs or increased revenue [Vyas 2005]. Having a comprehensive understanding of the factors or attributes that affect potential costs, scheduling and quality of construction, environment, human health, safety and comfort will allow an owner to make better choices as to which LEED credits a particular building should pursue [Matthiessen and Morris 2004].

Realizing that every construction project is unique and what might be a better choice for one project may not be for the other, this research has identified decision-making attributes, which influence a decision whether or not to use specific LEED SS and WE credits and developed a framework to assist owners in deciding which LEED site related credits his/ her project should pursue.

1.2 Problem and Need Statement

Healthy built environments are conceptualized as those that "provide environmental resources and interventions that promote enhanced well-being among occupants of an area" [Frank and Engelke 2001]. In support of healthy and sustainable design concepts, the LEED standards were developed. These standards focus on Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality and Innovation & Design Process. The successful design of a healthy built environment is heavily connected to a project's site design [Frank and Engelke 2001] and Sustainable Sites and Water Efficiency are the focus of this study. LEED SS Credits are designed to develop only appropriate sites, reuse existing buildings and / or sites, protect natural and agricultural areas, reduce the need for automobile use and protect and / or restore natural sites [USGBC-2]. LEED WE credits aim to reduce the quantity of water needed for the building and to reduce municipal water supply and treatment burden [USGBC-2].

The LEED-NC Version 2.2 Reference Guide shows a matrix that indicates which project team members are likely to carry decision-making responsibility for each credit. This matrix emphasizes those credits that are most likely to require strong participation by a particular team member. According to this matrix, the site related credits that require owner decision-making are Sustainable Sites (SS) credits SS1, SS2, SS3, SS4.1, SS4.3, SS4.4, SS5.1, SS5.2 and Water Efficiency (WE) credit WE1.2 [USGBC-2].

However, "most owners have little knowledge of the construction or design process. After all, this is not their business" [Vyas 2005]. Therefore, there is a need for a tool to guide them in the credit selection process. According to the United Nations Environment Programme, "building owners are faced with the need to make decisions in the short term with the possibility of huge consequences, yet they lack a sound basis for making these decisions. Likewise, the design and engineering community lacks the basic principles and rules to help guide the selection of integrated, sustainable solutions. Thus there is a need for practical tools to promote awareness and to encourage sustainable development" [UNEP 2001].

This research is also focused on public institutional buildings because of their relative impact on the construction industry. According to USGBC, as of June 8, 2006, institutional buildings such as schools, universities, libraries, laboratories and government buildings account for 23% of LEED certified buildings and have significant impact on new trends for adopting sustainable development practices.

Some governmental agencies require that public buildings be certified through the LEED program. Michigan and other states have created LEED or other sustainability requirements for state funded projects. For example, Michigan has mandated that Capital Outlay projects in excess of one million dollars be designed for a LEED certifiable level [MICHIGAN 2004]. Institutional buildings that receive funds from state and federal government agencies will have to start taking steps to follow LEED standards on new construction and major renovations.

A decision-making framework will aid institutional owners in deciding specific LEED SS and WE credits suitable for their projects thereby encouraging sustainable development.

1.3 LEED Overview

The United States Green Building Council (USGBC) developed the LEED Green Building Rating System. USGBC is the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work [USGBC-2].

The LEED system utilizes a list of performance based "credits" totaling 69 points. There are 4 prerequisite areas that every building must meet and several credit options in each area. These 69 credits are divided into six categories: Sustainable Sites (SS); Water Efficiency (WE); Energy and Atmosphere (EA); Materials and Resources (MR); Indoor Environmental Quality (IA); and Innovation & Design Process (ID). In order to attain LEED certification, a minimum of 26 points must be achieved. A Silver rating is achieved by earning between 33 and 38 points, Gold between 39-51 and Platinum between 52 and 69 points [USGBC-1]. The distribution of points by general category is shown in Figure 1.1 and Table 1.1 below.

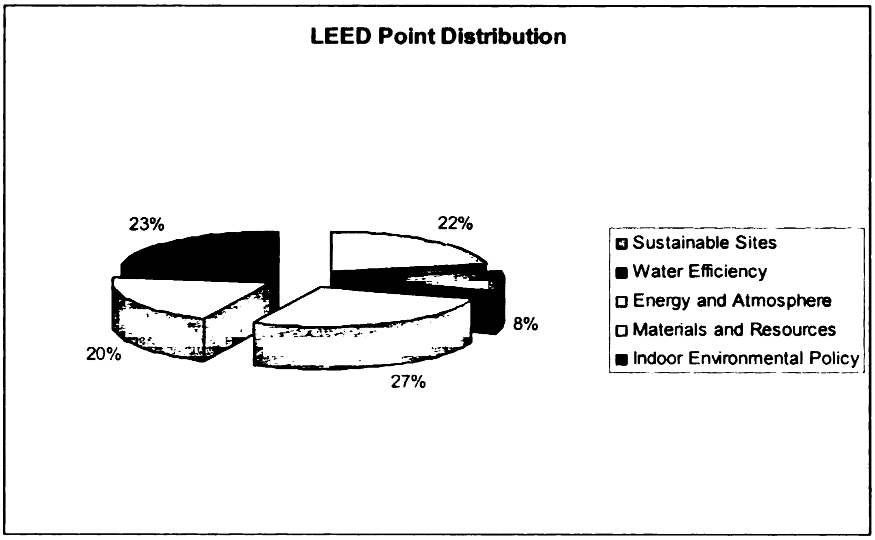

Figure 1.1: LEED Point Distribution [USGBC-1]

No. Of Credits in each Category	Category	Maximum points possible	%
8	Sustainable Sites	14	22%
3	Water Efficiency	5	8%
6	Energy and Atmosphere	17	27%
7	Materials and Resources	13	20%
8	Indoor Environmental Quality	15	23%
		64	
	Innovation and Design Process	4	
	LEED Accredited Professional	1	
	Total Points Available	69	

Table 1.1: LEED Point Distribution [USGBC-1]

1.3.1 LEED Sustainable Sites (SS) and Water Efficiency (WE) Credits

LEED SS Credits are designed to develop only appropriate sites, reuse existing buildings and / or sites, protect natural and agricultural areas, reduce the need for automobile use, and protect and / or restore natural sites [USGBC-2]. LEED WE credits aim to reduce the quantity of water needed for a building and its site and to reduce municipal water supply and treatment burden [USGBC-2]. Table 1.2 shows LEED-NC Version 2.2 point distribution for SS and WE credits.

LEED Rating System Point Categories and Possible Points

	Categories	*Possible Points*
Sustainable Sites		
Prereq 1	**Construction Activity Pollution Prevention**	Required
Credit 1	**Site Selection**	1
Credit 2	**Development Density & Community Connectivity**	1
Credit 3	**Brownfield Redevelopment**	1
Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	1
Credit 4.4	**Alternative Transportation**, Parking Capacity	1
Credit 5.1	**Site Development,** Protect of Restore Habitat	1
Credit 5.2	**Site Development,** Maximize Open Space	1
Credit 6.1	**Stormwater Design,** Quantity Control	1
Credit 6.2	**Stormwater Design,** Quality Control	1
Credit 7.1	**Heat Island Effect,** Non-Roof	1
Credit 7.2	**Heat Island Effect,** Roof	1
Credit 8	**Light Pollution Reduction**	1
Water Efficiency		
Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
Credit 2	**Innovative Wastewater Technologies**	1
Credit 3.1	**Water Use Reduction**, 20% Reduction	1
Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Table 1.2: LEED-NC Version 2.2 Point Distribution for SS and WE Credits [USGBC-2]

Appendix A provides a brief description of each of the SS and WE credits stating their intent, requirement and potential technologies and strategies as described in the LEED-NC Version 2.2 Reference Guide.

1.4 Research Goal and Objectives

The overall goal of this research is to facilitate sustainable development that has positive impacts on the environment and human health thus leading to the creation of healthy communities. In working towards achieving this goal, the research efforts were focused on these two steps:

1. Identifying the attributes of sustainable construction that are relevant in deciding to pursue or not to pursue specific LEED SS and WE credits.

2. Developing a decision-making framework to assist institutional owners in the task of deciding which LEED SS and WE credits to pursue within the context of specific projects.

1.5 Methodology

The research methods and activities were as follows:

1. **Literature Review**

The research explored and presented existing research on sustainable design decision-making methods, in order to identify an appropriate model to adopt for this research. Additionally, literature on importance of weighting attributes of sustainable development and studies addressing environmental, community and economic issues of LEED credits with emphasis on SS and WE credits were presented. Current status of LEED certified institutional buildings in the Great Lakes region was also analyzed.

2. **Identified attributes that influence the decision to use an individual LEED SS and WE credit**

The research identified attributes through literature review, analysis of interview responses of owners of four case study institutional projects in the Great Lakes region and analysis of data collected at a Collaborative Work Session held for the research project titled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006], conducted by the Construction Management and Landscape Architecture Programs in the School of Planning, Design and Construction at Michigan State University.

3. **Development of a framework to assist owners in deciding the use of sustainable site design practices for institutional buildings in the Great Lakes region**

The research adapted the AHP Multi-Attribute Model developed by Herkert et al. [1996] and the Sustainability Decision Support System Conceptual Framework developed by Pearce et al. [1995] to develop a new decision-making framework for aiding institutional owners as they consider use of specific LEED-NC 2.2 SS and WE credits.

4. **Proof of Concept**

   The framework was presented to owners of two of the case study projects in order to gain their perceptions on the comprehensiveness and usefulness of the framework.

5. **Demonstrative Case Study**

   A hypothetical case study of a community college was applied to show the use of the framework

6. **Final Revisions and Final Framework**

   Based on the conclusions of the proof of concept and the demonstrative case study, several terms in the framework were changed to make it more understandable and usable by owners and designers.

1.6 Deliverables

Through this research, the researcher developed and presented a framework for assisting owners in deciding to pursue or not to pursue individual LEED SS and WE credits within the context of cold climate institutional settings.

1.7 Research Scope and Limitations

As seen in Figure 1.2, within the larger realm of sustainable development, this research concentrated on the LEED Green Building Rating System. Within this smaller realm of the LEED Green Building Rating System, this research focused on LEED Sustainable Sites and Water Efficiency credits.

The limitations of the research were:

1. This research was focused on institutional projects in the Great Lakes region.
2. The focus of this research was primarily on the LEED Green Building Rating System and other standards of measuring sustainable development were not considered.

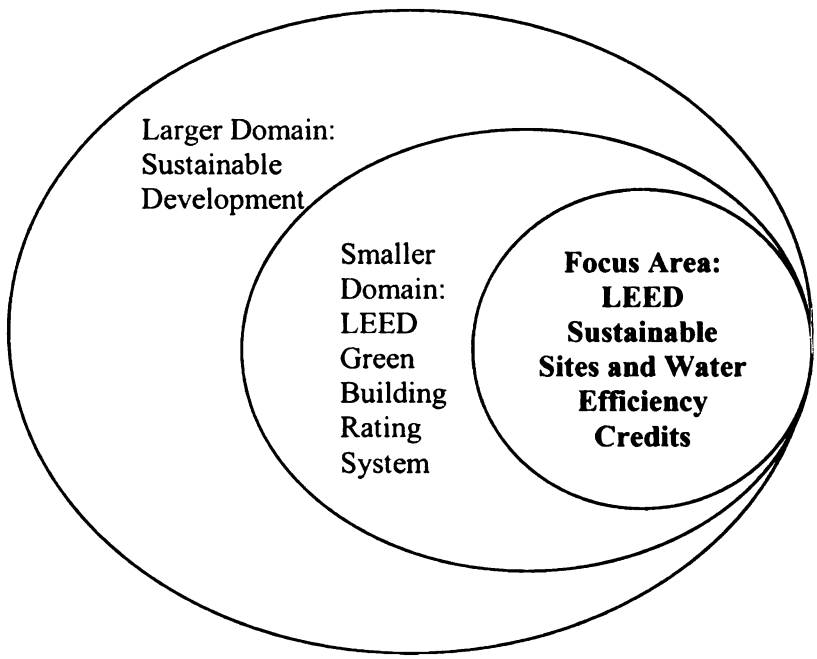

Figure 1.2: Realm and Focus Area of Research

3. The analysis was primarily focused on the LEED SS and WE Credits and other LEED credits were not considered.
4. The research examined institutional buildings that were certified under LEED Version 2.0 and LEED-NC Version 2.1 Certification. LEED Version 1.0 Certified projects were not considered.
5. Because of the recent development and issuance of LEED-NC 2.2, case studies were not found for LEED-NC 2.2.

6. There were a limited number of participants in the collaborative work session conducted for the research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006], whose responses were considered in identifying attributes, described in detail in chapters four and five of the thesis.
7. The collaborative work session participants included Michigan public officials from university and local governments; LEED Accredited Professionals (LAP) and design professionals including architects, planners, landscape architects, site engineers, and faculty and staff members from the Physical Plant Division at Michigan State University. These participants commented on the impact on the contractor of certain credits. However, there were no contractors at the work session.
8. This study used four case studies conducted for the research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006]. Additional case studies would be helpful in identifying attributes.
9. The attributes were identified by the researcher for each LEED SS and WE credits from the literature review, collaborative work session data and responses of owners of case study projects and were based on themes identified by the researcher rather than by quantitative methods.

1.8 Chapter Summary and Thesis Organization

This chapter presented the introduction, defined the problem area and a need for this research as well as identified the goal, objectives, methodology, deliverables, scope and limitations of the thesis. Additionally, the chapter provided an overview of LEED.

This thesis is presented in seven chapters and appendices. The first chapter introduced this thesis. The second chapter presents the literature review that includes existing research on sustainable decision-making, importance of weighting attributes of sustainable development and comparative analysis of LEED SS and WE credits based on environmental, community and economic issues. Additionally, the chapter establishes the current status of LEED accredited buildings in the Great Lakes region.

The third chapter describes the methodology used for the research. The fourth chapter presents the analyses of collaborative work session data and the owner responses of the four case studies conducted for the research "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006]. This chapter also identifies attributes related to each credit from the collaborative work session data, interview responses and literature review. The attributes identified from all the three sources are integrated and presented in a matrix according to their relation to the objectives of sustainable construction.

The fifth chapter summarizes the attributes that influence the decision to use individual LEED SS and WE credit. The sixth chapter presents a decision-making framework to assist institutional owners in deciding which LEED SS and WE credits to pursue within the context of specific projects. This chapter also presents proof of concept interviews, a framework demonstration and final revisions. The seventh chapter presents the research summary, areas for future research and conclusion of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of the literature review and is presented in the following four sections. Section 2.2 of this chapter describes existing decision-making frameworks for sustainable development. Section 2.3 includes discussion of studies on LEED SS and WE credits based on the three key objectives of sustainable development, which include environmental, community and economic issues [USGBC-2, Presley and Meade 2004 and ASTM 2004]. Existing literature on importance of weighting attributes of sustainable development is presented in Section 2.4. Finally, in Section 2.5, LEED certified buildings in the Great Lakes region are presented.

2.2 Existing Decision-Making Frameworks for Sustainable Development

This section presents existing decision-making frameworks for sustainable development and was used by the researcher to identify an appropriate model for adoption by this research. The frameworks addressed are 'The Konvergence Framework', 'Analytical Hierarchy Process Model', 'Environmental Decision-Making Process Framework', 'Sustainability Decision Support System Conceptual Framework' and 'Health Performance Criteria Framework'. The researcher explored frameworks that address environmental issues, community issues and economic issues of sustainable development.

2.2.1 The Konvergence Framework

Piet et al. [2003] at the University of Idaho developed the Konvergence Framework to make cleanup decisions using a 'mental model' that helped analyze and visualize the problem; 'strategy' that helped to include a wide range of alternatives and 'tactical processes' that is derived from experience, values and relevant literature. The 'mental model' states that sustainable decisions take place when knowledge, values and resources converge (the K, V, R in KONVERGENCE). "Knowledge means what is known about the problem and possible solutions, values mean what is important to those affected by the decision and resources mean what is available to implement possible solutions or improve knowledge. The problem can be analyzed and visualized with the help of this mental model as the decisions are made and kept" [Piet et al. 2003].

The left side of Figure 2.1 shows the KONVERGENCE framework, which includes the mental model, strategic improvements, tactical process improvements, and implications of research and development into possible solutions. The right side of Figure 2.1 shows the convergence of knowledge, values and resources so that the decisions work over time and help visualize what is happening. The key steps in the framework are [Piet et al. 2003]:

1. Determine alternatives that overlap with knowledge, values and resources.
2. Make sure that the knowledge is adequate by thoroughly investigating the problem and alternatives.
3. Include sufficient participation of diverse objectives in the values section of the process.
4. Make all key resources available in order to implement the decision.
5. Adopt the alternative where all three universes converge.

This framework has been developed to address decision challenges related to cleanup of contaminated waste sites and facilities. These decision challenges are complex, unusual, having high likelihood for conflict and relatively high ramifications extending over long time periods. However, the framework can be used for other applications with similar decision challenges for sustainable development [Piet et al. 2003].

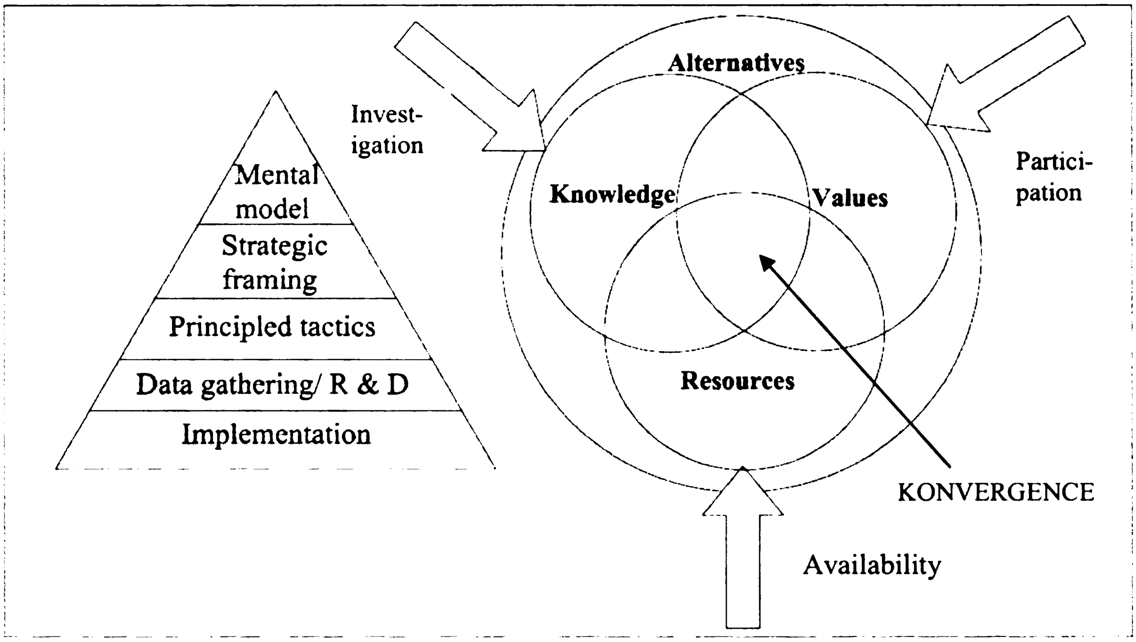

Figure 2.1: KONVERGENCE Framework (left) and KONVERGENCE Model (right)
Source: [Piet et al. 2003]

2.2.2 Analytical Hierarchy Process Model

Presley and Meade [2004] developed a conceptual decision model for Environmental Management Decision Making related to sustainable development and production, using the Analytical Hierarchy Process (AHP) as a framework. The "AHP is a comprehensive framework designed to deal with the intuitive, the rational, and the irrational when making multi-objective, multi-criterion and multi-actor decisions – exactly the decision-making situation found with environmental management. This framework assumes a unidirectional hierarchical relationship among decision levels. The top of the hierarchy (apex) is the overall goal for the decision model. The hierarchy then decomposes to a more specific characteristic until a level of manageable decision criteria is met. The hierarchy is a type of system where one group of entities influences another set of entities" [Presley and Meade 2004].

Identification of Criteria:

Literature was reviewed by Presley and Meade in order to identify evaluation criteria. Categories of factors identified were: stakeholders affected by implementation of the system and/or have input or influence into the decision process; benefits and disbenefits of sustainability referred to as the 'Dimensions of Sustainability' that helps in analysis, since it is believed that different stakeholders will have differing perceptions of the importance of the dimensions. Each dimension has some specific metrics that relates to the dimension [Presley and Meade 2004].

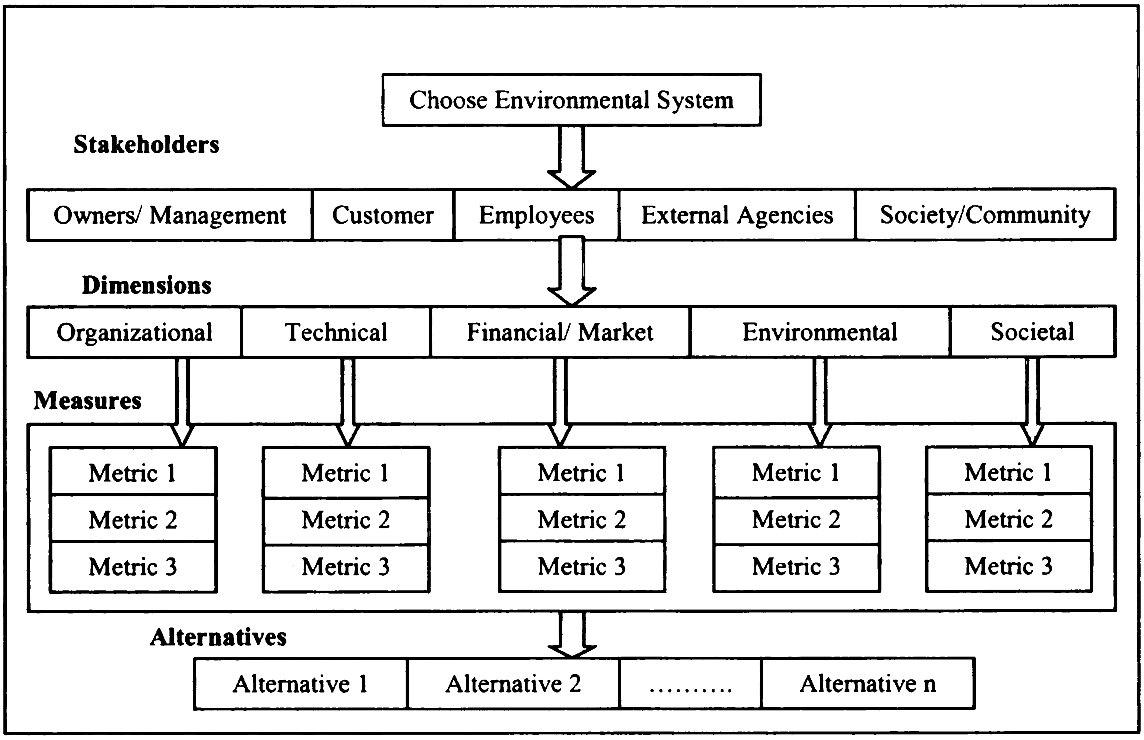

Figure 2.2: Generic Decision Framework [Presley and Meade 2004]

Development of the Model:

As seen in Figure 2.2, the apex of the framework developed by Presley and Meade [2004] is the environmental system for which the decision is to be made. The next level includes stakeholders such as Owners, Customer, Employees, etc. The third level is the 'Dimensions of Sustainability' discussed above, with different categories such as organizational, technical etc. each having metrics for evaluating the environmental system. For example, improved management, improved training, improved working conditions and safety all relate to the organizational dimension of sustainability. This level helps in analysis, since it is believed that different stakeholders will have differing perceptions of the importance of the dimensions. The lowest level of the model is the comparison of alternatives relative to each of the metrics [Presley and Meade 2004].

2.2.3 Environmental Decision-Making Process Framework

Tonn et al. [2000] developed a framework for understanding and improving public sector environmental decision-making. This comprehensive framework incorporates concepts from a number of fields such as planning, sociology, psychology, economics, etc.

The elements and activities that comprise the environmental decision-making process developed by Tonn et al. are listed in the framework as seen in Figure 2.3. The four major components are interrelated. The first component is the 'Environmental and Social Context' within which a decision is made. The second component is 'Planning and Appraisal' that precedes and follows decision-making. The next component is the 'Decision-making Modes' and last is the 'Decision Action' [Tonn et al. 2000].

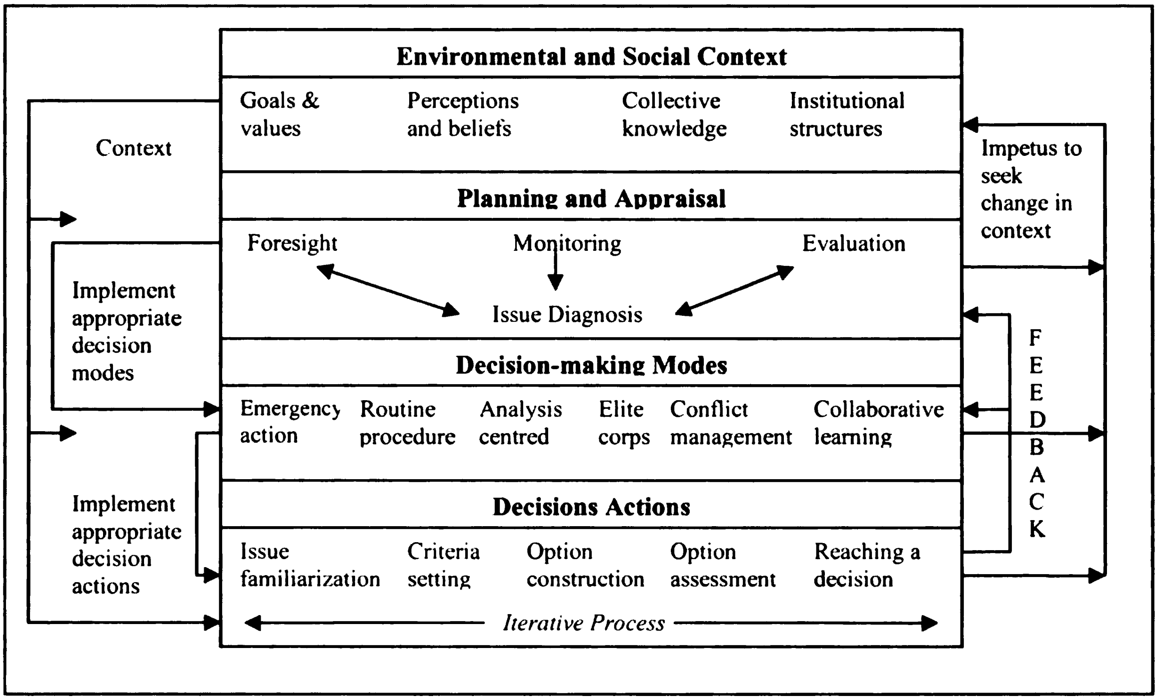

Figure 2.3: Environmental Decision Making: A Process Framework [Tonn et al. 2000]

Environmental and Social Context includes the goals and values related to environmental problems and the decision process, perceptions and beliefs of environmental problems, collective knowledge about environmental problems and the institutional structures within which the problems are addressed. Planning and Appraisal includes forecasting, monitoring and evaluating past decisions, which helps in issue diagnosis. Decision-making Modes include six ways of conducting an environmental solving process – emergency action, routine procedures, analysis-centered, elite corps, conflict management and collaborative learning. Decision Actions are the actual activities that lead to environmental decisions. It includes five steps: issue familiarization; criteria setting; option construction; option assessment; and reaching a decision. "This framework is designed not only to incorporate sustainability concerns but it also helps to enlighten interesting questions regarding institutional responsibility and decision process complexity" [Tonn et al. 2000].

2.2.4 Sustainability Decision Support System Conceptual Framework

Pearce et al. [1995] developed a conceptual framework for a sustainability decision support system (SDSS) to assist the materials selection and specification process. The SDSS framework was adopted and modified for this thesis research. Presented below is discussion of Pearce et al.'s [1995] original framework.

The SDSS Conceptual Framework helps designers in selecting materials that will enhance overall project sustainability. The first step in the development of the framework was to define sustainability with regards to construction materials, followed by making a complete list of variables that affect sustainability of materials. These variables were classified into the categories of technology, ecology, economics and ethics and are listed according to the three global objectives of sustainable construction: resource consumption, environmental impact and human satisfaction. Table 2.1 shows a

Factor	**Resource Consumption**	**Environmental Impact**	**Human Satisfaction**
Scope of harvest	•	•	•
Existence of harvest infrastructure	•	•	
Accessibility of raw materials	•	•	
Availability of material	•		
Abundance of raw materials	•	•	•
Degree of processing required	•	•	
Degree to which material is renewable	•	•	
Life cycle cost			•
Life span under conditions of projected use	•	•	•
Maintainability	•	•	•
Reusability	•	•	

Table 2.1: Attributes which Influence the Sustainability of Construction Materials [Pearce et al. 1995]

representative list of attributes, which affect the sustainability of construction materials. In the next step, a methodology for evaluating material sustainability was developed using a rational actor decision model. Finally, SDSS was developed based on the method of sustainability evaluation, to assist decision makers in the task of selecting materials.

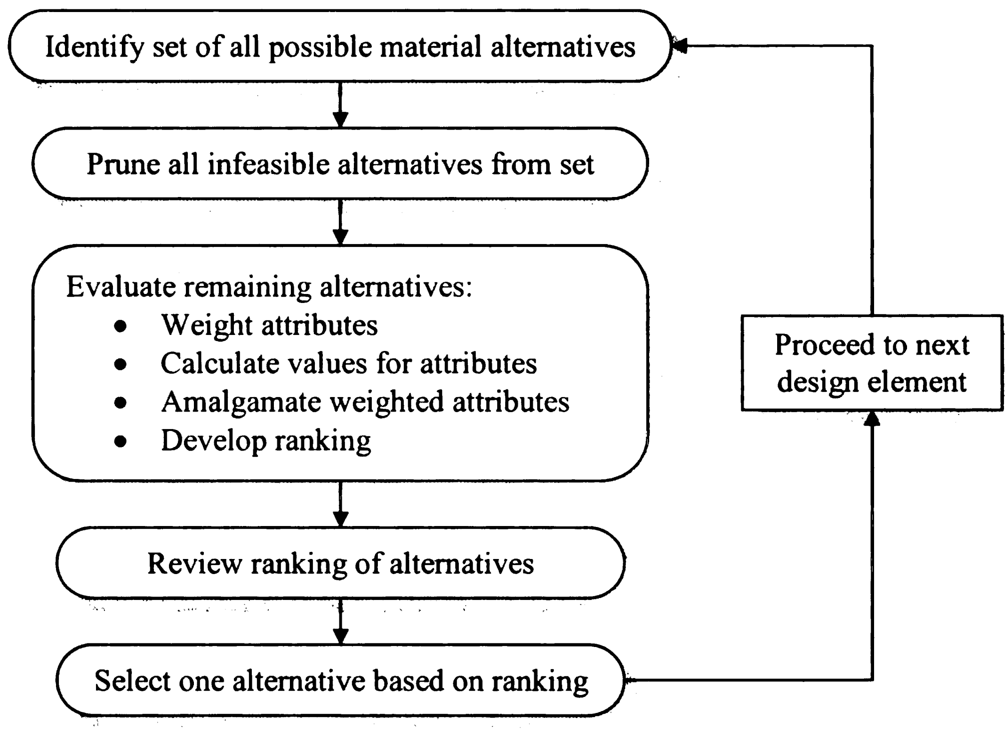

Figure 2.4: Materials Selection Methodology [Pearce et al. 1995]

Figure 2.4 shows the material selection methodology, which includes generating a list of all possible material alternatives, eliminating the materials that are not feasible from the list, evaluating the remaining materials and ranking them according to the utility of the material for an intended application. This is done by weighting the alternatives and calculating values for each variable. The alternative with the highest ranking is selected. The selection process then proceeds to the next element.

Figure 2.5 shows the SDSS Conceptual Framework for assisting sustainable materials selection. "First, the user describes the list of design elements, conceptual design and decision making parameters. The 'Material Choice Generator', with the help of Knowledge Base, Data Base and the information provided by the user, generates a list of feasible materials. The 'Value Extractor' then asks the user for attributes of sustainability based on owner's system of values. The Amalgamator Module then sorts the materials with relative ranking for each element based on the user's weightings and attribute values for each potential material. The material with the highest ranking is then recommended by the system. As the user selects materials, the knowledge base of the system checks to detect any potential conflicts between material choices. After material selection, the Sustainability Index Calculator provides a composite index of sustainability for the whole design" [Pearce et al. 1995].

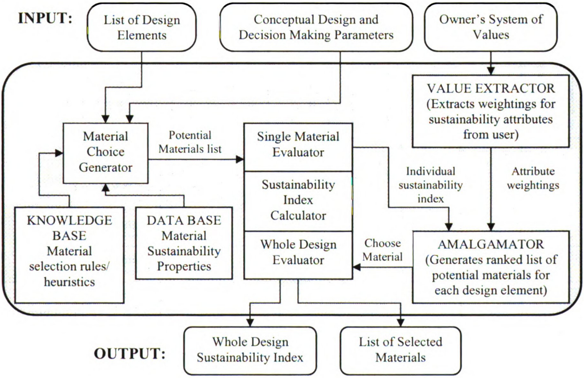

Figure 2.5: SDSS Conceptual Framework [Pearce et al. 1995]

2.2.5 Health Performance Criteria Framework

Pillai [2006] developed a Health Performance Criteria Framework for homes based on a "Whole House" approach and the "LEED" criteria. The "Whole House" approach encourages the idea that the home be viewed as a system composed of different components that work together so that negative interactions between various building systems can be avoided. External environment is inextricably connected to the indoor environment. The "LEED" green building criteria utilizes the whole system approach, with the intent to minimize environment damage attributable to buildings; while enhancing occupant health, safety and comfort" [Pillai 2006]. The Health Performance Criteria Framework consists of two sections. The first one is for compiling health performance goals as seen in Figure 2.6a and the next section is for building systems design/ construction/ integration strategies as seen in Figure 2.6b [Pillai 2006].

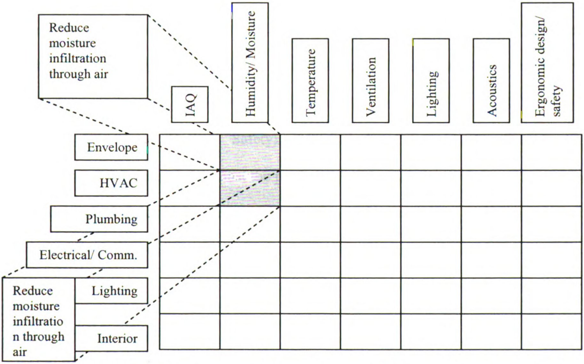

Figure 2.6a: Health Performance Criteria Framework – Health Performance Goals [Pillai 2006]

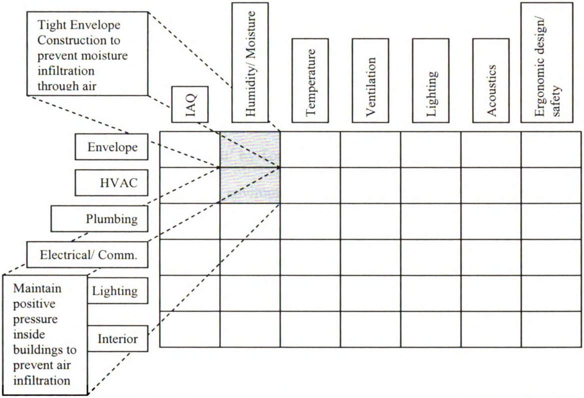

Figure 2.6b: Health Performance Criteria Framework – Building Systems D/C/I Strategies [Pillai 2006]

Figures 2.6a and 2.6b show building systems (Envelope, HVAC, Plumbing, Electrical/ Communication, Lighting and Interior) listed against seven health performance attributes (IAQ, Humidity/ moisture, Temperature, Ventilation, Lighting, Acoustics, Ergonomic Design/ Safety) identified by Pillai [2006]. The health performance goal is compiled against the particular building system and the performance attribute to which it is associated with. The health performance goal is then associated with a building systems design/construction/integration strategy in the next section of the framework. Strategies are specific to the user. The strategies section has provisions for scoring the performance and interaction potentials of each listed strategy [Pillai 2006].

The frameworks 'The Konvergence Framework', 'Analytical Hierarchy Process Model', 'Environmental Decision-Making Process Framework', 'Sustainability Decision

Support System Conceptual Framework' and 'Health Performance Criteria Framework', when taken together imply that environmental issues, community issues and economic issues are the key considerations. Although they are referred to differently, for instance, 'Environmental Impact and Human Satisfaction' by Pearce et al. [1995] and 'Environmental and Social Context' by Tonn et al. [2000], these four general themes can be extracted: cost, health benefits, environmental benefits and community benefits. After review of these frameworks, the 'Sustainability Decision Support System Conceptual Framework' developed by Pearce et al. [1995] was selected as a basis for developing a new decision-making framework for institutional owners in selecting LEED SS and WE credits because it helps to depict the role of each attribute in meeting the objectives of sustainable construction and considers multiple parameters affecting sustainability, unlike other models, which consider either economic issues or environmental issues only.

2.3 LEED SS and WE Credits Comparative Analysis

This section presents various studies that compare LEED SS and WE credits based on cost, environmental benefits and health benefits.

2.3.1 GSA Cost Study

The US General Services Administration (GSA) commissioned a study of two building designs and found a -0.4 to 2% cost increase for a LEED Certified level and -0.3 to 4.4% increase for LEED silver [SWA 2004]. This study is useful for this thesis research in documenting cost attributes of various LEED SS and WE credits. Tables 2.2a and 2.2b show a summary of the GSA study. All credit cost assumptions were made based on LEED-NC Version 2.1.

	New Courthouse (262,000 GSF, Base Construction Cost = $220/ GSF)					
	Certified		**Silver**		**Gold**	
	1A Low Cost	2A High Cost	1A Low Cost	2A High Cost	1A Low Cost	2A High Cost
LEED Construction Cost Impacts						
$/ GSF	($0.76)	$2.18	($0.07)	$9.57	$2.97	$17.79
% Change	-0.4%	1.0%	-0.03%	4.4%	1.4%	8.1%

Table 2.2a: LEED GSA Cost Study – New Courthouse [SWA 2004]

	Office Building Modernization (306,000 GSF, Base Construction Cost = $130/ GSF)					
	Certified		**Silver**		**Gold**	
	1A Low Cost	2A High Cost	1A Low Cost	2A High Cost	1A Low Cost	2A High Cost
LEED Construction Cost Impacts						
$/ GSF	$1.78	$2.73	$3.94	$5.55	$10.58	$10.22
% Change	1.4%	2.1%	3.1%	4.2%	8.2%	7.8%

Table 2.2b: LEED GSA Cost Study – Office Building Modernization [SWA 2004]

Additionally, this study analyzed the costs of each individual LEED prerequisite and credit and prepared a summary table, which classified costs in five categories as shown in Table 2.3 (only SS and WE credits shown).

1. GSA mandate (no cost)
2. No cost/ Potential Cost Decrease
3. Low Cost (<$50K)
4. Moderate Cost ($50K-150K)
5. High Cost (>$150K)

Credit	Credit Name	Cost Category
SS Prereq 1	**Erosion & Sedimentation Control**	2
SS Credit 1	**Site Selection**	2
SS Credit 2	**Development Density**	2
SS Credit 3	**Brownfield Redevelopment**	2
SS Credit 4.1	**Alternative Transportation**, Public Transportation Access	2
SS Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	5
SS Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	3
SS Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	3
SS Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	2
SS Credit 5.2	**Reduced Site Disturbance**, Development Footprint	2
SS Credit 6.1	**Stormwater Management**, Rate and Quantity	2 or 5
SS Credit 6.2	**Stormwater Management**, Treatment	4
SS Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	2
SS Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	2 or 5
SS Credit 8	**Light Pollution Reduction**	2
WE Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	2
WE Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	2
WE Credit2	**Innovative Wastewater Technologies**	Not pursued
WE Credit 3.1	**Water Use Reduction**, 20% Reduction	1
WE Credit 3.2	**Water Use Reduction**, 30% Reduction	4

Table 2.3: LEED Cost Categories [SWA 2004]

Winter found that SS Prerequisite SS1, Credits SS 1, SS 2, SS 3, SS 4.1, SS 5.1, SS 5.2, SS 7.1, SS 8, WE 1.1, WE 1.2, WE 3.1 were "No Cost Increase" or yielded "Cost Decreases". Credits SS 4.3 and SS 4.4 were found to lead to "Low" cost increases. WE 3.2 led to "Moderate" cost increase, SS 4.2 led to "High" cost increase and SS 6.2 and SS7.2 were found to lead to "Low" or "High" depending on design option used.

2.3.2 FPC Sustainability Guidelines

The Facilities Planning and Construction (FPC) Office of the University of Florida (UF) ranked each of the LEED credits and prerequisites to provide guidelines to the project team of the credit's applicability to UF facilities [FPC 2001]. Table 2.4

summarizes the ranking for each credit (only SS and WE credits shown). The credits were ranked as:

- "Required" (Req) – Credits required by law or by FPC.
- "Highly Recommended" (HR) – Credits that do not add cost or have strong life cycle cost justification
- "Recommended" (R)– Credits to be tested with regards to specific design solutions
- "Conditionally Recommended" (CR) – Credits not beneficial to all applications

FPC Sustainability Guidelines "Highly Recommended" credits SS1, SS4.1, SS4.2, SS4.4, SS5.1, SS5.2, SS6.2, SS7.1, SS7.2, SS8, WE1.1, WE1.2, WE2, WE3.1 and WE3.2 for UF projects. Credits SS2, SS4.3 and SS6.1 were "Recommended" and credit SS3 was "Conditionally Recommended". Credit SS Prerequisite 1 was "Required" by LEED and its compliance was mandatory on the UF campus.

Credit	Credit Name	Ranking
SS Prereq 1	**Erosion & Sedimentation Control**	Req
SS Credit 1	**Site Selection**	HR
SS Credit 2	**Development Density**	R
SS Credit 3	**Brownfield Redevelopment**	CR
SS Credit 4.1	**Alternative Transportation**, Public Transportation Access	HR
SS Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	HR
SS Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	R
SS Credit 4.4	**Alternative Transportation**, Parking Capacity	HR
SS Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	HR
SS Credit 5.2	**Reduced Site Disturbance**, Development Footprint	HR
SS Credit 6.1	**Stormwater Management**, Rate and Quantity	R
SS Credit 6.2	**Stormwater Management**, Treatment	HR
SS Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	HR
SS Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	HR
SS Credit 8	**Light Pollution Reduction**	HR
WE Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	HR
WE Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	HR
WE Credit2	**Innovative Wastewater Technologies**	HR
WE Credit 3.1	**Water Use Reduction**, 20% Reduction	HR
WE Credit 3.2	**Water Use Reduction**, 30% Reduction	HR

Table 2.4: FPC Sustainability Guidelines [FPC 2001]

2.3.3 Study by David Eijadi, et al. [2002]

Eijadi et al. [2002], on the basis of their LEED project experience as certified consultants, analyzed LEED credits by their direct or indirect value towards environmental benefits, healthy buildings and profitability [Eijadi et al. 2002]. Table 2.5 shows LEED credit categories based on Environment, Health and Cost Issues (only SS and WE credits are shown).

Table 2.5 indicates that all SS and WE credits address environmental concerns whereas none address health concerns; Credits WE1.1, WE1.2, WE2, WE3.1 and WE3.2 are cost effective for the owner; Credits SS Prerequisite 1, SS1, SS2, SS4.1, SS6.1 and SS8 can be achieved through standard practice; Credits SS4.2, SS4.4, SS5.1, SS5.2, SS7.1, WE1.2 and WE3.1 can be achieved through increased design effort but minimal construction cost and Credits SS3, SS4.3, SS6.2, SS7.2, WE1.1, WE2 and WE3.2 are those that lead to significant increased costs.

Researcher's Note: This lack of relationship to health impacts indicated by Eijadi et al. [2002] is not consistent with other literature. When considering health impacts, there may be "direct" health effects and "indirect" health effects. Direct impacts relate to benefits that can be correlated specifically with a design aspect and a benefit such as improved drinking water quality whereas reducing automobile use by encouraging use of public transportation likely improves the environment and therefore health. But its effects cannot be immediately and directly correlated to health improvement of a specific individual. This research suspects that Eijadi et al. may be indicating no "direct" health effects.

Credit	Credit Name	Environment Credits	Health Credits	Owner $ Benefit	Standard Practice	Design Effort, Minor Construction $	Significant Construction $
SS Prereq 1	**Erosion & Sedimentation Control**				Y		
SS Credit 1	**Site Selection**	1			1		
SS Credit 2	**Development Density**	1			1		
SS Credit 3	**Brownfield Redevelopment**	1					1
SS Credit 4.1	**Alternative Transportation**, Public Transportation Access	1			1		
SS Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1				1	
SS Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1					1
SS Credit 4.4	**Alternative Transportation**, Parking Capacity	1				1	
SS Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1				1	
SS Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1				1	
SS Credit 6.1	**Stormwater Management**, Rate and Quantity	1			1		
SS Credit 6.2	**Stormwater Management**, Treatment	1					1
SS Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1				1	
SS Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1					1
SS Credit 8	**Light Pollution Reduction**	1			1		
WE Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1		1			1
WE Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1		1		1	
WE Credit2	**Innovative Wastewater Technologies**	1		1			1
WE Credit 3.1	**Water Use Reduction**, 20% Reduction	1		1		1	
WE Credit 3.2	**Water Use Reduction**, 30% Reduction	1		1			1

Table 2.5: LEED Credits: Environment, Health and Cost Issues [Eijadi et al. 2002]

2.3.4 Land Policy Project

For the project "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] conducted by the Construction Management and Landscape Architecture Programs in the School of Planning, Design and Construction at Michigan State University, the researchers developed a table comparing LEED SS and WE credits based on literature evidence of health benefits, the GSA LEED credit cost study by Winter, LEED-NC credits obtained by the 63 Great Lakes region projects, LEED-NC credits obtained by four case studies, case study cost increases if any, collaborative work session recommendations for adoption of LEED- NC credits, work session perceived cost increases from the LEED-NC credits, work session perceived environmental benefits and work session perceived health benefits [Mrozowski et al. 2006]. Table 2.6 shows the summary table.

An important focus of the literature review of this study was to document health benefits of sustainable design practices. In order to organize the literature, a table was developed that related the individual LEED standards with, its intent, green building concerns, health effects, requirements and strategies. An excerpt of the health related literature table showing literature connection to health benefits for SS Credit 4.3: Alternative Transportation: Low Emitting & Fuel Efficient Vehicles is shown in Table 2.7. Similar tables were developed for each of the SS and WE credits in the Land Policy Project report.

The Land Policy Project concluded that credits SS Prerequisite 1, SS1, SS4.1, SS4.4, SS6.1, SS7.1, SS7.2, SS8, WE1.1 and WE3.1 are "Highly Recommended for Adoption"; credits SS4.2, SS4.3, WE2 and WE3.2 are "Recommended for Adoption"; credits SS2, SS3, SS5.1, SS6.2 and WE1.2 are "Situation Dependent" and credit SS5.2 is "Not Recommended as Criteria for Site Selection" in cold climate institutional settings [Mrozowski et al. 2006].

Credit	Credit Name	Lit Health Evidence	GSA Study Cost Increases	63 LEED Credit % Achieved	4 Case Study Credit % Achieved	Case Study Cost Increases	Recommendation for Adoption Work Session	Cost Increase Work Session	Enviro Benefit Work Session	Health Benefit Work Session
Sustainable Sites										
SS Prereq 1	Construction Activity Pollution Prevention		No cost	100	100	No cost	Highly Recommended	Low/no cost	High	Medium
SS Credit 1	Site Selection	Yes/atuo use	No cost	76	50	No cost	Situational/ Highly Recommended	High Costs	High	Medium
SS Credit 2	Development Density & Community Connectivity	Yes/auto use/psyc	No cost	22	0		Situational/ Highly Recommended	High Costs	High	High
SS Credit 3	Brownfield Redevelopment		No cost	17	0		Situational/ Highly Recommended	High Costs	High	High
SS Credit 4.1	Alternative Transportation, Public Transportation Access	Yes/atuo use/heat	No cost	62	75	No cost	Situational/ Highly Recommended	Low/no cost	High	Medium
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	Yes/atuo use/heat	High cost	83	25	No cost	Highly Recommended	Low/no cost	High	High
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	Yes/atuo/ water use	Low	32	0		Situational/ Highly Recommended	Medium cost	Medium	Low
SS Credit 4.4	Alternative Transportation, Parking Capacity	Yes heat	Low	59	25	No cost	Highly Recommended	Low/no cost	Medium	Low
SS Credit 5.1	Site Development, Protect of Restore Habitat	Yes psyc	No cost	38	25	No cost	Situational/ Highly Recommended	Medium cost	High	Medium

Table 2.6: Summary LEED SS and WE Credit Analysis [Mrozowski et al. 2006]

Credit	Credit Name	Lit Health Evidence	GSA Study Cost Increases	63 LEED Credit % Achieved	4 Case Study Credit % Achieved	Case Study Cost Increases	Recommendation for Adoption Work Session	Cost Increase Work Session	Enviro Benefit Work Session	Health Benefit Work Session
SS Credit 5.2	Site Development, Maximize Open Space	Yes psyc	No cost	64	50	No cost	Low Recommendation Situational	High Costs	High	Medium
SS Credit 6.1	Stormwater Design, Quantity Control	Yes water use	Variable Option Dependent	43	0		Highly Recommended	Low/no cost	High	Medium
SS Credit 6.2	Stormwater Design, Quality Control	Yes water use	Moderate	33	25	No cost	Situational/ Highly Recommended	Medium cost	High	High
SS Credit 7.1	Heat Island Effect, Non-Roof	Yes heat	No cost	60	75	Low cost Increased conc cost	Low Recommendation Situational	Medium cost	Medium	Medium
SS Credit 7.2	Heat Island Effect, Roof	Yes heat	Variable Option Dependent	54	75	No cost	Situational/ Highly Recommended	Low/no cost/Reflective roof/High Cost Green roof	High	High
SS Credit 8	Light Pollution Reduction		No cost	57	75	No cost	Situational/ Highly Recommended	Low/no cost	High	Low

Table 2.6 (Continuation): Summary LEED SS and WE Credit Analysis [Mrozowski et al. 2006]

Credit	Credit Name	Lit Health Evidence	GSA Study Cost Increases	63 LEED Credit % Achieved	4 Case Study Credit % Achieved	Case Study Cost Increases	Recommendation for Adoption Work Session	Cost Increase Work Session	Enviro Benefit Work Session	Health Benefit Work Session
Water Efficiency										
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%	Yes mold	No cost	89	75	No cost/rain collection	Highly Recommended	Low/no cost	Medium	Medium
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	Yes mold	No cost	78	50	No cost	Low Recommendation Situational	High Costs	Medium	Low
WE Credit 2	Innovative Wastewater Technologies		Not Pursued	24	25	No cost high cost compost grey water	Highly Recommended	Low cost/High Cost Option	Medium	Medium
WE Credit 3.1	Water Use Reduction, 20% Reduction		No cost	67	75	No cost high cost compost grey water	Highly Recommended	Medium cost	Medium	Medium
WE Credit 3.2	Water Use Reduction, 30% Reduction		Moderate	57	50	No cost high cost compost grey water	Divergent opinions	High Costs	Medium	Low

Table 2.6 (Continuation): Summary LEED SS and WE Credit Analysis [Mrozowski et al. 2006]

LEED Credit	Health Effects			Intent	Green Building Concerns			Requirements	Strategies
	Direct (Primary)	Indirect (Secondary)	Indirect (Tertiary)		Environmental Issues	Economic Issues	Community Issues		
SS Credit 4.3 - Alternative Transportation: Low Emitting & Fuel Efficient Vehicles	Short-term (i.e., acute) exposures can cause irritation and inflammatory symptoms of a transient nature (EPA, 2002). Ozone can exacerbate chronic respiratory diseases & cause short-term reductions in lung function. Health effects of exposures to CO, SO2, & NO2 can include reduced work capacity, aggravation of existing cardiovascular diseases, effects on pulmonary function, respiratory illnesses, lung irritation, and alterations in the lung's defense systems (Bernard et al., 2001)	Exposure to particulate matter can aggravate chronic respiratory and cardiovascular diseases, alter host defenses, damage lung tissue, lead to premature death, & possibly contribute to cancer (Bernard et al., 2001)	Long-term health care costs due to respiratory ailments.	"Reduce pollution and land development impacts from automobile use."	Operation of vehicles contribute to global change and air quality problems through the emission of green house gases & other pollutants generated from combustible engines and fuel evaporation. Vehicles also generate large portions of air pollutants responsible for smog and ground level ozone. Alternative fuel and alternative technology vehicles offer the possibility of reducing air pollutants from vehicular travel as well as the environmental effects of producing gasoline.	For fuel-efficient vehicles, reduced operating costs on a per-mile basis can offset higher initial purchase prices or higher fuel costs.	Decreased dependence on fossil fuels; decreased disruption of natural ecosystems, secondary to oil and gas exploration; cleaner air.	• Provide low-emitting and fuel-efficient vehicles for 3% of Full-Time Equivalent occupants AND provide preferred parking for these vehicles. OR • Provide preferred parking for low-emitting and fuel-efficient vehicles for 5% of the total vehicle parking capacity of the site. 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).	Provide transportation amenities such as alternative fuel refueling stations. Consider sharing the costs and benefits of refueling stations with neighbors.

Table 2.7: Excerpt of the Health Related Literature Review Matrix for SS Credit 4.3 [Mrozowski et al. 2006]

2.4 Existing Literature on Importance of Weighting Attributes of Sustainable Development

2.4.1 The Flag Model

Nijkamp and Ouwersloot [1998] developed the Flag Model for an empirical assessment of sustainability issues. Indicators of sustainability in the model are used in combination with Critical Threshold Values (CTV) that addresses the all-or-nothing character of sustainability. The Maximum CTV indicates the scenario is truly unsustainable whereas the Minimum CTV indicates the scenario is sustainable [Nijkamp and Ouwersloot 1998]. Figure 2.7 shows the range of CTV values.

```
                                   CTVmin      CTV       CTVmax
|----------------------------------|-----------|----------|------
0             A                      B     100     C          D
```

Figure 2.7: Range of CTV Values [Nijkamp and Ouwersloot 1998]

The line segments are interpreted in the following imaginative way:

- Section A: 'Green' Flag: no reason for specific concern
- Section B: 'Orange' Flag: be very alert
- Section C: 'Red' Flag: reverse trends
- Section D: 'Black' Flag: stop further growth

In the case of different perceptions or views on CTV of each sustainability indicator, the ranges are superimposed, and the indicator can then be classified as (a) entirely sustainable, (b) almost sustainable, (c) moderately sustainable, (d) moderately unsustainable, (e) almost unsustainable or (f) unsustainable. However, the sustainability indicator may fall in entirely different domain and in such a scenario; multiple criteria methods are useful since it allows using different weights for different indicators [Nijkamp and Ouwersloot 1998].

2.4.2 Multi-Attribute Model Using AHP

Herkert et al. [1996] developed a multi-attribute model using AHP to help make decisions for sustainable development. Such models are useful when there are multiple dimensions to a problem, such as in sustainability indicator sets where there are many different attributes. This model structures a problem, determines all-important attributes, weights their relative contribution to the problem and scores possible outcomes in terms of each attribute. The Multi-attribute model is shown in Figure 2.8 in the form of a decision hierarchy [Herkert et al. 1996].

The overall goal is decomposed into attributes and each attribute is assigned a weight to show how important the attribute is in order to achieve the goal. Weights of attributes are determined using the AHP. Scores that measure the performance of each alternative in terms of each attribute are created and the weights and the score together create a weighted additive function by which each alternative is evaluated in terms of the overall goal [Herkert et al. 1996].

"These models are used where there are multiple stakeholders in order to identify where differences between stakeholders are rooted, in identifying and weighting attributes and in determining the scores. The scoring techniques help in resolving the differences between stakeholders and when different attributes are selected by the stakeholders, the model helps to reduce conflict between them" [Herkert et al. 1996].

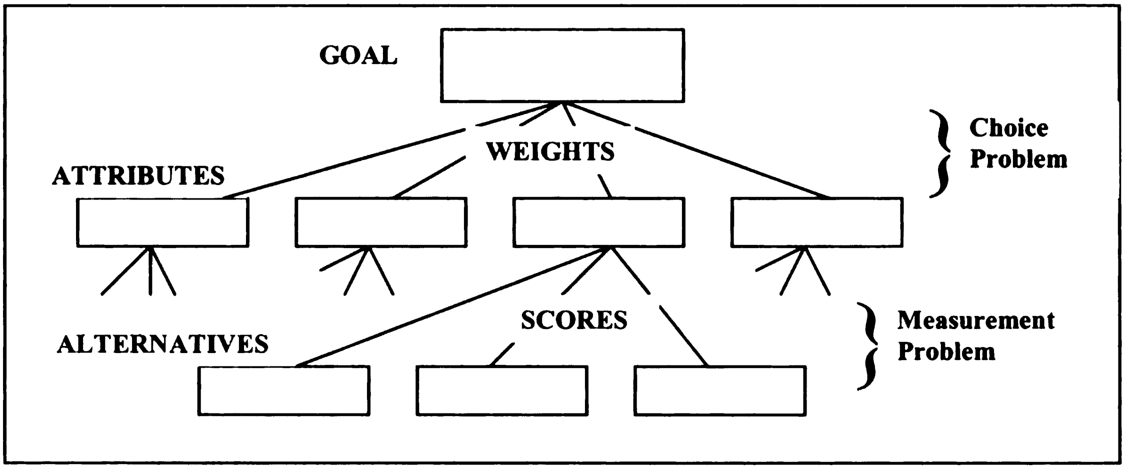

Figure 2.8: Hierarchy in Multi-Attribute Decisions [Herkert et al. 1996]

This concept of weighting is essential in selecting various design solutions. Weightings are owner and project specific and are not developed by this thesis. This weighting process must be undertaken by each owner. Discussion of weighting activities is further presented in Section 6.2 of this thesis.

2.5 Current Status of LEED Accredited Buildings in the Great Lakes Region

According to the LEED Certified Projects list[1], as of June 8, 2006, there were 63 LEED-NC versions 2.0 and 2.1 certified projects in the Great Lakes region. Figure 2.9 shows the states included in the Great Lakes region. They are Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin. Provinces in Canada are not included in this research.

[1] From USGBC website
http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx?CMSPageID=244&CategoryID=19&
Viewed – June 8, 2006

Figure 2.9: States Included in the Great Lakes Region.
Source: http://www.usembassycanada.gov/content/can_usa/images/GREATLAKES2.jpg
(Visited - May 17, 2006)

Appendix A provides information about these projects. Of the 63 LEED certified projects in the Great Lakes region, 28 were certified under LEED-NC 2.1 and 35 were certified under LEED-NC 2.0. The numbers of projects certified under LEED-NC version 2.1 by state are as follows: Michigan (7), Ohio (2), Illinois (4), Wisconsin (1), Minnesota (0), Indiana (0), Pennsylvania (9) and New York (5). Certified LEED version 2.0 projects by state are: Michigan (8), Ohio (2), Illinois (2), Wisconsin (3), Minnesota (1), Indiana (1), Pennsylvania (13) and New York (5). For each of these projects, the SS and WE credits that were successfully obtained are shown in Appendix B. Appendix C shows the percent distribution of each of the SS and WE credits for each state in the Great Lakes region.

Tables 2.8 and 2.9 are based on the entire 63 project set and show the percentage distribution of LEED-NC Versions 2.1 and 2.0 Sustainable Sites and Water Efficiency credits respectively achieved by Great Lakes region states. The 63 projects received 441 points in the Sustainable Sites category with of an average of 7 per project. A total of 198 points were achieved in the Water Efficiency category for an average of 3.14 points per project. In total 639 points were achieved in the combined Sustainable Sites and Water Efficiency categories, with an average point total of 10.14 points per project.

Credit	# Of projects	% Total
SS1	48	76.19048
SS2	14	22.22222
SS3	11	17.46032
SS4.1	39	61.90476
SS4.2	52	82.53968
SS4.3	20	31.74603
SS4.4	37	58.73016
SS5.1	24	38.09524
SS5.2	40	63.49206
SS6.1	27	42.85714
SS6.2	21	33.33333
SS7.1	38	60.31746
SS7.2	34	53.96825
SS8	36	57.14286

Table 2.8: Percent Distribution of Sustainable Sites Credits for 63 LEED Certified Buildings in the Great Lakes Region (LEED-NC Versions 2.0 and 2.1 Combined) (Adopted from data obtained at www.USGBC.org, date visited - June 2006)

Credit	# Of projects	% Total
WE1.1	56	88.88889
WE1.2	49	77.77778
WE2	15	23.80952
WE3.1	42	66.66667
WE3.2	36	57.14286

Table 2.9: Percent Distribution of Water Efficiency Credits for 63 LEED Certified Buildings in the Great Lakes Region (LEED-NC Versions 2.0 and 2.1 Combined) (Adopted from data obtained at www.USGBC.org, date visited - June 2006)

From the tabular data, it is clear that a majority of projects achieved several LEED-NC Sustainable Sites and Water Efficiency credits and only a limited number of projects achieved other credits. Table 2.10 shows the LEED-NC Version 2.1 and 2.0 credits in descending percentage order for all Great Lakes region projects. All projects achieved SS Prerequisite 1: Construction Activity Pollution Prevention (100%). Credits most commonly achieved (above 75%) were SS 4.2: Alternative Transportation, Bicycle Storage & Changing Rooms (83%), SS 1: Site Selection (76%), WE 1.1: Water Efficient Landscaping, Reduce by 50% (89%) and WE 1.2: Water Efficient Landscaping, No Potable Use or No Irrigation (78%).

Sustainable Sites

Credit Number	Credit Name	Percentage
100% to 75% of projects		
Prerequisite 1	Construction Activity Pollution Prevention	100%
SS 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	83%
SS 1	Site Selection	76%
75% to 50% of projects		
SS 5.2	Site Development, Maximize Open Space	63.5%
SS 4.1	Alternative Transportation, Public Transportation Access	62%
SS 7.1	Heat Island Effect, Non-Roof	60%
SS 4.4	Alternative Transportation, Parking Capacity	59%
SS 8	Light Pollution Reduction	57%
SS 7.2	Heat Island Effect, Roof	54%
Less than 50% of projects		
SS 6.1	Stormwater Design, Quantity Control	43%
SS 5.1	Site Development, Protect of Restore Habitat	38%
SS 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	38%
SS 6.2	Stormwater Design, Quality Control	33%
SS 2	Development Density & Community Connectivity	22%
SS 3	Brownfield Redevelopment	17%

Water Efficiency

Credit Number	Credit Name	Percentage
100% to 75% of projects		
WE 1.1	Water Efficient Landscaping, Reduce by 50%	89%
WE 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	78%
75% to 50% of projects		
WE 3.1	Water Use Reduction, 20% Reduction	67%
WE 3.2	Water Use Reduction, 30% Reduction	57%
Less than 50% of projects		
WE 2	Innovative Wastewater Technologies	24%

Table 2.10: Descending Order Percent Distribution of Sustainable Sites and Water Efficiency Credits for 63 LEED Certified Buildings in the Great Lakes Region (LEED-NC Versions 2.0 and 2.1 Combined)
(Adopted from data obtained at www.USGBC.org, date visited - June 2006)

LEED credits where 75% -50% of the projects achieved the credit were SS 5.2: Site Development, Maximize Open Space (63.5%), SS 4.1: Alternative Transportation, Public Transportation Access (62%), SS 7.1: Heat Island Effect, Non-Roof (60%), SS 4.4: Alternative Transportation, Parking Capacity (59%), SS 8: Light Pollution Reduction (57%), SS 7.2: Heat Island Effect, Roof (54%), WE 3.1: Water Use Reduction, 20% Reduction (67%) and WE 3.2: Water Use Reduction, 30% Reduction (57%).

LEED credits achieved by less than 50% of the projects included SS 6.1: Stormwater Design, Quantity Control (43%), SS 5.1: Site Development, Protect of Restore Habitat (38%), SS 4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles (38%), SS 6.2: Stormwater Design, Quality Control (33%), SS 2: Development Density & Community Connectivity (22%), SS 3: Brownfield Redevelopment (17%) and WE 2: Innovative Wastewater Technologies (24%). These credits may be situational based (i.e. if the site is not a brownfield site then that credit cannot be achieved) or have high associated costs.

2.6 Chapter Summary

This chapter summarized literature on existing decision-making frameworks for sustainable development and LEED credits comparative analysis. Additionally, existing literature on the importance of weighting attributes of sustainable development was presented and the current status of LEED certified buildings in the Great Lakes region was analyzed. The next chapter describes the methodology used for this research.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodology that was used to complete this research. Interview responses from four case studies and data collected at a collaborative work session were used in this research. The case studies and work session were conducted as part of research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] (referred to as the 'Land Policy Project'). This chapter also describes how the collaborative work session data and interview responses were analyzed and used to identify attributes relevant in deciding to pursue or not to pursue the individual LEED SS and WE credit. The fourth chapter presents data from the collaborative work session and the responses from the owners and identifies attributes related to each credit.

3.2 Methodology

The methodology that used for this research is depicted in Figure 3.1 and consisted of the following core activities:

1. Definition of research project, its goals and objectives.
2. Literature review of existing decision-making frameworks for sustainable development, comparative analysis of LEED credits, weighting attributes of sustainable development and current status of LEED accredited buildings in the Great Lakes region.
3. Extraction and analysis of data from the collaborative work session of Michigan public officials from state, university and local governments, LEED certified professionals and design and construction individuals including architects, planners, landscape architects; and LEED consultants, construction managers, and

contractors who are familiar with LEED standards and processes. The purpose of the collaborative work session was to gain input and advice from experienced design, planning and construction professionals on LEED credits affecting site and water requirements only.

4. Extraction and analysis of data from the interview responses of owners of four case study projects consisting of institutional buildings in the Great Lakes region.
5. Identification of attributes for each SS and WE credit with the help of literature review, collaborative work session responses and data obtained from case study projects.
6. Development of a framework to assist institutional owners in deciding which site related credits to pursue or not to pursue for their projects.
7. Interviews of owners of the case study projects in order to review the framework and gain their opinions about the comprehensiveness and usefulness of the framework.
8. Application of the framework to a hypothetical case study.
9. Revisions to the framework.
10. Final reporting and development of conclusions.

Sections 3.3 through 3.8 describe the methodology in detail.

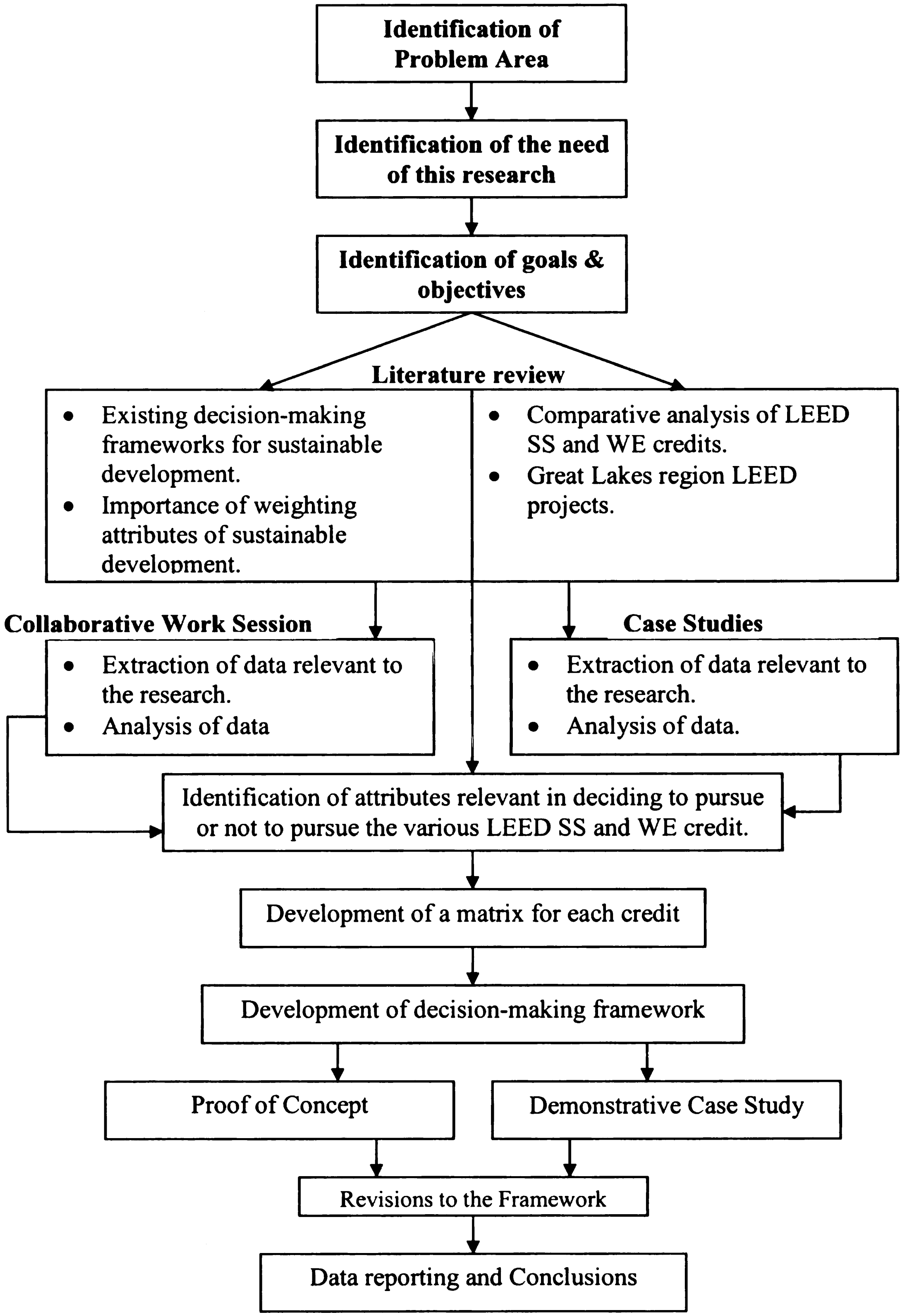

Figure 3.1: Thesis Methodology

3.3 Literature Review

The researcher reviewed technical papers and journal articles to identify existing decision-making frameworks for sustainable development, weighting attributes of sustainable development and comparative analysis of LEED credits. The current status of LEED accredited buildings in the Great Lakes region (with a focus on SS and WE credits) was documented using data from the USGBC website. Chapter two presented the literature, which the researcher regarded as relevant to this thesis.

3.4 Collaborative Work Session

Data collected at a Collaborative Work Session held for the research titled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] was used for this research. The primary objective of the collaborative work session held in April 2006 at Michigan State University was to gain perceptions from design, planning and construction professionals on LEED credits affecting site and water requirements. Three areas of concern served as the focus of the session: 1) what assumptions and premises must be made when evaluating LEED credits for northern climates; 2) which LEED credits are appropriate for use in cold climate institutional settings; and 3) what recommendations and strategies must accompany the LEED site related credits for compliance in northern climates.

Figure 3.2 shows a snapshot of the work sheets used by the work session participants. Appendix E shows the sample work sheet used for the collaborative work session in its entirety. Work session responses were transferred to Excel Spreadsheets and data relevant to this research was extracted from the spreadsheets. Responses obtained for the questions regarding organizational benefits and concerns in pursuing specific credits, strategies that could be used for compliance and the situational criteria that could influence the use of specific credits were used for this thesis research. Additionally, quadrant analyses completed by the work groups which related overall cost of complying with a standard to its benefit was used for this research. Options in the quadrant analysis included: High Cost/High Overall Benefit, High Cost/Low Overall Benefit, Low Cost/High Overall Benefit, Low Cost/Low Overall Benefit. This data helped to identify attributes that are related to each credit and are important in the decision-making process. Chapter four describes the collaborative work session data.

Collaborative Session Work Sheet

SS Credit 1: Site Selection

The intent of this credit is to avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site [USGBC-2].

Refer to separate summary of LEED-NC 2.2 in Work Session packet for summary of requirements.

Evaluate the standard in the context of public institution projects for the Great Lakes region / cold climates.

What organizational benefits / concerns do you foresee in pursuing this credit-standard?

Rank environmental benefits ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Figure 3.2: Partial Collaborative Session Work Sheet

3.5 Case Studies

Interview responses obtained from four case studies undertaken for the research entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] were also used in this research. Interviews with case study owners were aimed at gathering information about decision-making parameters that influence whether to pursue or not to pursue specific LEED SS and WE credits, as well as to gain insight into the organizational benefits and concerns that a project team expresses in selecting individual LEED SS and WE credits for their projects.

Interview data was recorded in Excel spreadsheets and data relevant to this research was extracted from the spreadsheets. Figure 3.3 is a snapshot of the interview questionnaire and Appendix F shows the full questionnaire used for the interviews. General themes regarding organizational benefits and concerns that were expressed by the project team for pursuing or not pursuing LEED SS and WE credits were considered. For each credit, the cost associated with required documentation, designing, planning, engineering, material purchase, construction labor and construction project management were considered as relevant. Chapter four presents the interview responses.

A	B	C	D	E	F	G	H	I
Q1. Is the attached list of credits on USGBC website correct?				☐ Yes	☐ No			
Q2. Your project was certified under which LEED™ standard?				☐ LEED 2.0	☐ LEED-NC 2.1			
For each LEED Site and Water related credit answer the questions in each column (This is an Excel Spreadsheet, use arrow keys to scroll)								
LEED™ credit-standard	**Prereq 1 (Erosion and Sedimentation Control)**	**SS1 (Site Selection)**	**SS2 (Urban Redevelopment)**	**SS3 (Brownfield Redevelopment)**	**SS4.1 (Alternative Transportation - Public Transportation**	**SS4.2 (Alternative Transportation - Bicycle Storage & Changing Rooms)**	**SS4.3 (Alternative Transportation - Alternative Fuel Refueling Stations)**	**SS4.4 (Alternative Transportation - Parking Capacity)**
Q3. Did you obtain this LEED™ credit-standard?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Q4. Who made the decision to obtain or not to obtain this LEED™ credit-standard?	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other
Q5. In the decision making process to pursue this LEED™ credit-standard, what organizational benefits or concerns were expressed?								
	If the LEED™ credit-standard below was obtained, please answer the questions below.							
LEED™ credit-standard	**Prereq 1 (Erosion and Sedimentation Control)**	**SS1 (Site Selection)**	**SS2 (Urban Redevelopment)**	**SS3 (Brownfield Redevelopment)**	**SS4.1 (Alternative Transportation - Public Transportation**	**SS4.2 (Alternative Transportation - Bicycle Storage & Changing Rooms)**	**SS4.3 (Alternative Transportation - Alternative Fuel Refueling Stations)**	**SS4.4 (Alternative Transportation - Parking Capacity)**
Q6a. Were cost increases associated with required documentation significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q6b. If yes, please explain								
Q6c. If known, indicate % increase.								
Q7a. Were cost increases associated with designing, planning or engineering significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q7b. If yes, please								

Figure 3.3: Partial Case Study Questionnaire

3.6 Identification of Attributes for Each Credit

Attributes relevant in deciding to pursue or not to pursue the various LEED SS and WE credits were identified from the literature review, collaborative work session data and interview responses. A matrix was developed for each credit and the attributes were listed according to their relationship with the three objectives of sustainable construction – environmental issues, community issues and economic issues identified by [USGBC-2, Presley and Meade 2004 and ASTM 2004]. The matrix also demonstrates the source of identification of attributes for each credit. The purpose of identifying attributes was to help in the development of decision-making framework for owners in deciding which credits to pursue or not to pursue for their project.

3.6.1 Matrix Showing Attributes Identified

A matrix was developed for each credit and patterned after the Sustainability Decision Support System (SDSS) Conceptual Framework developed by Pearce et al. [1995]. The matrix developed by this thesis is a variation of the matrix suggested by Pearce et al. [1995] presented in the literature review section 2.2.4. Table 3.1 below shows the format of the matrix that was used in this thesis for each credit. The attributes are presented in detail in chapters four and five.

Attribute	Objectives of sustainable construction			Source of identification of attribute
	Environmental issues	Community issues	Economic issues	
Attribute 1				
Attribute 2				
Attribute 3				
Attribute 4				
Attribute 5				
Attribute 6				
Attribute n				

Table 3.1: Matrix Format Used for Each Credit (Adapted from SDSS Framework)

While the matrix developed by Pearce et al. [1995] described in section 2.2.4 lists the indicators that can be used to measure the sustainability of construction materials, with each indicator listed in context to Resource Consumption, Environmental Impact and Human Satisfaction. This thesis research substitutes three global objectives of sustainable construction – environment, community and economic issues as identified by [USGBC-

2], [Presley and Meade 2004], and [ASTM 2004] in lieu of the indicators used by Pearce et al. [1995].

"Economic aspects of sustainability include, but are not limited to, financial performance, employee compensation and community contribution. Examples of community aspects are public policymaking, fair labor standards, and equal treatment of all employees. Environmental aspects include impacts on the air, water, land, natural resources and human health" [Presley and Meade 2004].

The researcher with some modifications used the format of the table because:

1. It enabled the researcher to list each attribute according to its relationship with the objectives of sustainable construction.
2. It enabled the researcher to identify the source from where the attribute was obtained.
3. A particular attribute could be related to one or more objectives of sustainable construction.

Figure 3.4 is a snapshot of the matrix showing attributes identified for SS Credit 4.1: Alternative Transportation: Public Transportation Access.

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to distance of building from mass transit	•			[USGBC-3], CS	
Subject to transportation needs of building occupants		•		[USGBC-3]	
Subject to availability of public transportation system	•	•		CWS, CS	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			[USGBC-3]	
Encourages building occupants to use mass transit		•		[USGBC-3], CWS	
Minimizes parking lots	•	•		[USGBC-3], CWS	
Reduces automobile use, air pollution	•	•		[USGBC-3], CWS	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al 2002]	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj. mgmt.			•	CS	
Addresses environmental impacts	•			[Eijadi et al 2002], CWS	[Eijadi et al 2002] concluded global environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al 2002] concluded no health impacts, [Mrozowski et al 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 4.1

Figure 3.4: Snapshot of Matrix Showing Attributes

3.7 Development of Framework

Based on the attributes of sustainable construction and literature review, a framework was developed to assist institutional owners in deciding to pursue or not to pursue individual LEED SS and WE credits for their projects. The AHP Multi-Attribute Model developed by Herkert et al. [1996] and the Sustainability Decision Support System (SDSS) Conceptual Framework developed by Pearce et al. [1995] were adapted to develop the framework for the following reasons:

1. The multi-attribute approach used in the SDSS Framework helps an owner understand the role of each attribute in meeting the objectives of sustainable construction.
2. Decisions made by using the SDSS Framework concept support sustainable development, since they consider all parameters affecting sustainability, unlike

other models, which consider either economic issues or environmental issues alone.

3. The AHP Multi-Attribute Model establishes the need to assign weights to attributes in order to determine their relative contribution to the overall goal.

Chapter six presents and describes the framework in detail.

3.8 Proof of Concept

In order to obtain practical evaluation, the framework was presented to owners of two of the case study projects for review. These owners were interviewed in order to gain their opinions about the comprehensiveness and usefulness of the framework.

Owners of the four case studies were contacted by email to determine their willingness to participate. Upon agreement to participate they were sent an information packet which included of a brief introduction stating the purpose of the research, a graphic depicting the framework and a two-page narrative description of the processes involved in the framework. They were also sent the list of attributes identified for SS Credit 4.1: Alternative Transportation: Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%, as illustration, in order to gain their opinion about the comprehensiveness of the attributes identified. Refer to Appendix H for the 'proof of concept' package sent to the owners for their review.

Owners were asked to review the following aspects of the framework:

1. Structure of the framework.
2. Content of the framework.
3. Usefulness of the framework.

The proof of concept process along with the suggestions made by the interviewees are reported in chapter six.

Additionally, the use of the framework was demonstrated with a hypothetical case study. For the case study, a hypothetical Michigan community college was identified as planning to construct a new building under LEED-NC Version 2.2. The demonstrative case study is described in detail in section 6.4 of this thesis.

Finally, based on the proof of concept interviews and the demonstrative case study, the framework was revised to form a final framework. Revisions included simplification of terms in order to make it more understandable and usable by the owners and designers.

3.9 Chapter Summary

This chapter described the methodology that was used for this research thesis. The next chapter describes the collaborative work session data and interviewee responses in a paraphrased format and identifies attributes from the collaborative work session data, interview responses and literature review.

CHAPTER 4

IDENTIFICATION OF ATTRIBUTES FROM THE COLLABORATIVE WORK SESSION, CASE STUDIES AND LITERATURE REVIEW

4.1 Introduction

One of the major contributions of this research is the identification of attributes relevant in deciding whether or not to pursue specific LEED SS and WE credits. These attributes represent the module 'Data Base' – LEED credits attributes [Khosla 2007] in Figure 6.1 of this thesis.

This chapter presents the approach adopted for identifying the attributes from the literature, collaborative work session data and owner's responses from the case study projects. The chapter begins by describing the collaborative work session and how its data was reported and analyzed. The next section describes the case study projects and how their interview responses were reported and analyzed. The literature review articles presented in chapter two are listed to show the source of identification of attributes. The chapter then provides a full demonstration of one credit (SS Credit 4.1: Alternative Transportation: Public Transportation Access) to show how attributes are identified from all the three sources for that credit. Finally, the attributes are integrated and a matrix is presented for that credit, showing the relation of the attributes to the objectives of sustainable construction – environment, community and economic issues as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004]. The same approach was used to identify attributes for all LEED SS and WE credits and the credit-by-credit analysis is included in Appendix G. Figure 4.1 presents a snapshot of a typical template for SS Credit 4.1: Alternative Transportation: Public Transportation Access from Appendix G.

Sustainable Sites (SS) Credits

SS Prerequisite 1: Construction Activity Pollution Prevention (Formerly - Erosion and Sedimentation Control) **Analysis:** The researcher found the important attributes for SS Prerequisite 1 to be – prevents loss of topsoil during construction, prevents sedimentation of storm waters or receiving streams, prevents air pollution and has no cost/ potential cost decrease. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation [USGBC-2].

Work Session: All work groups concluded this was a relatively straightforward prerequisite and highly recommended its adoption. Overall the groups in the quadrant analysis indicated this credit had high benefit (environmental) and low cost. The work groups indicated that this credit was usually being met in most communities, and reflected good practice, but that details of the newly referenced EPA standard should be

Figure 4.1: Snapshot of a Typical Template for a Credit from Appendix G

4.2 Collaborative Work Session

The collaborative work session was conducted to gain input and advice from design, planning and construction professionals about the assumptions made when evaluating LEED credits and what recommendations and strategies must accompany the LEED site related credits for compliance in northern climates institutional settings.

Nineteen professionals participated in the work session. Participants included Michigan public officials from university and local governments; LEED Accredited Professionals (LAP) and design professionals including architects, planners, landscape architects, site engineers, and faculty and staff members from the Physical Plant Division at Michigan State University. All participants were knowledgeable in sustainable design practices as well as traditional approaches. Although the number of participants was limited, the work session provided valuable insight and expertise from knowledgeable practitioners with regard to the LEED-NC SS and WE credits.

4.2.1 Analysis of Collaborative Work Session Data

Results of the work session were entered into a Microsoft Excel spreadsheet and data relevant for this research was extracted from the spreadsheets. The work sheets used for the collaborative work session are included in Appendix E. Responses obtained for the questions regarding organizational benefits and concerns in pursuing specific credits, strategies that could be used for compliance, and situational criteria that could influence the use of specific credits were used for this research. Additionally, the quadrant analyses described in chapter three were used.

4.2.2 Work Session Conclusions

The work session participants perceived credits to have high, medium or low environmental and health benefits and indicated credits to have high, medium or low cost impacts.

4.2.2.1 Environmental Benefits

Work session respondents indicated the following credits were likely to yield "high" environmental benefits: Prerequisite SS 1, SS 1, SS 2, SS 3, SS 4.1, SS 4.2, SS 5.1, SS 5.2, SS 6.1, SS 6.2, SS 7.2 and SS 8. Credits SS 4.3, SS 4.4, SS 7.1, WE 1.1, WE 1.2, WE 2, We 3.1 and WE 3.2 were indicated to return "medium" environmental benefit. Overall, no LEED-NC credits were ranked as providing "low" environmental benefit.

4.2.2.2 Health Benefits

Work session respondents indicated the following credits were likely to yield "high" health benefits: SS 2, SS 3, SS 4.2, SS 6.2, and SS 7.2. Prerequisite SS 1 and credits SS 1, SS 4.1, SS 5.1, SS 5.2, SS 6.1, SS 7.1, WE 1.1, WE 2 and WE 3.1 were indicated to return "medium" health benefits. The following credits were indicated as providing "low" health benefits: SS 4.3, SS 4.4 SS 8, WE 1.2 and WE 3.2. .

4.2.2.3 Costs

When considering cost of implementing the credits, work session respondents indicated the following credits were likely to be "low cost": Prerequisite SS 1, SS 4.1, SS 4.2 SS 4.4 SS 6.1, SS 7.2, SS 8, and WE 1.1. Credits SS 4.3, SS 5.1 SS 6.2 SS 7.1 and WE 3.1 were indicated to have a "medium" impact on costs. The following credits were indicated as having "high" costs to implement - SS 1, SS 2, SS 3, SS 5.2, WE 1.2 and WE 3.2. Two credits, SS 7.2 and WE 2 indicated as having "low cost" or "high cost" depending on the design option selected.

4.2.2.4 Communication

A theme raised by many of the participants of the work session was the need for close communication between parities of a project. Owners, designers and contractors all have key roles to play in creating a successful project. Sustainability objectives should be established early in the project and communicated throughout the planning, design and construction phases to all parties. Design teams should be integrated in planning the project and contractors must be consulted, as they will ultimately carry out these objectives in planning and constructing the project. Owners must also have close involvement as they will own, operate and maintain the project [Mrozowski et al. 2006].

Results from the work session were used to identify attributes and this process is discussed and demonstrated in Section 4.5.

4.3 Case Studies

Four case studies were conducted for the Land Policy Project in order to see how these projects implemented LEED SS and WE credits and the decision-making parameters used to decide to pursue or not to pursue certain credits. The projects included 1) Calvin College, Bunker Interpretive Center, Grand Rapids, Michigan (Case Study 1); 2) Grand Valley State University, Ontario Hall, Allendale, Michigan (Case Study 2); 3) Oriole Park Branch, Chicago Public Library, Chicago, Illinois (Case Study 3); and 4) the Chemistry Building Addition at Michigan State University (MSU), East Lansing Michigan (Case Study 4). Site visits and interviews were conducted in May and June 2006.

Case Study 1: Calvin College Bunker Interpretive Center Calvin College, Grand Rapids, Michigan, LEED Version 2.1, Gold Rating (44 points), May 2005

The Bunker Interpretive Center (BIC) serves as headquarters for the biology department at Calvin College, a liberal arts school in Grand Rapids, Michigan. Included in the 5,000 square foot, single story structure is a laboratory classroom, a multi-purpose room, and a display hall. The Interpretive Center is designed for education of students and the public in the science of ecology and environmental topics. Creating a sustainable building and achieving LEED requirements were driving program requirements.

Table 4.1 shows the credits pursued by BIC and Table 4.1a shows the credits not pursued by BIC.

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.1	Heat Island Effect, Non-Roof
SS Credit 8	Light Pollution Reduction
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies
WE Credit 3.1	Water Use Reduction, 20% Reduction
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 4.1: LEED SS and WE Credits Pursued by BIC

Credit	Credit Name
SS Credit 1	Site Selection
SS Credit 2	Development Density & Community Connectivity
SS Credit 3	Brownfield Redevelopment
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.1	Heat Island Effect, Non-Roof

Table 4.1a: LEED SS and WE Credits Not Pursued by BIC

Case Study 2: Grand Valley State University, Ontario Hall, Allendale, Michigan LEED Version 2.1, Silver Rating (34 points), December 2005

This 50,000 square foot academic building houses teaching spaces, offices, support functions, and is part of a campus wide green building /sustainability effort. It is one of several LEED buildings being pursued by Grand Valley State University. The building is designed to meet program requirements, create a high quality work and learning environment and meet sustainability objectives.

Table 4.2 shows the credits pursued by Grand Valley State University and Table 4.2a shows the credits not pursued by Grand Valley State University.

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 7.2	Heat Island Effect, Roof
SS Credit 8	Light Pollution Reduction
WE Credit 3.1	Water Use Reduction, 20% Reduction
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 4.2: LEED SS and WE Credits Pursued by Grand Valley State University

Credit	Credit Name
SS Credit 3	Brownfield Redevelopment
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.1	Heat Island Effect, Non-Roof
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies

Table 4.2a: LEED SS and WE Credits Not Pursued by Grand Valley State University

Case Study 3: Oriole Park Branch, Chicago Public Library, Chicago, Illinois LEED Version 2.1, Certified (27 points) December 2004

This project houses a branch library and is one of a number of LEED projects and "green" building program emphases being pursued by the city of Chicago. Creating a project that fit the local context was an important criterion, as well as meeting the program requirements and budget.

Table 4.3 shows the credits pursued by Chicago Public Library and Table 4.3a shows the credits not pursued by Chicago Public Library.

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 7.1	Heat Island Effect, Non-Roof
SS Credit 7.2	Heat Island Effect, Roof
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%

Table 4.3: LEED SS and WE Credits Pursued by Chicago Public Library

Credit	Credit Name
SS Credit 2	Development Density & Community Connectivity
SS Credit 3	Brownfield Redevelopment
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 8	Light Pollution Reduction
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies
WE Credit 3.1	Water Use Reduction, 20% Reduction
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 4.3a: LEED SS and WE Credits Not Pursued by Chicago Public Library

Case Study 4: Chemistry Building Addition at Michigan State University, East Lansing, Michigan

This project has been registered under LEED 2.1 and is currently under construction. Construction began in June 2006. The addition is a multi-story addition to the existing Chemistry Building. The project is being targeted for LEED Silver.

Table 4.4 shows the credits to be pursued by Michigan State University, Table 4.4a shows the credits not to be pursued by Michigan State University and Table 4.4b shows the credits likely to be pursued by Michigan State University.

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 7.1	Heat Island Effect, Non-Roof
SS Credit 7.2	Heat Island Effect, Roof
SS Credit 8	Light Pollution Reduction
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 3.1	Water Use Reduction, 20% Reduction

Table 4.4: LEED SS and WE Credits to be pursued by MSU

Credit	Credit Name
SS Credit 2	Development Density & Community Connectivity
SS Credit 3	Brownfield Redevelopment
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
WE Credit 2	Innovative Wastewater Technologies

Table 4.4a: LEED SS and WE Credits not to be pursued by MSU

Credit	Credit Name
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.2	Site Development, Maximize Open Space
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 4.4b: LEED SS and WE Credits likely to be pursued by MSU

4.3.1 Analysis of Interview Responses

Data obtained from the interviews was recorded in a questionnaire Microsoft Excel spreadsheet and general themes regarding organizational benefits and concerns that were expressed by the project team for pursuing or not pursuing LEED SS and WE credits were identified.

4.3.2 Motivations and Impacts of Using LEED

During the interviews, it was clear that these LEED projects had a high degree of support from staff and upper administration. All four organizations have made a commitment to sustainable design and construction. Sustainability is an important educational objective at Calvin College and Grand Valley State University and it is being embodied in new campus buildings. Similarly, the owners of Grand Valley State University are pursuing multiple LEED projects. The owners of Calvin College will use the LEED criteria when applicable. Engineering and Architectural Services (EAS) at Michigan State University has embarked on an evaluation of all of its required construction and planning standards and is changing them to include sustainability. These commitments from both upper administration and staff have been important forces for pursuing these projects.

Impacts of LEED credits are seen as positive by building users, staff and administrators. Although some adaptations must be made in learning to manage, operate and live with nontraditional materials and systems, such as native plants, rainwater collection systems, reduced parking etc., building users, staff and managers seem to take pride in knowing that the building is different in its design and approach.

Interviewees reported that most of the LEED SS and WE credits did not add cost to their projects. Exceptions were the composting toilet and grey water system at Calvin College. Because environmental education was part of the programmatic mission of Calvin College, costs of the composting and grey water systems were seen as a part of meeting that mission. Other solutions that increased costs were the rain water storage system in meeting WE 1.1 and the use of white Portland cement to achieve reflective requirements for credit SS 7.1 at Oriole Park Branch, Chicago Public Library.

Results from the case studies were used to identify attributes and this process is discussed and demonstrated in Section 4.5.

4.4 Literature Review

[USGBC-2], [SWA 2004], [Eijadi et al. 2002], [FPC 2001] and [Mrozowski et al. 2006] are the primary references to identify attributes relevant in deciding to pursue or not to pursue specific LEED SS and WE credits. For further reference, the author recommends the reader refer to the literature review in chapter two.

Results from the literature review were also used to identify attributes and this process is discussed and demonstrated in Section 4.5.

4.5 Identification of Attributes

This section shows a full demonstration of one credit (SS Credit 4.1: Alternative Transportation: Public Transportation Access) to show how attributes are identified from all the three sources identified above. Finally, attributes from all the sources are integrated and a matrix is presented for SS Credit 4.1: Alternative Transportation: Public Transportation Access, showing the relation of the attributes to the objectives of sustainable construction – environment, community and economic issues as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004]. The same approach is used to identify attributes for all LEED SS and WE credits and the credit-by-credit analyses and list of attributes for all the credits is included in Appendix G.

The relevant themes expressed by the work groups and the paraphrased responses obtained for SS Credit 4.1: Alternative Transportation: Public Transportation Access are shown below. The attributes suggested by the work session responses for SS Credit 4.1 are identified and listed.

From the work session, three questions were relevant in identifying attributes. The first question was 'what organizational benefits / concerns do you foresee in pursuing this credit-standard?' The responses to this question were used in identifying those attributes relating to benefits and concerns in pursuing the credit. For instance, for SS Credit 4.1: Alternative Transportation: Public Transportation Access, the work session participants indicated that pursuing this credit reduces pollution. According to the author's judgment, the attribute indicated by this response is "Reduces pollution".

The second question used from the work session in identifying attributes was 'Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain.' For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the work session participants expressed the need for public transportation systems for access to doctors, stores etc. on non-business days. According to the author's judgment, the attribute indicated by this response is "Subject to availability of public transportation system".

The third question used from the work session in identifying attributes was 'what situational criteria might influence use of this credit-standard? Explain.' For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the work session participants indicated promotions or incentives to be given to employees to use public transportation system. According to the author's judgment, the attribute indicated by this response is "Encourages building occupants to use mass transit".

Work Session: SS Credit 4.1: Alternative Transportation: Public Transportation Access: Although this credit was viewed as situational because it is dependent on availability of public transportation, all work groups indicated that for the right site this credit had no cost associated with it and high health and environmental benefit. Public sector owners should be encouraged to select sites with available public transportation. Additionally public sector owners may have the ability to work with public bus systems to alter routes to accommodate this credit. Table 4.5 shows the work session responses obtained for SS Credit 4.1 and Table 4.5a shows the attributes identified for SS Credit 4.1 from the work session responses.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Equity benefit (hire people who don't have cars); reduce pollution and parking lots costs; some more walking behavior in employees	2
	Amenity to building occupants & employers – Concerns: Transit system is not in place and needs to be expanded or building needs to follow transit master plan	3
	Should be a requirement for any state building. Makes sense to keep with population growth.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Need to create reasonable options that promote use of bus. What to do on the off day you need to get to the doctor, store, etc	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	promotions, incentives	4

Table 4.5: Collaborative Work Session Responses for SS Credit 4.1

Work session responses suggest the following attributes for SS Credit 4.1:

Subject to availability of public transportation system
Encourages building occupants to use mass transit
Minimizes parking lots
Reduces automobile use and air pollution
No cost / potential cost decrease
High environmental benefits
High health benefits

Table 4.5a: Attributes Identified for SS Credit 4.1 from Work Session

The relevant themes expressed by the project owners and the paraphrased responses obtained for SS Credit 4.1: Alternative Transportation: Public Transportation Access are shown below. The cost impact associated with the required documentation, designing, planning, engineering, material purchase, construction labor and construction project management is also presented. The attributes suggested by the case studies for SS Credit 4.1 are identified and listed.

From the case study questionnaire, six questions were relevant in identifying attributes. The first question asked about the organizational benefits / concerns that were expressed by the project team for pursuing or not pursuing LEED SS and WE credits. The responses to this question were used in identifying those attributes that indicate benefits / concerns in pursuing the credit. For instance, for SS Credit 4.1: Alternative Transportation: Public Transportation Access, Case Study 4 indicated that their building is located across the street from the main campus bus hub, and adjacent to numerous bus routes. According to the author's judgment, the attribute indicated by this response is "Subject to availability of public transportation system" and "Subject to distance of building from mass transit".

The second question was "were cost increases associated with required documentation significant". The respondents indicated that there were no cost increases associated with required documentation. According to the author's judgment, the attribute indicated by this response is "No cost increase associated with required documentation".

The third question was "were cost increases associated with designing, planning or engineering significant". For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the respondents indicated that there were no cost increases associated with designing, planning or engineering. According to the author's judgment, the attribute indicated by this response is "No cost increase associated with designing, planning or engineering".

The fourth question was "were cost increases associated with material purchase significant". For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the respondents indicated that there were no cost increases associated with material purchase. According to the author's judgment, the attribute indicated by this response is "No cost increase associated with material purchase".

The fifth question was "were cost increases associated with construction labor significant". For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the respondents indicated that there were no cost increases associated with construction labor. According to the author's judgment, the attribute indicated by this response is "No cost increase associated with construction labor".

The sixth question was "were cost increases associated with construction project management significant". For SS Credit 4.1: Alternative Transportation: Public Transportation Access, the respondents indicated that there were no cost increases associated with construction project management. According to the author's judgment, the attribute indicated by this response is "No cost increase associated with construction project management".

Case Studies: SS Credit 4.1: Alternative Transportation: Public Transportation Access:

Three bus lines within ¼ mile of the project site serve the Case Study 2 project site. Case Study 4 is located across the street from the main campus bus hub, and adjacent to numerous bus routes. The respondents indicated there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit.

The interview responses suggest the following attributes for SS Credit 4.1:

Subject to distance of building from mass transit
Subject to availability of public transportation system
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Table 4.6: Attributes Identified for SS Credit 4.1 from Case Studies

[USGBC-2], [SWA 2004], [Eijadi et al. 2002], [FPC 2001] and [Mrozowski et al. 2006] are the primary references to identify attributes from the literature review chapter. According to the author's judgment, one of the attributes indicated by [Eijadi et al. 2002] for SS Credit 4.1: Alternative Transportation: Public Transportation Access is "Achieved through standard practice (increased design efforts but minimal construction first costs)".

Literature Review: Literature Review indicates the following attributes for SS Credit 4.1:

Subject to distance of building from mass transit [USGBC-2]
Subject to transportation needs of building occupants [USGBC-2]
Subject to availability of sidewalks, paths and walkways to existing mass transit stops [USGBC-2]
Encourages building occupants to use mass transit [USGBC-2]
Minimizes parking lots [USGBC-2]
Reduces automobile use and air pollution [USGBC-2]
No cost / potential cost decrease [SWA 2004] and [FPC]
Achieved through standard practice (increased design efforts but minimal construction first costs) [Eijadi et al. 2002]
Addresses global environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Table 4.7: Attributes Identified for SS Credit 4.1 from Literature Review

4.6 Matrix Showing Attributes Identified from Collaborative Work Session, Case Studies and Literature Review

The attributes identified from the collaborative work session data, case studies and literature review are integrated and presented in the form of a matrix. The relation of each attribute to the objectives of sustainable construction – environment, community and economic issues as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004] is shown in the table and is represented by the symbol '•'. The table demonstrates the source of identification of various attributes. CWS indicate attributes identified from the collaborative work session and CS indicate attributes identified from the case studies. The highlighted portions in the tables indicate attributes with low confidence level as seen in the 'discussion' column in all of the credits. Table 4.8 shows the attributes identified for SS Credit 4.1: Alternative Transportation: Public Transportation Access as a demonstration. Appendix G includes the credit-by-credit analyses and list of attributes for all LEED SS and WE credits.

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to distance of building from mass transit	•			[USGBC-2], CS	
Subject to transportation needs of building occupants		•		[USGBC-2]	
Subject to availability of public transportation system	•	•		CWS, CS	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			[USGBC-2]	
Encourages building occupants to use mass transit		•		[USGBC-2], CWS	
Minimizes parking lots	•	•		[USGBC-2], CWS	
Reduces automobile use, air pollution	•	•		[USGBC-2], CWS	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al. 2002]	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj. mgmt.			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Table 4.8: Attributes related to SS Credit 4.1

4.7 Chapter Summary

This chapter presented the approach for identifying attributes from the literature, collaborative work session data and the case study responses. First, the chapter described the collaborative work session data and interview responses. The chapter then provided a full demonstration of one credit (SS Credit 4.1: Alternative Transportation: Public Transportation Access) to show how attributes are identified from all the three sources for that credit. Finally, the attributes were integrated and a matrix was presented for SS Credit 4.1: Alternative Transportation: Public Transportation Access, showing the relation of the attributes to the objectives of sustainable construction – environment, community and economic issues. The next chapter summarizes and presents all attributes for each LEED SS and WE credit.

CHAPTER 5

ATTRIBUTES

5.1 Introduction

The approach used to identify attributes from the literature review, collaborative work session data and interview responses was described in chapter four for LEED SS Credit 4.1: Alternative Transportation: Public Transportation Access. Input data for all the LEED SS and WE credits are included in detail in Appendix G. This chapter summarizes the attributes relevant in deciding to pursue or not to pursue the various LEED SS and WE credits.

5.2 Attributes Identified for LEED Sustainable Sites (SS) Credits

Figures 5.1 through 5.3 summarize the attributes identified for LEED SS credits. The sources of identification of each attribute are also shown in the figures. CWS indicate attributes identified from the collaborative work session and CS indicates attributes identified from the case studies. Each attribute is presented according to its relation to the three objectives of sustainable construction – Environment (indicated by 'E'), Community (indicated by 'C') and Economic (indicated by 'Ec'), as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004] and the relation is represented by the symbol '•'.

The attributes identified for all the credits related to site selection and development are grouped and shown in Figure 5.1. These credits are SS Prerequisite 1: Construction Activity Pollution Prevention; SS 1: Site Selection; SS 2: Development Density & Community Connectivity; SS 3: Brownfield Redevelopment and SS 8: Light Pollution Reduction. Figure 5.2 shows attributes identified for credits that are related to transportation such as SS 4.1: Alternative Transportation, Public Transportation Access; SS 4.2: Alternative Transportation, Bicycle Storage & Changing Rooms; SS 4.3:

Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles and SS 4.4: Alternative Transportation, Parking Capacity and shows attributes related to credit SS 5.1: Site Development, Protect or Restore Habitat. The attributes identified for all the remaining SS credits are shown in Figure 5.3. These credits are SS 5.2: Site Development, Maximize Open Space; SS 6.1: Stormwater Design, Quantity Control; SS 6.2: Stormwater Design, Quality Control; SS 7.1: Heat Island Effect, Non-Roof and SS 7.2: Heat Island Effect, Roof.

SS PREREQUISITE 1: Construction Activity Pollution Prevention	E	C	EC
Reduces pollution from construction activities - *[USGBC-2]*	•	•	
Prevents loss of topsoil during construction, air pollution - *[USGBC-2], CS*	•		
Prevents sedimentation of storm waters or receiving streams - *[USGBC-2], CS*	•		
Requires designer to evaluate EPA stds v/s local codes - *[USGBC-2], CWS*	•		
No cost / potential cost decrease - *[SWA 2004], CWS*			•
Achieved through standard practice - *[Eijadi et al. 2002]*			•
Benefits the host community and project neighbors - *CWS*	•	•	
Reduces site exposure over the duration of the project - *CWS*	•		
Requires high maintenance of implemented system during construction - *CWS*	•		•
Requires effective monitoring of the site activity - *CWS, CS*	•		•
No cost increase associated with designing, planning or engineering; material			•
purchase; construction labor; construction project management - *CS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	
Cost associated with required documentation varies - *CS*			•

SS CREDIT 1: Site Selection	E	C	EC
Avoids development of inappropriate sites - *[USGBC-2], CS*	•	•	
Reduces environmental impact from the location of a building on a site- *[USGBC-2]*	•		
Subject to site availability - *[USGBC-2], CWS, CS*	•		
Requires designers to determine zoning requirements of local community & the			
community master plan; Reduces sprawl - *[USGBC-2], CWS*	•	•	
Minimizes disruption of the environmentally sensitive areas - *[USGBC-2], CS*	•		
Encourages designers to incorporate site features into the design - *[USGBC-2]*	•		
Limits development footprint - *[USGBC-2]*	•		
Achieved through standard practice - *[Eijadi et al. 2002]*			•
No cost increase associated with designing, planning or engineering; material purchase;			•
construction labor; construction project management - *CS*			•
No cost / Potential cost decrease - *[SWA 2004], [FPC 2001]*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	
Cost associated with required documentation varies - *CS*			•

SS CREDIT 3: Brownfield Redevelopment	E	C	EC
Rehabilitates damaged sites - *[USGBC-2]*	•		
Subject to availability of "brownfield" site - *[USGBC-2], CWS,*	•		
CS	•		
Reduces greenfield development - *[USGBC-2], CWS*	•		
Enhances property value - *CWS*			•
Encourages use of existing transportation & infrastructure -	•	•	
CWS	•	•	
Cost varies - *[SWA 2004], CWS*			•
Addresses environmental impacts -*[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

SS CREDIT 2: Development Density & Community Connectivity	E	C	EC
Channels development to urban areas with existing infrastructure - *[USGBC-2]*	•		
Protects greenfields and preserves habitat and natural resources - *[USGBC-2]*	•		
Subject to availability of previously developed site - *[USGBC-2], CWS*	•		
Increases density of community; Reduces sprawl - *[USGBC-2], CWS*	•	•	
Subject to distance of site from residential zone or neighborhood, distance of site from	•		
basic services; availability of pedestrian access between the building and services -	•		
[USGBC-2]	•		
Achieved through standard practice - *[Eijadi et al. 2002]*			•
Decreases land use; Encourages walking and bicycling - *CWS*	•	•	
Easier to meet in community settings where property lines help define density;	•	•	•
Reduces unnecessary extension of infrastructure; Minimizes auto demand - *CWS*	•	•	•
Supports urban redevelopment & mixed use; Keeps development compact - *CWS*	•	•	
Cost varies - *[SWA 2004], CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 8: Light Pollution Reduction	E	C	EC
Minimizes light trespass from the building and site - *[USGBC-2]*	•	•	
Reduces sky-glow to increase night sky access - *[USGBC-2]*	•	•	
Improves night time visibility through glare reduction - *[USGBC-2]*	•	•	
Reduces development impact on nocturnal environments - *[USGBC-2]*	•	•	
No cost / potential cost decrease - *[SWA 2004], [FPC 2001], [Eijadi et al.*			•
2004] and CWS			•
Some concern about public safety in campus settings - *CWS, CS*		•	
No cost increase associated with required documentation - *CS*			•
No cost increase associated with designing, planning or engineering- *CS*			•
No cost increase associated with material purchase - *CS*			•
No cost increase associated with construction labor - *CS*			•
No cost increase associated with construction project management - *CS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

Figure 5.1: Attributes Related to Credits SS Prerequisite 1, SS1, SS2, SS3 and SS8

SS CREDIT 4.1: Alternative Transportation, Public Transportation Access	E	C	EC
Subject to distance of building from mass transit - *[USGBC-2], CS*	•		
Subject to transportation needs of building occupants - *[USGBC-2]*		•	
Subject to availability of public transportation system - *CWS, CS*	•	•	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops - *[USGBC-2]*	•		
Encourages building occupants to use mass transit - *[USGBC-2], CWS*		•	
Minimizes parking lots - *[USGBC-2], CWS*	•	•	
Reduces automobile use, air pollution - *[USGBC-2], CWS*	•	•	
No cost / potential cost decrease - *[SWA 2004], [FPC 2001], CWS*			•
Achieved through standard practice - *[Eijadi et al. 2002]*			•
No cost increase associated with required documentation; designing, planning or engineering; material purchase; construction labor; const proj. mgmt. - *CS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 4.4: Alternative Transportation, Parking Capacity	E	C	EC
Minimizes parking lot/ garage size - *[USGBC-2], CS*	•	•	•
Provides parking space for carpools or vanpools - *[USGBC-2], CS*	•	•	
Subject to location of project site - *[USGBC-2]*	•		
Subject to number of cars likely to drive to the site - *[USGBC-2]*	•	•	
Encourages use of public transportation - *[USGBC-2], CWS, CS*	•	•	
Reduces amount of impervious surface, reduces stormwater runoff - *[USGBC-2], CWS*	•		
Low costs - *[SWA 2004], [Eijadi et al. 2002], CWS*			•
Reduces air pollution - *[USGBC-2], CWS*	•	•	
Makes community more amenable for walking - *CWS*		•	
No cost increase associated with required documentation; designing, planning or engineering; material purchase; construction labor; construction project management - *CS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 5.1: Site Development, Protect or Restore Habitat	E	C	EC
Conserves existing natural areas and restores damaged areas - *[USGBC-2], CS*	•		
Limits construction on greenfield site or previously developed site - *[USGBC-2]*	•		
Reduces building footprint - *[USGBC-2]*	•		
Maintains existing natural ecosystem - *[USGBC-2], CWS, CS*	•		
Reduces infrastructure construction - *[USGBC-2], CS*	•		•
Requires effective implementation of landscape management - *CWS*	•		
Enhances water quality - *CWS*	•	•	
Provides better visual impact - *CS*		•	
No cost increase associated with required documentation; designing, planning or engineering; material purchase; construction labor; const project management - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impacts varies - *Literature Review, CWS*		•	

SS CREDIT 4.2: Alt. Transportation, Bicycle Storage & Changing Rooms	E	C	EC
Subject to space available for shower facilities - *[USGBC-2], CWS, CS*			•
Provides secure bicycle storage areas for cyclists - *[USGBC-2]*		•	
Reduces automobile use, air pollution - *[USGBC-2], CWS*	•	•	•
Minimizes parking lots - *[USGBC-2], CWS*	•	•	•
Reduces noise pollution - *CWS*		•	
High financial costs (square footage and plumbing) - *CWS, CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 4.3: Alt. Transportation, Low-Emitting and Fuel-Efficient Vehicles	E	C	EC
Provides low-emitting and fuel efficient vehicles for 3% of full time equivalent occupants - *[USGBC-2]*	•	•	
Provides preferred parking for low-emitting and fuel efficient vehicles; Provides alternative-fuel refueling stations - *[USGBC-2]*	•	•	
Reduces air pollution, automobile use - *[USGBC-2], CWS*	•	•	
Higher initial costs for alternative vehicles - *[USGBC-2]*			•
High infrastructure cost - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

Figure 5.2: Attributes Related to Credits SS4.1, SS4.2, SS4.3, SS4.4 and SS5.1

SS CREDIT 5.2: Site Development, Maximize Open Space

Attribute	E	C	EC
Reduces development footprint - *[USGBC-2], CS*	•		
Provides vegetated open space - *[USGBC-2], CS*	•		
Minimizes site disruption - *[USGBC-2], CS*	•		
Increases amount of daylighting - *[USGBC-2], CWS*		•	
Reduces heat island effects - *[USGBC-2], CWS*	•	•	
Promotes sprawl; Increases water infiltration - *CWS*	•	•	
Provides better visual impact - *CS*		•	
No cost increase associated with required documentation; designing, planning or engineering; material purchase; construction labor; construction project management - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 7.1: Heat Island Effect, Non-Roof

Attribute	E	C	EC
Reduces heat islands - *[USGBC-2], CWS*	•	•	
Minimizes impact on microclimate and human and wildlife habitat - *[USGBC-2]*	•	•	
Limits the amount of impervious hardscape areas - *[USGBC-2], CS*	•		
Provides shading for hard surfaced areas – *[USGBC-2], CWS, CS*	•		
Has issues with snow removal in winter with certain pavement - *CWS*	•		
No cost increase associated with designing, planning or engineering; construction labor; construction project management - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	
Cost increase associated with required documentation varies - *CS*			•
Cost increase associated with material purchase varies - *CS*			•

SS CREDIT 6.1: Stormwater Design, Quantity Control

Attribute	E	C	EC
Limits disruption of natural hydrology - *[USGBC-2]*	•		
Increases on-site infiltration - *[USGBC-2]*	•		
Minimizes impervious surfaces - *[USGBC-2]*	•		
Decrease in the volume of stormwater runoff - *[USGBC-2]*	•		
Requires careful design and maintenance of system - *[USGBC-2], CWS*	•		
High equipment purchase cost - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts -*[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 6.2: Stormwater Design, Quality Control

Attribute	E	C	EC
Reduces or eliminates water pollution - *[USGBC-2], CWS*	•	•	
Minimizes impervious surfaces - *[USGBC-2], CS*	•		
Increases on-site infiltration - *[USGBC-2], CWS, CS*	•		
Eliminates sources of contaminants - *[USGBC-2], CWS*	•		
Removes pollutants from stormwater runoff - *[USGBC-2], CWS*	•		
Decreases stormwater runoff - *[USGBC-2], CS*	•		
No cost increase associated with required documentation; designing, planning or engineering; material purchase; construction labor; construction project management - *CS*			•
High equipment purchase cost - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

SS CREDIT 7.2: Heat Island Effect, Roof

Attribute	E	C	EC
Reduces heat islands - *[USGBC-2], CWS*	•		
Minimizes impact on microclimate and human and wildlife habitat - *[USGBC-2]*	•	•	
Green roofs provide insulating benefits, aesthetic appeal and lower maintenance than standard roofs - *[USGBC-2]*	•	•	•
Garden roofs reduce stormwater volumes - *[USGBC-2]*	•		
Minor cost increase associated with required documentation - *CS*			•
No cost increase associated with designing, planning or engineering; material purchase; construction labor; construction project management - *CS*			•
High cost for installing green roof - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *Literature Review, CWS*		•	

Figure 5.3: Attributes Related to Credits SS5.2, SS6.1, SS6.2, SS7.1 and SS7.2

5.3 Attributes Identified for LEED Water Efficiency (WE) Credits

This section summarizes the attributes identified for LEED WE credits. Figure 5.4 shows the attributes identified for all WE credits – WE 1.1: Water Efficient Landscaping, Reduce by 50%; WE 1.2: Water Efficient Landscaping, No Potable Use or No Irrigation; WE 2: Innovative Wastewater Technologies; WE 3.1: Water Use Reduction, 20% Reduction and WE 3.2: Water Use Reduction, 30% Reduction.

The sources of identification of each attribute are also shown in the figure. CWS indicate attributes identified from the collaborative work session and CS indicate attributes identified from the case studies. Each attribute is presented according to its relation to the three objectives of sustainable construction – Environment (indicated by 'E'), Community (indicated by 'C') and Economic (indicated by 'Ec'), as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004] and the relation is represented by the symbol '•'.

WE CREDIT 1.1: Water Efficient Landscaping, Reduce by 50%

Attribute	E	C	EC
Limits or eliminates the use of potable water or other natural surface or subsurface water - *[USGBC-2]*	•		
	•		
Encourages use of captured rainwater – *[USGBC-2]*	•		
Encourages use of recycled wastewater - *[USGBC-2]*	•		
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses – *[USGBC-2]*	•		
	•		
Encourages use of native or adaptive plants - *[USGBC-2], CWS, CS*	•		
Requires careful landscape design - *CWS*	•		
No cost increase associated with designing, planning or engineering; construction labor; construction project management - *CS*			•
			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al 2002], CWS*	•		
Health impact varies - *[Eijadi et al 2002], CWS*		•	
Cost increase associated with required documentation varies - *CS*			•
Cost increase associated with material purchase varies - *CS*			•

WE CREDIT 1.2: Water Efficient Landscaping, No Potable Use or Irrigation

Attribute	E	C	EC
Limits or eliminates the use of potable water or other natural surface or subsurface water - *[USGBC-2]*	•		
	•		
Encourages use of captured rainwater - *[USGBC-2]*	•		
Encourages use of recycled wastewater - *[USGBC-2]*	•		
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses for irrigation - *[USGBC-2]*	•		
	•		
Encourages installing landscaping that does not require permanent irrigation systems – *[USGBC-2]*	•		
	•		
Does not encourage use of supplementary irrigation - *[USGBC-2], CS*	•		
Encourages use of native or adaptive plants - *[USGBC-2], CWS, CS*	•		
No cost increase associated with required documentation; designing, planning or engineering; material purchase; const labor; const project management - *CS*			•
			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

WE CREDIT 2: Innovative Wastewater Technologies

Attribute	E	C	EC
Reduces generation of wastewater and potable water demand; Increases the local aquifer recharge - *[USGBC-2]*	•		
	•		
Encourages use of high-efficiency/ dry fixtures - *[USGBC-2], CWS, CS*	•		•
Encourages reuse of stormwater or graywater - *[USGBC-2]*	•		
Encourages treating wastewater on-site - *[USGBC-2], CWS, CS*	•		•
High cost associated with required documentation; designing, planning or engineering; material purchase; construction labor; const project management - *CS*			•
			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al.. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

WE CREDIT 3.1: Water Use Reduction, 20% Reduction

Attribute	E	C	EC
Maximizes water efficiency within buildings - *[USGBC-2]*	•		
Reduces burden on municipal water and wastewater systems - *[USGBC-2]*	•		
Encourages use of high-efficiency/ dry fixtures - *[USGBC-2], CWS, CS*	•		•
Encourages reuse of stormwater or graywater – *[USGBC-2]*	•		
High cost associated with required documentation - *CS*			•
High cost associated with designing, planning or engineering - *CS*			•
High cost associated with material purchase - *CS*			•
High cost associated with construction labor - *CS*			•
High cost associated with construction project mgmt - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

WE CREDIT 3.2: Water Use Reduction, 30% Reduction

Attribute	E	C	EC
Maximizes water efficiency within buildings - *[USGBC-2]*	•		
Reduces burden on municipal water and wastewater systems - *[USGBC-2]*	•		
Encourages use of high-efficiency/ dry fixtures - *[USGBC-2], CWS, CS*	•		•
Encourages reuse of stormwater or graywater - *[USGBC-2]*	•		
High cost associated with required documentation - *CS*			•
High cost associated with designing, planning or engineering - *CS*			•
High cost associated with material purchase - *CS*			•
High cost associated with construction labor and const project mgmt. - *CS*			•
Cost varies - *Literature Review, CWS*			•
Addresses environmental impacts - *[Eijadi et al. 2002], CWS*	•		
Health impact varies - *[Eijadi et al. 2002], CWS*		•	

Figure 5.4: Attributes Related to Credits WE1.1, WE1.2, WE2, WE3.1 and WE3.2

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5.4 Attributes

One of the major contributions of this research is the identification of attributes relevant in deciding whether or not to pursue specific LEED SS and WE credits. These attributes were identified and presented according to their relation with the three objectives of sustainable construction – Environment, Community and Economic issues. The author, in her literature search, did not find any studies that identified attributes of LEED credits.

These attributes as shown in Figures 5.1 through 5.4 represent the module 'Data Base' - LEED credits attributes [Khosla 2007] indicated in Figure 6.1 in chapter six. This module is analogous with the 'Data Base' module in the SDSS Framework developed by Pearce et al. [1995], which represents the material sustainability properties or the attributes that influence sustainability of construction materials as shown in Table 2.1. The framework is discussed in detail in the next chapter.

5.5 Chapter Summary

This chapter summarized the attributes identified for all LEED SS and WE credits from the literature review, collaborative work session and interview responses. The next chapter presents the framework developed for assisting institutional owners in deciding the use of specific LEED SS and WE credits for their projects.

CHAPTER 6

DEVELOPMENT OF FRAMEWORK

6.1 Introduction

Chapter four identified and presented the process of identifying the attributes from the literature review, collaborative work session data and responses from case studies. Chapter five summarized the attributes identified for each LEED SS and WE credit. The development of the framework for assisting institutional owners in deciding the use of specific LEED SS and WE credits for their projects and its description are presented in this chapter as well as the proof of concept process. This chapter also demonstrates use of the framework through a hypothetical case study of a community college located in Michigan. Based on the conclusion of the demonstrative case study, the framework was modified and presented in its final form.

6.2 Framework to Assist Institutional Owners in Deciding to Use Specific LEED SS and WE Credits for their Projects

The researcher incorporated the AHP Multi-Attribute Model developed by Herkert et al. [1996] to Pearce et al.'s [1995] Sustainability Decision Support System Conceptual Framework in order to develop a new decision-making framework for aiding institutional owners as they consider use of specific LEED-NC 2.2 SS and WE credits for their projects. Figure 6.1 shows a framework developed by this research for assisting institutional owners in deciding to select LEED SS and WE credits for their projects.

The framework consists of three main inputs required from the owner. The first is 'List all SS and WE credits', the second input is represented by the module 'Conceptual design and decision-making parameters' and the third is 'Owner's system of values'. Below is a description of each module used in the framework.

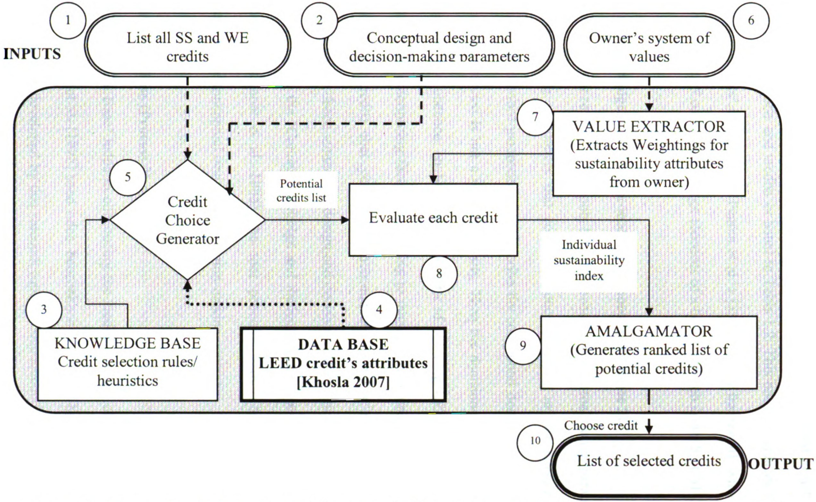

Figure 6.1: Framework to Assist Institutional Owners in Deciding to Select LEED SS and WE Credits for their Projects (Modified from Pearce et al's [1995] SDSS Framework)

List all SS and WE Credits (Process 1)

This is the first step in the framework. Here, the owner is required to list all the SS and WE prerequisite and credits as listed in Table 1.2. This module replaces the 'List of Design Elements' module from Pearce et al.'s [1995] SDSS framework where the user provides a list of conceptual design elements of a facility broken down by CSI Divisions.

Conceptual design and decision-making parameters (Process 2)

This process requires two inputs from the owner – conceptual design parameters and decision-making parameters that could influence pursuing or not pursuing specific credits. The relevant parameters that describe the conceptual design are described, such as the site selected is not a brownfield site. Then the decision-making parameters are described. For instance, environmental benefits of pursuing LEED SS and WE credits could be the determining factor in deciding to pursue certain credits. The owner might want to use credits that yield high environmental benefits and have low cost of implementation. Such conceptual design and decision-making parameters are required in this module. In the 'Conceptual design and decision-making parameters' of the SDSS framework [Pearce et al. 1995], the user provides values for relevant parameters describing the conceptual design and decision-making context.

Knowledge Base (Process 3)

'Knowledge Base' helps in eliminating the credits that are clearly infeasible for the project. Pearce et al. [1995] used rules/ heuristics in the SDSS Framework at this stage. The framework developed by this research replaces this activity with a ruling process to eliminate credits which are infeasible based on project conditions. For example, if a brownfield site is not available, SS Credit 3: Brownfield Redevelopment, cannot be achieved. The 'Knowledge Base' process reduces the complete set of alternatives by eliminating those alternatives that are clearly infeasible for the application.

Data Base (Process 4)

'Data Base' is the list of attributes identified for each LEED SS and WE credit by the author in this research, as described in detail in chapters Four and Five and Appendix G. In Pearce et al.'s [1995] SDSS framework, 'Data Base' represents the material sustainability properties or the attributes that influence sustainability of construction materials as shown in Table 2.1.

Credit Choice Generator (Process 5)

'Credit Choice Generator' with the help of the Knowledge Base, Data Base and the information provided by the owner generates a list of potential credits. This module replaces 'Material Choice Generator' from Pearce et al.'s [1995] SDSS framework that generates a list of feasible materials with the help of Knowledge Base, Data Base and the information provided by the user.

For instance, in the first step all the LEED SS and WE credits are listed. In the 'Conceptual design and decision-making parameters' module, the owner states that he/ she wants to use credits that yield high environmental benefits and have low cost of implementation. The 'Credit Choice Generator' will integrate information provided by the owner, information from Knowledge Base and Data Base and generate a list of potential credits that yield high environmental benefits and have low cost of implementation. Assuming that the site selected is not a brownfield site, then SS credit 3: Brownfield Redevelopment, will be pruned from the set even though it meets the owner's requirements. The 'Credit Choice Generator' will then generate this list of potential credits: SS Prerequisite 1, SS 1, SS 2, SS 4.1, SS 4.2, SS 5.1, SS 5.2, SS 6.1, SS 6.2, SS 7.2 and WE 1.1, since all of these credits yield high environmental benefits and have low cost of implementation.

Owner's system of values (Process 6)

The next step in the framework is to evaluate the potential credits such that a ranking can be developed according to the utility of the credit for a specific project. Based on 'Owner's system of values', which is the third input required from the owner, first the owner weights each attribute of sustainability according to the subjective importance or utility which that attribute holds for the owner.

Researcher's Note: The owner might use internal reviews, such as consultation with the design team or the planning committee of the organization, in order to determine weights for the attributes of each credit.

Value Extractor (Process 7)

The module 'Value Extractor' extracts weightings for sustainability attributes from the owner. Then, values for each of the sustainability attributes are determined for each credit from other sources such as project team, architect, engineer, landscape architect, designer, etc. and a normalized value between zero and one is calculated for each attribute value. A similar approach is used in Pearce et al.'s [1995] SDSS framework, except that the values for each of the sustainability attributes are determined for each material from manufacture information and other sources.

This approach is also described in the multi-attribute model using AHP developed by Herkert et al. [1996] where the overall goal is decomposed into attributes and each attribute is assigned a weight to show how important the attribute is in order to achieve the goal. Weights of attributes are determined using the AHP. Scores that measure the performance of each alternative in terms of each attribute are created and the weights and the score together create a weighted additive function by which each alternative is evaluated in terms of the overall goal [Herkert et al. 1996].

Since determining weights of attributes is not within the scope of this research, the author recommends that owners use the AHP multi-attribute model developed by Herkert et al. [1996] in order to determine weights of sustainability attributes for each credit. This model is described in detail in chapter two of this thesis.

Evaluate Each Credit (Process 8)

In the module 'Evaluate each credit', after weights have been established and values calculated for each attribute for a particular credit, the weights and normalized values are multiplied and summed to create an individual sustainability index or an index of subjective utility for that credit [Pearce et al. 1995]. This module replaces the 'Single material evaluator' module in the SDSS framework [Pearce et al. 1995], where after weights have been established and values calculated for each attribute for a particular material, the weights and normalized values are multiplied and summed to create an index of subjective utility for that material.

The SDSS framework [Pearce et al. 1995] also consists of the 'Whole Design Evaluator' module, which provides the composite index of sustainability for the whole design based on the materials selected by the user. This module is not included in the framework developed by this research because the focus of the thesis is on LEED Sustainable Sites and Water Efficiency credits only. Other categories of LEED credits – Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality and Innovation in Design, were not considered in this research. (Researcher's Note: The author believes that the 'Whole Design Evaluator' module is helpful when all the LEED credit categories are considered which would help in determining the composite index of sustainability for the whole design based on the LEED credits selected from all the categories stated above.)

Amalgamator (Process 9)

The next step in the framework is the 'Amalgamator' module, which amalgamates the owner's weightings with the attribute values for each credit and sorts them, resulting in a relative ranking of potential credits. A similar approach is used in the SDSS framework [Pearce et al. 1995], where the material with the highest ranking is recommended by the system.

List of selected credits (Process 10)

In the module 'List of selected credits' which represents the output of the entire process, the owner can review the credits recommended by the framework and select credits from the list. This module replaces the 'List of selected materials' module in the SDSS framework [Pearce et al. 1995], where the user can review the materials recommended by the system and select materials from the list.

6.3 Proof of Concept

The original interviewees of the research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] were contacted through e-mail to review the framework. The purpose of interviewing the owners was to gain their opinions about the comprehensiveness and usefulness of the framework.

Upon their agreement to participate in the 'proof of concept' process, they were sent, through e-mail, a review package consisting of a brief introduction stating the purpose of the research, a graphic depicting the framework and a two-page narrative description of the processes involved in the framework. They were also sent the list of attributes identified for SS Credit 4.1: Alternative Transportation: Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%, for illustration, in order to gain their perceptions about the comprehensiveness of the attributes identified. Refer to Appendix H for the 'proof of concept' package sent to the owners for their review and their paraphrased responses. Figures 6.2a, 6.2b, 6.2c and 6.2d are snapshots of 'proof of concept' package.

Introduction

This research developed a decision-making framework for aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites (SS) and Water Efficiency (WE) credits for their projects. This conceptual framework could be incorporated with a decision-support system or a software program to automate the methodology for selecting LEED credits for a project. Development of a working computer program is beyond the scope of this thesis.

The researcher identified decision-making attributes (characteristics), which influence a decision whether or not to use specific LEED SS and WE credits, through literature review, data collected at a collaborative work session of design professionals held at Michigan State University, and interviews of four case study projects, to address use of SS and WE credits of LEED. The researcher identified and presented these attributes,

Figure 6.2a: Snapshot of 'Proof of Concept' Package from Appendix H

Framework

Figure 1 shows the conceptual framework developed for assisting institutional owners in deciding to select LEED SS and WE credits for their projects. The framework consists of three main inputs required from the owner. The first is '**List all SS and WE credits**', the second input is represented by the module '**Conceptual design and decision-making parameters**' and the third is '**Owner's system of values**'. Below is a description of each module used in the framework.

Process 1: List all SS and WE Credits

This is the first step in the framework. Here, the owner is required to list all the SS and WE prerequisite and credits.

Figure 6.2b: Snapshot of 'Proof of Concept' Package from Appendix H

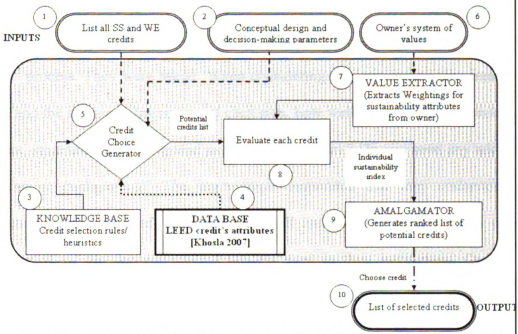

Figure 1 Framework to Assist Institutional Owners in Deciding to Select LEED SS and WE Credits for their Projects

Figure 6.2c: Snapshot of 'Proof of Concept' Package from Appendix H

Section Break (Next Page)

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to distance of building from mass transit	•			[USGBC-3], CS	
Subject to transportation needs of building occupants		•		[USGBC-3]	
Subject to availability of public transportation system	•	•		CWS, CS	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			[USGBC-3]	
Encourages building occupants to use mass transit		•		[USGBC-3], CWS	
Minimizes parking lots	•	•		[USGBC-3], CWS	
Reduces automobile use, air pollution	•	•		[USGBC-3], CWS	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al 2002]	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj mgmt			•	CS	
Addresses environmental impacts	•			[Eijadi et al 2002], CWS	[Eijadi et al 2002] concluded global environmental impacts, CWS concluded high

Figure 6.2d: Snapshot of 'Proof of Concept' Package from Appendix H

6.3.1 Proof of Concept Response Summary

Two of the owners of the case study projects agreed to participate in the 'Proof of Concept' process. They were asked 'When considering the introduction, the framework graphic and the narrative description of each step, how well do you feel you understand the intent, structure and the intended use of the framework? Do you need any additional discussion or background?' The interviewees responded that they understood the introduction, framework and its description well and that the framework is a good approximation of the decision-making process used in their institutions. One of the interviewees responded that the Credit Choice Generator, Value Extractor, Evaluate Each Credit, Amalgamator are the 'gut' of the framework where you decide whether or not you are going for the credit. However, owners system of values may differ since weighted values come from a variety of sources in their institution.

The next question addressed the usefulness of the framework in aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites and Water Efficiency credits for their projects. The interviewees responded that the framework is very useful and it formalizes the decision-making process.

The next question asked if there were additional steps or processes, which they can suggest as key in deciding to use SS and WE credits. The interviewees responded that there were no additional steps or processes that they could advise which is not included in the framework.

The next question asked if the attributes identified by the research for SS Credit 4.1: Alternative Transportation, Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%, comprehensive or are there other important attributes they would suggest or are there some indicated which should be deleted. One of the interviewees responded that the attributes were covered fairly well and the other interviewee responded that they had an additional "value" attribute for outreach and community education for WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%.

The final question asked the interviewees to give any additional suggestions regarding the content and form of the framework. The interviewees responded that they had no additional suggestions.

6.4 Demonstrative Case Study

The framework was applied to a hypothetical case study consisting of a community college located in a city in the eastern side of Michigan in order to test the use of the framework. The case study was cited in a city measuring approximately 8 square miles and with a population of about 32,000. It was assumed that the college served as the primary center of higher education for the area and served more than 6,000 students annually. It was also assumed that the college consists of a 25-acre riverfront campus located in a downtown area and nine buildings are located on campus with 400,755 Gross Square Feet of building. There were 816 parking spaces available on site with certain areas reserved for faculty and staff parking and additional paid parking was available at city-operated facilities nearby. It was assumed that the pedestrian circulation throughout the campus was accommodated through an extensive walkway system. Public transit system operated with support from state, federal and local governments was available to the students, staff and faculty.

The hypothetical community college was planning to construct a new building, which was to be certified under LEED-NC Version 2.2. For the planning committee of the organization, cost was the most important consideration for achieving LEED credits. The planning committee wanted to pursue credits that had low cost of implementation, as well as yielded high environmental benefits. The next important consideration for the planning committee was the effect of credits on human health. Table 6.1 below indicates these important considerations.

Important Considerations
Low cost of implementation
High environmental benefits
Effect on human health

Table 6.1: Important Considerations for Deciding LEED Credits

6.4.1 LEED Assumptions

Several assumptions were made so that the new building satisfies the requirements of LEED-NC 2.2 Sustainable Sites and Water Efficiency credits. The assumptions are discussed in detail below.

- Erosion and Sedimentation Control Plan for all the construction activities associated with the project conformed to the erosion and sedimentation control requirements of the 2003 EPA Construction General Permit.
- The site was not a prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations (citation 7CFR657.5).
- The site was a previously developed site within 1/2 mile of a residential zone which had an average density of 10 units per acre net and within 1/2 mile of 10 Basic Services such as bank, library, post office etc. and there was pedestrian access between the building and the services.
- The site was not a brownfield site.

- There were two bus lines on streets that provided access to the site and there was one bus line within 1/4 mile from campus entrance.
- Parking capacity met but did not exceed minimum local zoning requirements.
- General lighting standards of the college, both for internal and external lighting, complied with the LEED requirements.

6.4.2 Framework

Process 1: List all SS and WE Credits

In this step, all the SS and WE prerequisite and credits were listed as shown in Table 6.2:

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 2	Development Density & Community Connectivity
SS Credit 3	Brownfield Redevelopment
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.1	Heat Island Effect, Non-Roof
SS Credit 7.2	Heat Island Effect, Roof
SS Credit 8	Light Pollution Reduction
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies
WE Credit 3.1	Water Use Reduction, 20% Reduction
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 6.2: List of LEED SS and WE Credits

Process 2: Conceptual design and decision-making parameters

Two inputs were required from the owner in this process - conceptual design parameters and decision-making parameters. The assumptions made in section 6.4.1 above, were the parameters that describe the conceptual design. The planning committee of the organization wanted to pursue credits that had low cost of implementation and yielded high environmental benefits. These were the most important considerations in deciding whether or not to pursue LEED SS and WE credits. The next decision-making parameter was the effect of the credits on human health. Listed below were the decision-making parameters (assumptions) so that the new building satisfied the requirements of LEED-NC 2.2 Sustainable Sites and Water Efficiency credits.

- Secure bicycle racks for 5% of the building occupants and shower and changing facilities for 0.5% of Full-Time Equivalent occupants were to be provided in the building.
- Alternative fuel refueling stations and preferred parking for low-emitting and fuel-efficient vehicles could not be provided. In addition, low-emitting and fuel-efficient vehicles for building occupants could not be provided.
- 5% of the total parking space was to be reserved for carpools or vanpools.
- 50% of the site area was to be restored with native or adapted vegetation.
- Vegetated open space equal to the building footprint was to be provided adjacent to the building.
- Project site was to maintain natural stormwater flows by promoting infiltration.
- Alternate surfaces and nonstructural techniques were to be used to reduce pollutant loadings.
- 50% of the site hardscape was to be provided with a combination of shade and high reflective material.
- 75% of roof surface was to be provided with high reflective material.

- Landscape design included native or adapted plants, which eliminated irrigation requirements.
- High-efficiency fixtures and dry fixtures such as composting toilet systems and non-water using urinals were to be used to reduce wastewater volumes.

Process 3: Knowledge Base

Based on the conceptual design parameters described in Process 2 above, in this process referred to as 'Knowledge Base', credits which were clearly infeasible for the project were eliminated. According to the project conditions, the credits that could be achieved by the college are shown below in Table 6.3:

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 2	Development Density & Community Connectivity
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.1	Heat Island Effect, Non-Roof
SS Credit 7.2	Heat Island Effect, Roof
SS Credit 8	Light Pollution Reduction
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies
WE Credit 3.1	Water Use Reduction, 20% Reduction
WE Credit 3.2	Water Use Reduction, 30% Reduction

Table 6.3: LEED Credits based on Credit Selection Rules/ Heuristics

SS Credit 3: Brownfield Redevelopment and SS Credit 4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles were clearly infeasible for the project.

Process 4: Data Base

According to the list of attributes identified for each LEED SS and WE credit by the author in this research, Table 6.4 below shows a sample table that indicated the cost impact, environmental benefits and health benefits of each credit. The owner can refer to Figures 5.1, 5.2, 5.3 and 5.4 to create similar tables with their objectives in various columns.

Credit	Credit Name	Cost	Environmental Benefits	Health Benefits
SS Prerequisite 1	Construction Activity Pollution Prevention	Low	High	Medium
SS 1	Site Selection	Low	High	Medium
SS 2	Development Density & Community Connectivity	Low/ High	High	High
SS 3	Brownfield Redevelopment	Low/ High	High	High
SS 4.1	Alternative Transportation, Public Transportation Access	Low	High	High
SS 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	Low/ High	High	High
SS 4.3	Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	Low/ High	Medium	Low
SS 4.4	Alternative Transportation, Parking Capacity	Low	Medium	Low
SS 5.1	Site Development, Protect of Restore Habitat	Low/ Medium	High	Medium
SS 5.2	Site Development, Maximize Open Space	Low/ High	High	Medium
SS 6.1	Stormwater Design, Quantity Control	Low/ High	High	Medium
SS 6.2	Stormwater Design, Quality Control	Low/ High	High	High
SS 7.1	Heat Island Effect, Non-Roof	Medium/ High	Medium	Medium
SS 7.2	Heat Island Effect, Roof	Low/ High	High	High
SS 8	Light Pollution Reduction	Low	Medium	Low
WE 1.1	Water Efficient Landscaping, Reduce by 50%	Low/ High	High	Medium
WE 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	Low/ High	Medium	Low
WE 2	Innovative Wastewater Technologies	Low/ High	Medium to High	Medium
WE 3.1	Water Use Reduction, 20% Reduction	Medium/ High	Medium	Medium
WE 3.2	Water Use Reduction, 30% Reduction	Medium/ High	Medium	Low

Table 6.4: LEED Credits Summary

Process 5: Credit Choice Generator

'Credit Choice Generator' with the help of Knowledge Base, Data Base and the decision-making parameters processes provided by the owner generated a list of potential credits as shown below in Table 6.5. Since cost was the most important criteria, credits that have 'Medium/ High' costs, as shown in Table 6.4, were eliminated in this process. Credits having 'Low/ High' costs, as shown in Table 6.4 were not pruned from the list of potential credits.

Credit	Credit Name
SS Prerequisite 1	Construction Activity Pollution Prevention
SS Credit 1	Site Selection
SS Credit 2	Development Density & Community Connectivity
SS Credit 4.1	Alternative Transportation, Public Transportation Access
SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS Credit 4.4	Alternative Transportation, Parking Capacity
SS Credit 5.1	Site Development, Protect of Restore Habitat
SS Credit 5.2	Site Development, Maximize Open Space
SS Credit 6.1	Stormwater Design, Quantity Control
SS Credit 6.2	Stormwater Design, Quality Control
SS Credit 7.2	Heat Island Effect, Roof
SS Credit 8	Light Pollution Reduction
WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%
WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE Credit 2	Innovative Wastewater Technologies

Table 6.5: List of Potential Credits

Process 6: Owner's system of values

In this step, the owner weighted each attribute of sustainability according to the subjective importance or utility, which that attribute held for the owner. The planning committee of the college had decided to weight the attributes on a scale of 1 to 7 (1 being least important attribute and 7 being the most important). Following were the weights determined for the attributes by the owner:

'7' – For attributes having low cost of implementation, high environmental benefits or high health benefits.

'5' – For attributes having medium cost of implementation, medium environmental benefits or medium health benefits.

'3' – For attributes having high cost of implementation, low environmental benefits and low health benefits.

Process 7: Value Extractor

In this step, weightings for sustainability attributes were extracted from the owner. Then, values for each of the sustainability attributes were determined for each credit from other sources such as the project team, architect, engineer, landscape architect, designer and also the staff and faculty of the college and a normalized value between zero and one was calculated for each attribute value. The following values were assumed for the attributes:

'0.75' - For attributes having low cost of implementation, high environmental benefits or high health benefits.

'0.5' – For attributes having medium cost of implementation, medium environmental benefits or medium health benefits.

'0.25' – For attributes having high cost of implementation, low environmental benefits and low health benefits.

Process 8: Evaluate each credit

In this step, the weights (obtained from Process 6) and values (obtained from Process 7) are multiplied and summed to create individual sustainability index or an index of subjective utility for that credit. Since the number of attributes identified for each credit differs, average sustainability index for an individual credit is calculated by dividing its sustainability index by the number of attributes identified for that credit. Table 6.6 below shows the weights, values, the product of weights and values, and the average sustainability index for SS Credit 4.1: Alternative Transportation, Public Transportation Access as demonstration. Refer to Appendix I for the average sustainability index obtained for each of the potential credits identified in Process 5 above.

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Subject to distance of building from mass transit	•			3	0.25	0.75
Subject to transportation needs of building occupants		•		3	0.25	0.75
Subject to availability of public transportation system	•	•		3	0.25	0.75
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			3	0.25	0.75
Encourages building occupants to use mass transit		•		3	0.25	0.75
Minimizes parking lots	•	•		7	0.75	5.25
Reduces automobile use, air pollution	•	•		7	0.75	5.25
No cost / potential cost decrease			•	7	0.75	5.25
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	7	0.75	5.25
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with const proj. mgmt.			•	7	0.75	5.25
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 4.1 =						**61.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 4.1 =						**61.5/16 = 3.84**

Table 6.6: Average Sustainability Index for SS Credit 4.1 for Demonstrative Case Study

Process 9: Amalgamator

In this step, the credits are sorted based on their relative ranking. Table 6.7 below shows the ranked list of credits suggested by the framework.

Ranking	Credit	Credit Name	Average Sustainability Index
1	SS Credit 8	Light Pollution Reduction	4.48
2	SS Credit 6.2	Stormwater Design, Quality Control	4.27
3	SS Credit 4.1	Alternative Transportation, Public Transportation Access	3.84
4	SS Prerequisite 1	Construction Activity Pollution Prevention	3.83
5	SS Credit 5.2	Site Development, Maximize Open Space	3.77
6	SS Credit 1	Site Selection	3.73
7	SS Credit 4.4	Alternative Transportation, Parking Capacity	3.72
8	SS Credit 2	Development Density & Community Connectivity	3.71
9	SS Credit 5.1	Site Development, Protect of Restore Habitat	3.66
10	SS Credit 7.2	Heat Island Effect, Roof	3.57
11	WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	3.30
12	WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%	3.16
13	SS Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	2.94
14	SS Credit 6.1	Stormwater Design, Quantity Control	2.61
15	WE Credit 2	Innovative Wastewater Technologies	1.83

Table 6.7: Ranked List of Credits for Demonstrative Case Study

The ranked list of credits above was unexpected by the researcher. The researcher believed that SS Credit 4.1: Alternative Transportation, Public Transportation Access would top the list as it has low cost of implementation, high environmental and high health benefits as suggested by the literature, case studies and the collaborative work session data. Also, the researcher believed that WE Credit 1.1: Water Efficient Landscaping, Reduce by 50% would rank higher than WE Credit 1.2: Water Efficient Landscaping, No Potable Use or No Irrigation since WE 1.1 has a lower cost of implementation as compared to WE 1.2, as suggested by the work session data. The researcher also believed that SS Credit 6.1: Stormwater Design, Quantity Control would rank higher than SS Credit 6.2: Stormwater Design, Quality Control because of its low cost of implementation, as suggested by the work session data. These results for the hypothetical case study resulted from the weightings and values used. Actual owner may use different weightings and values. It is interesting to note that despite the deviation. From the expected results, these credits all exceed the 3.0 minimum kevel defined as acceptable to the owner.

Process 10: List of selected credits

In this step, the owner can review the credits recommended by the framework and select credits from the list. It was assumed that the planning committee of the college wanted to pursue credits that had average sustainability index more than 3.0. Therefore, the credits selected by the owner are shown below in Table 6.8.

Ranking	Credit	Credit Name	Average Sustainability Index
1	SS Credit 8	Light Pollution Reduction	4.48
2	SS Credit 6.2	Stormwater Design, Quality Control	4.27
3	SS Credit 4.1	Alternative Transportation, Public Transportation Access	3.84
4	SS Prerequisite 1	Construction Activity Pollution Prevention	3.83
5	SS Credit 5.2	Site Development, Maximize Open Space	3.77
6	SS Credit 1	Site Selection	3.73
7	SS Credit 4.4	Alternative Transportation, Parking Capacity	3.72
8	SS Credit 2	Development Density & Community Connectivity	3.71
9	SS Credit 5.1	Site Development, Protect of Restore Habitat	3.66
10	SS Credit 7.2	Heat Island Effect, Roof	3.57
11	WE Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	3.30
12	WE Credit 1.1	Water Efficient Landscaping, Reduce by 50%	3.16

Table 6.8: List of Selected Credits for Demonstrative Case Study

6.4.3 Conclusion of Demonstrative Case Study

After reviewing the demonstration, the researcher concluded that certain terms used in the framework could be simplified for better interpretation by the owners and to make the framework more usable. The researcher also concluded that making these revisions would make it easier for the owners and designers to use the framework and thus lead to accurate results.

6.5 Modified Framework

Framework changes resulting from the proof of concept interviews and demonstrative case study included changing several terms used in the framework and are presented in Figure 6.3, to make it more understandable and usable by owners and designers.

Figure 6.3 below shows the modified framework. Process 1 (List all SS and WE credits) remain unchanged in the modified framework. Process 2: Conceptual design and decision-making parameters was changed to 'Identify Owner's Objectives and Decision-Making Parameters' in the modified framework.

Process 3: Knowledge Base (Credit selection rules/ heuristics) was referred to as 'Selecting credits based on project conditions' in the modified framework. This was because, in this process the credits were selected based on the requirements stated in the LEED-NC 2.2 Reference Guide and depending on the project conditions; credits that were clearly infeasible for the project were eliminated from the process whereas in the SDSS Framework [Pearce et al. 1995], Knowledge Base (Credit selection rules/ heuristics) used technical performance thresholds or other heuristics to eliminate those alternatives that were clearly infeasible for the application.

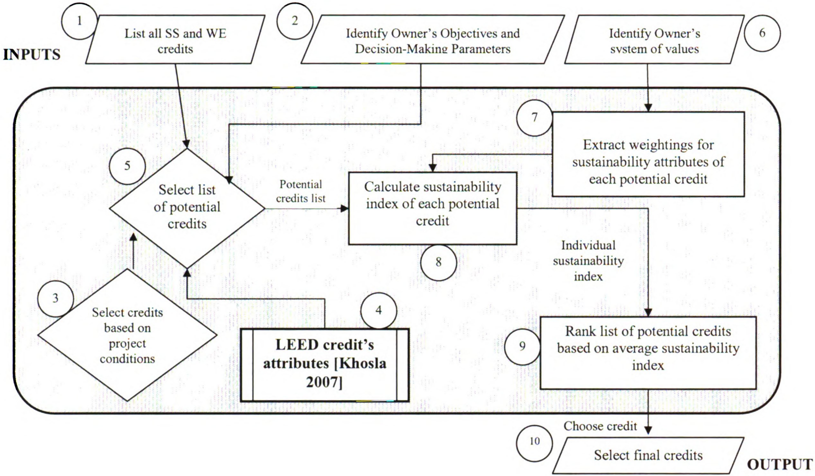

Figure 6.3: Final Framework (Modified from Pearce et al's [1995] SDSS Framework)

Process 4: Data Base (LEED credit's attributes) was called 'LEED credit's attributes' in the modified framework. Process 5 which was originally referred to as 'Credit Choice Generator' was changed to 'Select list of potential credits' in the modified framework. Process 6: Owner's system of values was referred to as "Identify Owner's system of values' in the modified framework. Process 7: Value Extractor (Extracts weightings for sustainability attributes from owner) was called 'Extract weightings for sustainability attributes of each potential credit' in the modified framework. Process 8, which was called 'Evaluate each credit' was changed to 'Calculate sustainability index of each potential credit' in the modified framework. Process 9: Amalgamator (Generates ranked list of potential credits) was referred to as 'Rank list of potential credits based on average sustainability index' in the modified framework. Finally, Process 10: List of selected credits was changed to 'Select final credits' in the modified framework.

6.6 Chapter Summary

This chapter presented and described the framework developed for assisting institutional owners in deciding the use of specific LEED SS and WE credits for their projects and presented the proof of concept. Additionally, the use of the framework was demonstrated with the help of a hypothetical case study. Finally, the framework was modified based on the conclusions drawn from the demonstrative case study. One of the major reasons for doing this was to make the framework more user-friendly.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 Introduction

Chapter five summarized the attributes identified for each LEED SS and WE credit. Chapter six presented the framework developed for assisting institutional owners in deciding the use of specific LEED SS and WE credits for their projects. Chapter concludes the thesis, presents contributions of the research, recommendations for institutional project owners, areas for future research, limitations of this research, and reiterates goals and objectives of the research.

7.2 Research Objectives

The objectives of this research were:

1. To identify the attributes of sustainable construction that are relevant in deciding to pursue or not to pursue specific LEED SS and WE credits.
2. To develop a decision-making framework to assist institutional owners in the task of deciding which LEED SS and WE credits to pursue within the context of specific projects.

The overall goal of this research was to develop a framework to assist institutional owners in deciding the use of specific LEED SS and WE credits for their projects. The researcher incorporated the AHP Multi-Attribute Model developed by Herkert et al. [1996] to Pearce et al.'s [1995] Sustainability Decision Support System Conceptual Framework in order to develop this framework.

7.3 Research Contributions

The following are the major contributions of this research:

1. Developed a decision-making framework to aid institutional owners in deciding to pursue or not to pursue specific LEED site related credits for their projects. Through the literature review, no pre-existing decision-making framework could be found that would assist an owner to select LEED site and water credits for their projects.
2. Identified and presented attributes relevant in deciding to pursue or not to pursue LEED SS and WE credits.
3. Presented the relation of these attributes with the objectives of sustainable construction, which are environment, community and economic issues [USGBC-2, Presley and Meade 2004, ASTM 2004].
4. Analyzed the current status of LEED certified buildings in the Great Lakes region with emphasis on SS and WE credits. This analysis could be used for other studies.

7.4 Research Limitations

The limitations of the research were:

1. This research focused on institutional projects in the Great Lakes region.
2. The focus of this research was primarily on the LEED Green Building Rating System and other standards of measuring sustainable development were not considered.
3. The analysis was primarily focused on the LEED SS and WE Credits and other LEED credits were not considered.
4. The research examined institutional buildings that were certified under LEED Version 2.0 and LEED-NC Version 2.1 Certification. LEED Version 1.0 Certified projects were not considered.
5. Because of the recent development and issuance of LEED-NC 2.2, case studies were not found for LEED-NC 2.2.

6. There were a limited number of participants in the collaborative work session conducted for the research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006], whose responses were considered in identifying attributes, described in detail in chapters four and five of the thesis.
7. The collaborative work session participants included Michigan public officials from university and local governments; LEED Accredited Professionals (LAP) and design professionals including architects, planners, landscape architects, site engineers, and faculty and staff members from the Physical Plant Division at Michigan State University. These participants commented on the impact on the contractor of certain credits. However, there were no contractors at the work session.
8. This study used four case studies conducted for the research project entitled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006]. Additional case studies would be helpful in identifying attributes.
9. The attributes were identified by the researcher for each LEED SS and WE credits from the literature review, collaborative work session data and responses of owners of case study projects and were based on themes identified by the researcher rather than by quantitative methods.

7.5 Recommendations for Institutional Project Owners

The following recommendations are suggested by the researcher based on the framework developed by this thesis for deciding the use of LEED SS and WE credits for institutional projects, and are applicable to universities or institutional project owners:

1. Establish conceptual design and decision-making parameters early in the project. Identifying sustainability objectives plays a vital role in using the framework developed by this research.
2. Develop weightings for each sustainability attribute identified and presented in this research. The owner according to the subjective importance or utility should identify these weightings. In doing so, the owner might use internal reviews such as consultation with the design team or the planning committee of the organization.
3. The owner might seek guidance of a professional consultant such as architect, designer, engineer, etc. to use the framework developed by this research.
4. The framework could be made more effective by incorporating it with an expert system or a software program to automate the methodology for selecting LEED credits for a project.

Researcher's Note: Although this was not the focus of this study, the collaborative work session participants and the case study responses indicate the need for early involvement of designers and contractors in all the phases of construction. They recommend that design teams should be incorporated in planning the project and contractors should be consulted, as they will ultimately carry out these objectives in planning and constructing the project.

7.6 Areas of Future Research

The research focused on the LEED Sustainable Sites and Water Efficiency credits. Future research could include other categories of LEED credits - Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality and Innovation in Design, which will enable owners to adopt the framework in order to decide LEED credits which can be pursued for a project.

From the case studies, responses were obtained from owners to identify attributes relevant in deciding whether to pursue or not to pursue specific LEED SS and WE credits. Future research could include responses from architects, designers, engineers, construction managers and contractors in order to identify more attributes for each credit and enhance the comprehensiveness of the framework.

The framework could then be incorporated with a decision-support system to automate the methodology for selecting LEED credits for a project.

7.7 Research Conclusion

Data obtained from the collaborative work session, case studies and literature was used by the researcher to identify attributes for LEED SS and WE credits and develop a new decision-making framework to assist institutional owners in selecting credits for their projects. From this process, the following major conclusions were drawn:

1. The sustainability attributes, which influence a decision of whether or not to pursue LEED SS and WE credits have been identified in this thesis. It can be concluded that weighting these attributes is one of the important criteria in the working of this framework. The owner might consider seeking guidance from professional consultants such as architect, engineer, designer, etc. for this purpose. Additionally, these attributes were identified based on themes identified by the researcher rather than by quantitative methods. An owner might want to add certain attributes, which they consider important for their institution that might influence their decision-making process.

2. The attributes, relevant to each credit, were presented according to their relation with the objectives of sustainable construction – environment, community and economic issues. It can be concluded that the focus of any institution can be either one or all these three considerations, as demonstrated with the hypothetical case study, where economic consideration was the deciding factor whether or not to pursue certain credits.
3. From the 'proof of concept' responses presented in chapter six, it can be concluded that institutions typically use the same decision-making process as suggested by the framework developed by this research. However, the framework formalizes this process, which might be helpful for some members of the institution.
4. After reviewing the demonstrative case study, the researcher concluded that the framework could be made more user-friendly by simplifying the terms in the framework. The researcher believes that simplifying certain terms will help the owner better understand the framework and make it more usable.

7.8 Chapter Summary

This chapter concluded the thesis, presented contributions of this research, limitations, recommendations for institutional project owners and areas of future research.

APPENDICES

APPENDIX A

LEED-NC Sustainable Sites (SS) and Water Efficiency (WE) Credits

Sustainable Sites

Hendee [2006] has defined a sustainable site as "the one in which land use densities, civil, planning, landscape, water use, and other issues are taken into consideration and planned for in a way that assists in reducing the ecological footprint of a new construction on the ecosystem" [Hendee 2006].

SS Prerequisite 1: Construction Activity Pollution Prevention (Formerly: Erosion and Sedimentation Control) – This credit is a prerequisite that any development should obtain in order to qualify for any of the points within the overall SS category. The intent of this credit is "to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation". The requirements are to:

1) "Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse" since erosion greatly reduces the soil's ability to support plant life, regulate water flow, and maintain the biodiversity of soil microbes and insects that controls disease and pest outbreaks;

2) "Prevent sedimentation of storm sewer or receiving streams" since sedimentation degrades water quality and

3) "Prevent polluting the air with dust and particulate matter".

Typically, an Erosion Control and Sedimentation Plan will be required with any development proposal. "Techniques used for erosion control include a variety of measures such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps and sediment basins" [USGBC-2].

SS Credit 1: Site Selection – The intent of this credit is "to avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site". The best strategy for site selection is to choose a previously developed site that has already been disturbed in order to limit damage to the environment and preserve sensitive land areas. The first requirement encourages development on portions of sites that are not considered to be prime farmlands. Another requirement prevents development of "land whose elevation is lower than 5 feet above the elevation of the 100-year flood". Other requirements states that no development should be carried out on "land identified as habitat for any species, within 100 feet of any water including wetlands, previously undeveloped land that is within 50 feet of a water body, 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". It is suggested that during the site selection process, such sites that do not include sensitive site elements and restrictive land types be preferred [USGBC-2].

SS Credit 2: Development Density & Community Connectivity – The intent of this credit is "to channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources". This credit requires "construction to be carried on a previously developed site and in a community with a minimum density of 60,000 sq. ft. per acre net. The second option is to carry out construction on a previously developed site within 1/2 mile of a residential zone or neighborhood which has an average density of 10 units per acre net and within 1/2 mile of at least 10 Basic Services such as bank, library, post office etc. such that there is pedestrian access between the building and the services". It is suggested to select such an urban site that has pedestrian access to a variety of services [USGBC-2].

SS Credit 3: Brownfield Redevelopment – The intent of this credit is to "rehabilitate damaged sites where development is complicated by environmental contamination, reducing pressure on undeveloped land". To qualify for this credit, "development must be carried out on a site documented as contaminated or on a brownfield site as defined by local, state or federal government agency". Strategies include – preferring brownfield sites for development, identifying tax incentives and property cost savings, coordinating site development with remediation activity [USGBC-2].

SS Credit 4.1: Alternative Transportation: Public Transportation – The intent of this credit is "to reduce pollution and land development impacts from automobile use". This credit requires "locating project within ½ a mile of commuter rail, light rail or subway station or alternatively the project should be located within ¼ mile of bus lines that could be used by building occupants". It is suggested to site the building near mass transit [USGBC-2].

SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms – The intent of this credit is to "reduce pollution and land development impacts from automobile use". To meet the criteria for this credit, "the building should provide secure bicycle racks and/ or storage for 5% of the building occupants and also provide shower and changing facilities in the building for 0.5% of Full-Time Equivalent occupants". It is recommended to design the buildings with such amenities in order to qualify for this credit [USGBC-2].

SS Credit 4.3: Alternative Transportation: Low Emitting & Fuel Efficient Vehicles – The intent of this credit is "to reduce pollution and land development impacts from automobile use". There are three options to achieve this credit. First, by "providing low-emitting and fuel-efficient vehicles for 3% of Full-Time Equivalent occupants and also providing parking facilities for these vehicles", this credit could be achieved. Second option is "to provide parking facilities for such vehicles for 5% of the total parking capacity on the site and the third option is to install alternative-fuel refueling stations for 3% of the total vehicle parking capacity of the site". It is suggested to consider sharing the costs and benefits of refueling stations with neighbors [USGBC-2].

SS Credit 4.4: Alternative Transportation: Parking Capacity – The intent of this credit is "to reduce pollution and land development impacts from single occupancy vehicle use". Non-residential development to qualify for this credit should provide parking that does not exceed minimum local zoning requirements and 5% of the total parking space should be reserved for carpools or vanpools. Technical strategies that could be used to obtain this credit are: minimize parking lot/garage size, share parking facilities with adjacent buildings or consider alternatives that will limit the use of single occupancy vehicles" [USGBC-2].

SS Credit 5.1: Site Development: Protect or Restore Habitat (Formerly: Reduced Site Disturbance: Development Footprint) – The intent of this credit is "to conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity. If the development is to be done on a greenfield site, then in order to obtain this credit, it is required to limit all site disturbance to 40 feet beyond the building perimeter; 10 feet beyond surface walkways, patios, surface parking and utilities less than 12 inches in diameter; 15 feet beyond primary roadway curbs and main utility branch trenches; and 25 feet beyond constructed areas with permeable surfaces that require additional staging areas in order to limit compaction in the constructed area. If the development is to be carried out on a previously developed or graded site, it is required to restore or protect a minimum of 50% of the site area with native or adapted vegetation. It is possible to achieve this credit by minimizing disruption to existing ecosystems, minimizing the building footprint, minimizing disruption of the existing site, restoring previously degraded areas to its natural state and prohibiting plant materials listed as invasive or noxious weed species" [USGBC-2].

SS Credit 5.2: Site Development: Maximize Open Space – The intent of this credit is "to provide a high ratio of open space to development footprint to promote biodiversity". One of the following three options could be satisfied in order to achieve this credit. The first option is "to reduce the development footprint and/ or provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site by 25%". The second option is for areas with no local zoning requirements. They can achieve this credit by "providing vegetated open space area adjacent to the building that is equal to the building footprint. The third option is for the area where a zoning ordinance exists, but there is no requirement for open space. They can qualify for the credit by providing vegetated open space equal to 20% of the project's site area. Strategies include designing the building with minimum footprint to minimize site disruption and adopting a master plan for the development of the project site" [USGBC-2].

Major credit changes from LEED-NC 2.1 to 2.2: "Open space definition has been refined to address both urban and suburban settings" [USGBC-3].

SS Credit 6.1: Stormwater Design: Quantity Control (Formerly: Storm water Management: Rate and Quantity) – The intent of this credit is "to limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants. If existing imperviousness is less than or equal to 50% then this credit could be achieved by implementing a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two-year 24-hour design storms. The other method is to implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies. But if the existing imperviousness is greater than 50%, then this credit could be achieved by implementing a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year 24-hour design storm. Project site could be designed in such a way so as to maintain natural stormwater flows by promoting infiltration. Impervious surfaces could be minimized by vegetated roofs, pervious paving etc. methods could be adopted to reuse stormwater for non-potable purposes such as landscape irrigation, toilet and urinal flushing and custodial uses" [USGBC-2].

SS Credit 6.2: Stormwater Design: Quality Control (Formerly: Storm water Management: Treatment) – The intent of this credit is "to limit disruption and pollution of natural water flows by managing stormwater runoff. To qualify for this credit, a stormwater management plan should be implemented in order to reduce impervious cover, to promote infiltration, and to capture and treat the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs). Strategies include using alternative surfaces such as vegetated roofs, pervious pavement or grid pavers and nonstructural techniques such as rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling to reduce imperviousness and promote infiltration thereby reducing pollutant loadings. Other strategies include using sustainable design techniques to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff" [USGBC-2].

Major credit changes from LEED-NC 2.1 to 2.2: "Stormwater control systems must be capable of treating 90% of runoff and removing 80% of total suspended solids. System performance information on phosphorous removal is no longer required" [USGBC-3].

SS Credit 7.1: Heat Island Effect: Non-Roof – The intent of this credit is "to reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat". This credit could be obtained by satisfying any one of the following to requirements: "1) Provide any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots): Shade (within 5 years of occupancy), Paving materials with a Solar Reflectance Index (SRI)2 of at least 29, Open grid pavement system. 2) Place a minimum of 50% of parking spaces under cover (defined as under ground, under deck, under roof, or under a building). Any roof used to shade or cover parking must have an SRI of at least 29. The following techniques could be used to satisfy the above requirement - shading constructed surfaces on the site with landscape features and utilizing high-reflectance materials for hardscape, Replacing constructed surfaces (i.e. roof, roads, sidewalks, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specifying high-albedo materials to reduce the heat absorption" [USGBC-2].

SS Credit 7.2: Heat Island Effect: Roof – The intent of this credit is "to reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat". There are three options to achieve this credit. First, "by using roofing materials that have a Solar Reflective Index (SRI) equal to or greater than the following values for a minimum of 75% of the roof area: Low-Sloped Roof (Slope <= 2:12), SRI should be >=78 and for High-Sloped Roof (Slope >=2:12), SRI should be >= 29. Second, by installing a vegetated roof for at least 50% of the roof area this credit could be achieved. Third, by installing high albedo and vegetated roof surfaces that, in combination, meet the following criteria: (Area of SRI Roof / 0.75) + (Area of vegetated roof / 0.5) >= Total Roof Area. Installing high-albedo and vegetated roofs could be considered to reduce heat absorption" [USGBC-2].

Major credit changes from LEED-NC 2.1 to 2.2: "New performance metric (Solar Reflectance Index)" [USGBC-3].

SS Credit 8: Light Pollution Reduction – The intent of this credit is "to minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments". There are requirements to be satisfied for interior as well as exterior lighting to qualify for this credit. Following is the requirement for interior lighting – "The angle of maximum candela from each interior luminaire as located in the building should intersect opaque building interior surfaces and not exit out through the windows. Alternatively, all non-emergency interior lighting should be automatically controlled to turn off during non-business hours. Manual override capability should be provided for after hours use". Following is the requirement for exterior lighting – "Only light areas as required for safety and comfort, not exceeding 80% of the lighting power densities for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section, without amendments. Design strategies include adopting site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution, minimizing site lighting where possible and model the site lighting using a computer model" [USGBC-2]. Major credit changes from LEED-NC 2.1 to 2.2: "Requirements for control of interior lighting to prevent spillover and restructuring of the exterior lighting requirement" [USGBC-3].

Water Efficiency

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50% - The intent of this credit is "to limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation. This credit requires reducing potable water consumption for irrigation by 50% from a calculated mid-summer baseline case. These reductions shall be attributed to any combination of the following items: plant species factor, irrigation efficiency, use of captured rainwater, use of recycled wastewater, use of water treated and conveyed by a public agency specifically for non-potable uses. Following are the strategies: Perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements, where irrigation is required use high-efficiency equipment and/or climate-based controllers" [USGBC-2].

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation – The intent of this credit is "to eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation. This credit could be achieved by achieving WE Credit 1.1 and also by satisfying one of the following two options: Using only captured rainwater, recycled wastewater, recycled greywater, or water treated and conveyed by a public agency specifically for non-potable uses for irrigation or install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation. The strategies include performing a soil/climate analysis to determine appropriate landscape types and designing the landscape with indigenous plants to reduce or eliminate irrigation requirements. Also, using stormwater, greywater, and/or condensate water for irrigation could be considered" [USGBC-2].

Major credit changes from LEED-NC 2.1 to 2.2: "Use of municipally provided non-potable water is acceptable for credit compliance" [USGBC-3].

WE Credit 2: Innovative Wastewater Technologies – The intent of this credit is "to reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge". By satisfying one of the following two options, this credit could be pursued. "First option is to reduce potable water use for building sewage conveyance by 50% through the use of water conserving fixtures (water closets, urinals) or non-potable water (captured rainwater, recycled greywater, and on-site or municipally treated wastewater). The second alternative is to treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site. Following are some of the strategies: Specifying high-efficiency fixtures and dry fixtures such as composting toilet systems and non-water using urinals to reduce wastewater volumes and considering reusing stormwater or greywater for sewage conveyance or on-site wastewater treatment systems (mechanical and/or natural)" [USGBC-2].

WE Credit 3.1: Water Use Reduction: 20% Reduction – The intent of this credit is "to maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems. To qualify for this credit, it is required to employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. These calculations are based on estimated occupant usage and include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks. It is suggested to use high-efficiency fixtures, dry fixtures such as composting toilet systems and non-water using urinals, and occupant sensors to reduce the potable water demand. Also, reuse of stormwater and greywater for non-potable applications such as toilet and urinal flushing and custodial uses could be considered" [USGBC-2].

WE Credit 3.2: Water Use Reduction: 30% Reduction – The intent of this credit is "to maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems. To qualify for this credit, it is required to employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. These calculations are based on estimated occupant usage and include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks. It is suggested to use high-efficiency fixtures, dry fixtures such as composting toilet systems and non-water using urinals, and occupant sensors to reduce the potable water demand. Also, reuse of stormwater and greywater for non-potable applications such as toilet and urinal flushing, mechanical systems and custodial uses could be considered" [USGBC-2].

APPENDIX B

LEED Certified Buildings in the “Great Lakes” Region

Overall Summary of the 21 LEED NC 2.0 and 2.1 Certified Buildings in Michigan

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	Detroit Lions HQ & Training Facility	Ford Motor Land Services Corp.	Allen Park	Certified	2.0	Commercial
2	Goodwillie Environmental School	Forest Hills Public Schools	Grand Rapids	Certified	2.0	***Institutional***
3	The Herman Miller MarketPlace - an intellisys building	Granger Group of Companies	Zeeland Township	Gold	2.0	Commercial office
4	Ice Mountain Bottling Plant	Nestle Waters North America	Stanwood	Certified	2.0	Commercial
5	Herman Miller C1 Main Site	Herman Miller, Inc.	Zeeland	Gold	2.0	Commercial office
6	FHPS New Secondary Building	Forest Hills Public Schools	Grand Rapids	Certified	2.1	***Institutional***
7	Detroit School of Arts	Detroit Public Schools Project Management	Detroit	Certified	2.1	***Institutional***
8	Forest Hills Fine Arts Center	Forest Hills Public Schools	Grand Rapids	Silver	2.0	***Institutional***
9	Knapp Forest Elementary	Forest Hills Public Schools	Grand Rapids	Certified	2.1	***Institutional***
10	S.T. Dana Building Renovations	University of Michigan	Ann Arbor	Gold	2.0	***Institutional***
11	Bazzani Associates Headquarters	Bazzani Holdings, LLC	Grand Rapids	Silver	2.0	Commercial office, Multi-unit residential
12	Richard J. Lacks, Sr. Cancer Center	"Saint Mary's Mercy Medical Center"	Grand Rapids	Certified	2.1	Health Care
13	Ford Rouge Visitor Center	Ford Motor Company	Dearborn	Gold	2.0	Museum, Visitor Center
14	First National Bank in Howell - Green Oak Township Office	First National Bank in Howell	Whitmore Lake	Certified	2.1	Financial and Communications
15	Water/Environmental Services Facility	Water Systems Department	Grand Rapids	Certified	2.1	Industrial

Overall Summary of the 21 LEED NC 2.0 and 2.1 Certified Buildings in Michigan

16	Interurban Transit Partnership	ITP	Grand Rapids	Certified	2.1	Commercial OfficeTransportation
17	Calvin College Bunker Interpretive Center	Calvin College	Grand Rapids	Gold	2.1	***Institutional***
18	Michigan Alternative and Renewable Energy	City of Muskegon	Muskegon	Gold	2.1	Office
19	BCBSM/Steketees Building	Monroe Center JV, L.L.C	Grand Rapids	Certified	2.1	Commercial
20	Lake Ontario Hall, Grand Valley State University	GVSU	Allendale	Silver	2.1	***Institutional***
21	Keystone Community Church	Keystone Community Church	Grand Rapids	Certified	2.1	Religious

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the 7 LEED NC 2.0 and 2.1 Certified Buildings in Ohio

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	Howard M. Metzenbaum U.S. Courthouse	U.S. General Services Administration	Cleveland	Certified	2.1	Courthouse
2	Nathaniel R. Jones Federal Building		Youngstown	Certified	2.0	***Institutional***
3	Giant Eagle Market #229	Giant Eagle Inc.	Brunswick	Certified	2.0	Supermarket
4	Cleveland Foodbank		Cleveland	Certified	2.1	Commercial
5	PNC Bank - Beckett Ridge	PNC Bank	West Chester	Silver	2.1	Bank
6	Building 10	Honda R&D Americas, Inc.	Raymond	Gold	2.1	Commercial
7	Heapy Engineering Headquarters	Heapy Engineering LLC	Dayton	Silver	2.1	Commercial

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the 9 LEED NC 2.0 and 2.1 Certified Buildings in Illinois

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	CNT Renovation		Chicago	Platinum	2.1	
2	Bolingbrook High School	Valley View School District 365U	Bolingbrook	Certified	2.1	***Institutional***
3	Central Supply Facility	Argonne National Laboratory	Argonne	Silver	2.0	***Institutional***
4	22nd District Police Station	City of Chicago	Chicago	Silver	2.0	Government
5	West Englewood Public Library	City of Chicago Public Library	Chicago	Certified	2.1	***Institutional***
6	Northwestern University - Ford Motor Com		Evanston	Silver	2.1	***Institutional***
7	Chicago Public Library, Oriole Park Branch	Chicago Public Library	Chicago	Certified	2.1	***Institutional***
8	Children's Discovery Museum	Town of Normal	Normal	Silver	2.1	Museum
9	EXELON PAVILIONS	Millennium Park Inc	Chicago	Silver	2.1	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the 4 LEED NC 2.0 and 2.1 Certified Buildings in Wisconsin

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	AEI Office Building	University Research Park Facilities Corporation	Madison	Certified	2.0	Office Building
2	Boldt Wisconsin River Valley Office	Boldt Company	Stevens Point	Silver	2.0	Office and Warehouse Bldg
3	Schlitz Audubon Nature Center	Schlitz Audubon Nature Center	Bayside	Gold	2.0	Learning Center
4	Willie G. Davidson Product Development Center Expansion 2002	Harley-Davidson Motor Company	Wauwatosa	Certified	2.1	Commercial

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the LEED NC 2.0 Certified Building in Minnesota

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	Westwood Elementary	Elk River School District	Zimmerman	Certified	2.0	***Institutional***

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the LEED NC 2.0 and 2.1 Certified Buildings in Iowa

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	Vermeer Science Center Renovation & Addition	Central College	Pella	Silver	2.0	***Institutional***
2	Grinnell College CERA Environmental Educ		Kellogg	Gold	2.1	***Institutional***

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the 26 LEED NC 2.0 and 2.1 Certified Buildings in Pennsylvania

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	PNC Firstside Center	PNC Financial Services Group	Pittsburgh	Silver	2.0	Commercial Office
2	McGowan Institute for Regenerative Medicine	University of Pittsburgh	Pittsburgh	Gold	2.0	***Institutional***
3	Clearview Elementary School	Hanover Public School District	Hanover	Gold	2.0	***Institutional***
4	Phipps Conservatory and Botanical Garden	Phipps Conservatory and Botanical Garden	Pittsburgh	Silver	2.1	
5	David L. Lawrence Convention Center	Sports & Exhibition Authority	Pittsburgh	Gold	2.1	Convention Center
6	Cambria Office Building	PA Department of the Environment	Ebensburg	Gold	2.0	Commercial Office
7	Swarthmore College Science Center	Swarthmore College	Swarthmore	Certified	2.1	***Institutional***

Overall Summary of the 26 LEED NC 2.0 and 2.1 Certified Buildings in Pennsylvania

8	Shuster Hall - A Dining Hall/Multi-purpose Building	Juniata College	Penn Township	Certified	2.0	Multi-purpose bldg/ college
9	New House	Carnegie Mellon University	Pittsburgh	Silver	2.0	Residence Hall/ University
10	The Plaza at PPL Center	Liberty Property Trust	Allentown	Gold	2.0	Commercial Office
11	DEP California Office Building	MBC Properties	California	Gold	2.1	Office Building
12	PA-DEP Moshannon District Office	Miller Bros Construction	Philipsburg	Gold	2.0	Office Building
13	W. S. Cumby Office Complex	W. S. Cumby	Springfield	Certified	2.0	Office Building
14	U. S. Steel Research and Technology Center	United States Steel Corporation	Munhall	Certified	2.1	Research Institute
15	Henderson House	Carnegie Mellon University	Pittsburgh	Silver	2.1	Residence Hall/ University
16	Gardner Integrated Athletic Center	Haverford College	Haverford	Gold	2.1	
17	DEP Southeast Regional Office Building	Tiger Norristown	Norristown	Gold	2.0	Office Building
18	Central Administration Building	Pennsylvania Turnpike Commission	Middletown	Certified	2.0	Administrative
19	Heinz History Center Smithsonian Wing	Historical Society of Western Pennsylvania	Pittsburgh	Silver	2.0	
20	Children's Museum of Pittsburgh Expansion	"Children's Museum of Pittsburgh"	Pittsburgh	Silver	2.1	Museum
21	Lower Windsor Township Community Center	Lower Windsor Township	Wrightsville	Silver	2.1	Community Center
22	office building for Pennsylvania Housing		Harrisburg	Gold	2.1	Office Building
23	PA DEP Bureau of Laboratories	Vartan Enterprises	Harrisburg	Gold	2.0	***Institutional***
24	Southern York County Library	Southern York County Library	Shrewsbury	Certified	2.1	***Institutional***

Overall Summary of the 26 LEED NC 2.0 and 2.1 Certified Buildings in Pennsylvania

25	Posner Center	Carnegie Mellon University	Pittsburgh	Certified	2.1	***Institutional***
26	Highmark Data Center	Highmark	Harrisburg	Silver	2.1	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

Overall Summary of the 11 LEED NC 2.0 and 2.1 Certified Buildings in New York

No	Project Name	Owner	City	LEED Rating	Version	Bldg Type
1	625 Broadway Office Complex	New York State Dept of Environmental Conservation	Albany	Silver	2.0	Office (Government)
2	The Solaire/20 River Terrace	River Terrrace Associates, LLC	New York	Gold	2.0	
3	The Patrick H. Dollard Discovery Health Center	SDTC-The Center for Discovery	Harris	Certified	2.1	Special needs Housing/ Healthcare
4	NYS DOT Regional Headquarters	Garfield Corporation	Schenectady	Silver	2.0	
5	Creekside Village Community Center	SUNY Buffalo	Buffalo	Certified	2.0	Community Center
6	Heimbold Visual Arts Center	Sarah Lawrence College	Bronxville	Certified	2.0	***Institutional***
7	Tompkins County SPCA Dorothy and Roy Park Pet Adoption Center	Executive Director Tompkins Co. SPCA	Ithaca	Silver	2.1	Animal Care
8	West Campus Residential Initiative, Phase One	Cornell University	Ithaca	Certified	2.1	Residential housing/ university
9	Niagara Falls Bridge Commission	Niagara Falls Bridge Commission	Lewiston	Certified	2.1	Bridge
10	Frito-Lay Jim Rich Service Station	Frito-Lay, Inc	Rochester	Gold	2.1	Office, Warehouse
11	Skenandoa House	Hamilton College	Clinton	Silver	2.1	Multi-unit Residential

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: October 7, 2005)

APPENDIX C

SS and WE Credits obtained by LEED Certified Buildings in "Great Lakes" Region

Spread Sheet Comparing Michigan LEED™ Projects (LEED-NC 2.1)

Project	Detroit School of Arts	First Nat. Bank	Calvin College	ITP	Keystone	W & E	Mich. Alt Renewable Energy		Percent of projects that pursued credits
Credits								**Total**	
SS1: Site Selection	1	1	0	1	1	0	0	4	57.14%
SS2: Development Density & Community Connectivity	1	0	0	0	1	0	0	2	28.57%
SS3: Brownfield Redevelopment	1	0	0	1	0	0	1	3	42.86%
SS4.1: Alternative Transportation, Public Transportation Access	1	0	0	1	1	1	1	5	71.43%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	0	0	1	1	1	1	5	71.43%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	0	0	1	0	1	2	28.57%
SS4.4: Alternative Transportation, Parking Capacity	0	0	1	1	0	1	1	4	57.14%
SS5.1: Site Development, Protect of Restore Habitat	0	0	1	0	0	1	1	3	42.86%
SS5.2: Site Development, Maximize Open Space	0	0	1	0	1	0	1	3	42.86%
SS6.1: Stormwater Design, Quantity Control	0	1	0	0	0	0	1	2	28.57%
SS6.2: Stormwater Design, Quality Control	0	0	1	1	0	1	0	3	42.86%
SS7.1: Heat Island Effect, Non-Roof	0	0	1	1	1	1	1	5	71.43%
SS7.2: Heat Island Effect, Roof	1	0	0	1	1	0	1	4	57.14%
SS8: Light Pollution Reduction	0	1	1	0	0	0	1	3	42.86%
Total - SS	***6***	***3***	***6***	***8***	***8***	***6***	***11***	***48***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	1	1	1	1	1	7	100.00 %
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	0	1	1	0	1	1	1	5	71.43%
WE2: Innovative Wastewater Technologies	0	1	1	0	0	0	0	2	28.57%
WE3.1: Water Use Reduction, 20% Reduction	0	1	1	0	0	1	1	4	57.14%

Spread Sheet Comparing Michigan LEED™ Projects (LEED-NC 2.1)

Project	Detroit School of Arts	First Nat. Bank	Calvin College	ITP	Keystone	W & E	Mich. Alt Renewable Energy		Percent of projects that pursued credits
WE3.2: Water Use Reduction, 30% Reduction	0	1	1	0	0	1	1	4	57.14%
Total - WE	***1***	***5***	***5***	***1***	***2***	***4***	***4***	***22***	
Total - SS, WE	***7***	***8***	***11***	***9***	***10***	***10***	***15***	***70***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Michigan LEED™ Projects (LEED 2.0)

Project	Bazzani	Detroit Lions	Ford Rouge	Goodwillie School	H. M. - Main site	Ice Mountain	S.T. Dana	H. M.- Market		Percent of projects that pursued credits
Credits									Total	
SS1: Site Selection	1	0	1	1	1	0	1	1	6	75.00%
SS2: Development Density & Community Connectivity	0	0	0	0	0	0	1	0	1	12.50%
SS3: Brownfield Redevelopment	0	0	1	0	0	0	0	0	1	12.50%
SS4.1: Alternative Transportation, Public Transportation Access	1	0	1	1	0	0	1	0	4	50.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	1	1	0	1	1	1	7	87.50%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	1	1	0	0	1	0	1	4	50.00%
SS4.4: Alternative Transportation, Parking Capacity	1	0	1	1	0	0	1	1	5	62.50%
SS5.1: Site Development, Protect of Restore Habitat	0	0	1	1	1	1	1	0	5	62.50%
SS5.2: Site Development, Maximize Open Space	0	1	1	1	1	1	0	0	5	62.50%

Spread Sheet Comparing Michigan LEED™ Projects (LEED 2.0)

Project	Bazzani	Detroit Lions	Ford Rouge	Goodwillie School	H. M. - Main site	Ice Mountain	S.T. Dana	H. M.- Market		Percent of projects that pursued credits
SS6.1: Stormwater Design, Quantity Control	1	0	1	1	1	0	0	0	4	50.00%
SS6.2: Stormwater Design, Quality Control	0	0	1	0	1	1	0	0	3	37.50%
SS7.1: Heat Island Effect, Non-Roof	0	0	0	1	1	0	1	1	4	50.00%
SS7.2: Heat Island Effect, Roof	1	1	1	0	0	1	0	1	5	62.50%
SS8: Light Pollution Reduction	1	1	1	1	0	0	0	1	5	62.50%
Total - SS	*7*	*5*	*12*	*9*	*6*	*6*	*7*	*7*	*59*	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	0	1	1	0	1	1	1	6	75.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	0	1	1	0	1	1	1	6	75.00%
WE2: Innovative Wastewater Technologies	0	0	1	0	0	1	1	0	3	37.50%
WE3.1: Water Use Reduction, 20% Reduction	1	0	1	1	1	1	1	1	7	87.50%
WE3.2: Water Use Reduction, 30% Reduction	1	0	1	1	1	1	1	0	6	75.00%
Total - WE	*4*	*0*	*5*	*4*	*2*	*5*	*5*	*3*	*28*	
Total - SS, WE	*11*	*5*	*17*	*13*	*8*	*11*	*12*	*10*	*87*	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Ohio LEED™ Projects (LEED-NC 2.1)

Project	Heapy Engg	PNC Bank		Percent of projects that pursued credits
Credits			Total	
SS1: Site Selection	1	1	2	100.00%

Spread Sheet Comparing Ohio LEED™ Projects (LEED-NC 2.1)

Project	Heapy Engg	PNC Bank		Percent of projects that pursued credits
SS2: Development Density & Community Connectivity	0	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	1	0	1	50.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	2	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	0	0.00%
SS4.4: Alternative Transportation, Parking Capacity	1	0	1	50.00%
SS5.1: Site Development, Protect of Restore Habitat	0	0	0	0.00%
SS5.2: Site Development, Maximize Open Space	1	0	1	50.00%
SS6.1: Stormwater Design, Quantity Control	1	0	1	50.00%
SS6.2: Stormwater Design, Quality Control	0	1	1	50.00%
SS7.1: Heat Island Effect, Non-Roof	0	1	1	50.00%
SS7.2: Heat Island Effect, Roof	0	0	0	0.00%
SS8: Light Pollution Reduction	1	1	2	100.00%
Total - SS	***7***	***5***	***12***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	0	1	1	50.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	0	1	1	50.00%
WE2: Innovative Wastewater Technologies	0	1	1	50.00%

Spread Sheet Comparing Ohio LEED™ Projects (LEED-NC 2.1)

Project	Heapy Engg	PNC Bank		Percent of projects that pursued credits
WE3.1: Water Use Reduction, 20% Reduction	1	1	2	100.00%
WE3.2: Water Use Reduction, 30% Reduction	0	1	1	50.00%
Total - WE	***1***	***5***	***6***	
Total - SS, WE	***8***	***10***	***18***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Ohio LEED™ Projects (LEED 2.0)

Project	Giant Eagle	Federal Bldg		Percent of projects that pursued credits
Credits			Total	
SS1: Site Selection	0	1	1	50.00%
SS2: Development Density & Community Connectivity	0	1	1	50.00%
SS3: Brownfield Redevelopment	0	1	1	50.00%
SS4.1: Alternative Transportation, Public Transportation Access	0	1	1	50.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	0	0	0	0.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	0	0.00%
SS4.4: Alternative Transportation, Parking Capacity	0	0	0	0.00%
SS5.1: Site Development, Protect of Restore Habitat	0	1	1	50.00%
SS5.2: Site Development, Maximize Open Space	0	1	1	50.00%
SS6.1: Stormwater Design, Quantity Control	0	1	1	50.00%

Spread Sheet Comparing Ohio LEED™ Projects (LEED 2.0)

Project	Giant Eagle	Federal Bldg		Percent of projects that pursued credits
SS6.2: Stormwater Design, Quality Control	1	0	1	50.00%
SS7.1: Heat Island Effect, Non-Roof	0	1	1	50.00%
SS7.2: Heat Island Effect, Roof	1	1	2	100.00%
SS8: Light Pollution Reduction	1	1	2	100.00%
Total - SS	***3***	***10***	***13***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	2	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	0	1	1	50.00%
WE2: Innovative Wastewater Technologies	0	0	0	0.00%
WE3.1: Water Use Reduction, 20% Reduction	0	0	0	0.00%
WE3.2: Water Use Reduction, 30% Reduction	0	0	0	0.00%
Total - WE	***1***	***2***	***3***	
Total - SS, WE	***4***	***12***	***16***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Illinois LEED™ Projects (LEED-NC 2.1)

Project	Chicago Public Library	CNT	West E. Public Lib	Children's Discovery Museum		Percent of projects that pursued credits
Credits					Total	
SS1: Site Selection	1	1	1	1	4	100.00%

Spread Sheet Comparing Illinois LEED™ Projects (LEED-NC 2.1)

Project	Chicago Public Library	CNT	West E. Public Lib	Children's Discovery Museum		Percent of projects that pursued credits
SS2: Development Density & Community Connectivity	0	0	0	1	1	25.00%
SS3: Brownfield Redevelopment	0	0	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	0	1	1	1	3	75.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	0	1	0	1	2	50.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	1	0	1	25.00%
SS4.4: Alternative Transportation, Parking Capacity	0	1	0	0	1	25.00%
SS5.1: Site Development, Protect of Restore Habitat	0	1	0	0	1	25.00%
SS5.2: Site Development, Maximize Open Space	0	1	1	0	2	50.00%
SS6.1: Stormwater Design, Quantity Control	0	1	0	0	1	25.00%
SS6.2: Stormwater Design, Quality Control	0	1	0	0	1	25.00%
SS7.1: Heat Island Effect, Non-Roof	1	1	1	0	3	75.00%
SS7.2: Heat Island Effect, Roof	1	1	0	1	3	75.00%
SS8: Light Pollution Reduction	0	1	0	1	2	50.00%
Total - SS	***3***	***11***	***5***	***6***	***25***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	0	1	3	75.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	0	1	0	1	2	50.00%
WE2: Innovative Wastewater Technologies	0	0	0	0	0	0.00%

Spread Sheet Comparing Illinois LEED™ Projects (LEED-NC 2.1)

Project	Chicago Public Library	CNT	West E. Public Lib	Children's Discovery Museum		Percent of projects that pursued credits
WE3.1: Water Use Reduction, 20% Reduction	0	1	1	0	2	50.00%
WE3.2: Water Use Reduction, 30% Reduction	0	1	0	0	1	25.00%
Total - WE	***1***	***4***	***1***	***2***	***8***	
Total - SS, WE	***4***	***15***	***6***	***8***	***33***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Illinois LEED™ Projects (LEED 2.0)

Project	D. Police Station	C. Suppl y Facili ty		Percent of projects that pursued credits
Credits			Total	
SS1: Site Selection	1	1	2	100.00%
SS2: Development Density & Community Connectivity	0	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	1	1	2	100.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	2	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1	1	2	100.00%
SS4.4: Alternative Transportation, Parking Capacity	0	0	0	0.00%
SS5.1: Site Development, Protect of Restore Habitat	0	1	1	50.00%

Spread Sheet Comparing Illinois LEED™ Projects (LEED 2.0)

Project	D. Police Station	C. Supply Facility		Percent of projects that pursued credits
SS5.2: Site Development, Maximize Open Space	0	1	1	50.00%
SS6.1: Stormwater Design, Quantity Control	0	1	1	50.00%
SS6.2: Stormwater Design, Quality Control	0	1	1	50.00%
SS7.1: Heat Island Effect, Non-Roof	1	0	1	50.00%
SS7.2: Heat Island Effect, Roof	1	1	2	100.00%
SS8: Light Pollution Reduction	1	0	1	50.00%
Total - SS	***7***	***9***	***16***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	2	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	1	2	100.00%
WE2: Innovative Wastewater Technologies	0	0	0	0.00%
WE3.1: Water Use Reduction, 20% Reduction	1	1	2	100.00%
WE3.2: Water Use Reduction, 30% Reduction	0	1	1	50.00%
Total - WE	***3***	***4***	***7***	
Total - SS, WE	***10***	***13***	***23***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Wisconsin LEED™ Projects (LEED 2.1)

Project	Willie Davidson		Percent of projects that pursued credits
Credits		Total	
SS1: Site Selection	0	0	0.00%
SS2: Development Density & Community Connectivity	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	0	0	0.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	0.00%
SS4.4: Alternative Transportation, Parking Capacity	0	0	0.00%
SS5.1: Site Development, Protect of Restore Habitat	1	1	100.00%
SS5.2: Site Development, Maximize Open Space	1	1	100.00%
SS6.1: Stormwater Design, Quantity Control	1	1	100.00%
SS6.2: Stormwater Design, Quality Control	1	1	100.00%
SS7.1: Heat Island Effect, Non-Roof	0	0	0.00%
SS7.2: Heat Island Effect, Roof	0	0	0.00%
SS8: Light Pollution Reduction	1	1	100.00%
Total - SS	***6***	***6***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	1	100.00%
WE2: Innovative Wastewater Technologies	0	0	0.00%

Spread Sheet Comparing Wisconsin LEED^{TM} Projects (LEED 2.1)

Project	Willie Davidson		Percent of projects that pursued credits
WE3.1: Water Use Reduction, 20% Reduction	0	0	0.00%
WE3.2: Water Use Reduction, 30% Reduction	0	0	0.00%
Total - WE	***2***	***2***	
Total - SS, WE	***8***	***8***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Wisconsin LEED^{TM} Projects (LEED 2.0)

Project	AEI Office Bldg	Boldt	Schlitz		Percent of projects that pursued credits
Credits				Total	
SS1: Site Selection	0	1	1	2	66.67%
SS2: Development Density & Community Connectivity	0	0	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	1	0	0	1	33.33%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	1	3	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	1	1	33.33%
SS4.4: Alternative Transportation, Parking Capacity	0	1	1	2	66.67%
SS5.1: Site Development, Protect of Restore Habitat	1	0	1	2	66.67%
SS5.2: Site Development, Maximize Open Space	1	1	1	3	100.00%

Spread Sheet Comparing Wisconsin LEED™ Projects (LEED 2.0)

Project	AEI Office Bldg	Boldt	Schlitz		Percent of projects that pursued credits
SS6.1: Stormwater Design, Quantity Control	0	1	1	2	66.67%
SS6.2: Stormwater Design, Quality Control	0	1	1	2	66.67%
SS7.1: Heat Island Effect, Non-Roof	0	0	1	1	33.33%
SS7.2: Heat Island Effect, Roof	0	0	1	1	33.33%
SS8: Light Pollution Reduction	1	1	1	3	100.00%
Total - SS	***5***	***7***	***11***	***23***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	1	3	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	0	1	2	66.67%
WE2: Innovative Wastewater Technologies	0	0	0	0	0.00%
WE3.1: Water Use Reduction, 20% Reduction	0	0	1	1	33.33%
WE3.2: Water Use Reduction, 30% Reduction	0	0	1	1	33.33%
Total - WE	***2***	***1***	***4***	***7***	
Total - SS, WE	***7***	***8***	***15***	***30***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet showing Minnesota LEED™ Projects (LEED-NC 2.0)

Project	Westwd. Element.		Percent of projects that pursued credits
Credits		Total	
SS1: Site Selection	0	0	0.00%
SS2: Development Density & Community Connectivity	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0.00%

Spread Sheet showing Minnesota LEED™ Projects (LEED-NC 2.0)

Project	Westwd. Element.		Percent of projects that pursued credits
SS4.1: Alternative Transportation, Public Transportation Access	0	0	0.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	0	0	0.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	0	0.00%
SS4.4: Alternative Transportation, Parking Capacity	0	0	0.00%
SS5.1: Site Development, Protect of Restore Habitat	0	0	0.00%
SS5.2: Site Development, Maximize Open Space	1	1	100.00%
SS6.1: Stormwater Design, Quantity Control	1	1	100.00%
SS6.2: Stormwater Design, Quality Control	1	1	100.00%
SS7.1: Heat Island Effect, Non-Roof	0	0	0.00%
SS7.2: Heat Island Effect, Roof	0	0	0.00%
SS8: Light Pollution Reduction	1	1	100.00%
Total - SS	***4***	***4***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	0	0	0.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	0	0	0.00%
WE2: Innovative Wastewater Technologies	0	0	0.00%

Spread Sheet showing Minnesota LEED^{TM} Projects (LEED-NC 2.0)

Project	Westwd. Element.		Percent of projects that pursued credits
WE3.1: Water Use Reduction, 20% Reduction	1	1	100.00%
WE3.2: Water Use Reduction, 30% Reduction	1	1	100.00%
Total - WE	***2***	***2***	
Total - SS, WE	***6***	***6***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet showing Iowa LEED^{TM} Projects (LEED 2.0)

Project	Vermeer Science Center		Percent of projects that pursued credits
Credits		Total	
SS1: Site Selection	1	1	100.00%
SS2: Development Density & Community Connectivity	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	0	0	0.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1	1	100.00%

Spread Sheet showing Iowa LEED™ Projects (LEED 2.0)

Project	Vermeer Science Center		Percent of projects that pursued credits
SS4.4: Alternative Transportation, Parking Capacity	1	1	100.00%
SS5.1: Site Development, Protect of Restore Habitat	1	1	100.00%
SS5.2: Site Development, Maximize Open Space	1	1	100.00%
SS6.1: Stormwater Design, Quantity Control	0	0	0.00%
SS6.2: Stormwater Design, Quality Control	0	0	0.00%
SS7.1: Heat Island Effect, Non-Roof	1	1	100.00%
SS7.2: Heat Island Effect, Roof	1	1	100.00%
SS8: Light Pollution Reduction	1	1	100.00%
Total - SS	***9***	***9***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	1	100.00%
WE2: Innovative Wastewater Technologies	0	0	0.00%
WE3.1: Water Use Reduction, 20% Reduction	1	1	100.00%
WE3.2: Water Use Reduction, 30% Reduction	1	1	100.00%
Total - WE	***4***	***4***	
Total - SS, WE	***13***	***13***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing New York LEED™ Projects (LEED-NC 2.1)

Project	Frito-Lay	Niagara Falls	West Campus Res	Patrick Dollard Dis Health Center	Tompkins County		Percent of projects that pursued credits
Credits						Total	
SS1: Site Selection	1	1	1	1	0	4	80.00%
SS2: Development Density & Community Connectivity	0	0	0	0	0	0	0.00%
SS3: Brownfield Redevelopment	0	0	0	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	0	0	1	0	1	2	40.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	1	1	1	5	100.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1	0	1	0	0	2	40.00%
SS4.4: Alternative Transportation, Parking Capacity	1	1	0	1	1	4	80.00%

Spread Sheet Comparing New York LEED™ Projects (LEED-NC 2.1)

Project	Frito-Lay	Niagara Falls	West Campus Res	Patrick Dollard Dis Health Center	Tompkins County		Percent of projects that pursued credits
SS5.1: Site Development, Protect of Restore Habitat	1	0	0	1	1	3	60.00%
SS5.2: Site Development, Maximize Open Space	1	1	0	1	1	4	80.00%
SS6.1: Stormwater Design, Quantity Control	1	0	0	1	0	2	40.00%

Spread Sheet Comparing New York LEED™ Projects (LEED-NC 2.1)

Project	Frito-Lay	Niagara Falls	West Campus Res	Patrick Dollard Dis Health Center	Tompkins County		Percent of projects that pursued credits
SS6.2: Stormwater Design, Quality Control	1	0	0	0	1	2	40.00%
SS7.1: Heat Island Effect, Non-Roof	1	0	1	1	1	4	80.00%
SS7.2: Heat Island Effect, Roof	1	0	0	0	0	1	20.00%
SS8: Light Pollution Reduction	0	0	1	0	1	2	40.00%
Total - SS	***10***	***4***	***6***	***7***	***8***	***35***	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	0	1	1	1	4	80.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	0	1	1	1	4	80.00%
WE2: Innovative Wastewater Technologies	1	0	0	0	0	1	20.00%
WE3.1: Water Use Reduction, 20% Reduction	1	0	0	0	1	2	40.00%
WE3.2: Water Use Reduction, 30% Reduction	1	0	0	0	1	2	40.00%
Total - WE	***5***	***0***	***2***	***2***	***4***	***13***	
Total - SS, WE	***15***	***4***	***8***	***9***	***12***	***48***	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing New York LEED™ Projects (LEED 2.0)

Project	Broadway Office Complex	Creekside Village Com Center	Heimbold Visual Arts Center	NYS DOT	Solaire		Percent of projects that pursued credits
Credits						Total	
SS1: Site Selection	0	0	1	1	1	3	60.00%
SS2: Development Density & Community Connectivity	1	0	0	1	1	3	60.00%
SS3: Brownfield Redevelopment	0	0	0	0	0	0	0.00%
SS4.1: Alternative Transportation, Public Transportation Access	1	1	0	1	1	4	80.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	0	1	1	4	80.00%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1	1	0	0	0	2	40.00%
SS4.4: Alternative Transportation, Parking Capacity	1	1	1	0	1	4	80.00%
SS5.1: Site Development, Protect of Restore Habitat	0	0	0	0	0	0	0.00%
SS5.2: Site Development, Maximize Open Space	0	1	0	0	0	1	20.00%
SS6.1: Stormwater Design, Quantity Control	0	0	0	0	1	1	20.00%

Spread Sheet Comparing New York LEED™ Projects (LEED 2.0)

Project	Broadway Office Complex	Creekside Village Com Center	Heimbold Visual Arts Center	NYS DOT	Solaire		Percent of projects that pursued credits
SS6.2: Stormwater Design, Quality Control	0	0	0	0	1	1	20.00%
SS7.1: Heat Island Effect, Non-Roof	1	1	1	1	1	5	100.00%
SS7.2: Heat Island Effect, Roof	1	0	0	1	1	3	60.00%
SS8: Light Pollution Reduction	0	1	1	0	1	3	60.00%
Total - SS	*7*	*7*	*4*	*6*	*10*	*34*	
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	1	1	1	5	100.00%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	1	1	1	1	5	100.00%
WE2: Innovative Wastewater Technologies	0	0	0	0	1	1	20.00%
WE3.1: Water Use Reduction, 20% Reduction	0	0	1	1	1	3	60.00%
WE3.2: Water Use Reduction, 30% Reduction	0	0	0	1	1	2	40.00%
Total - WE	*2*	*2*	*3*	*4*	*5*	*16*	
Total - SS, WE	*9*	*9*	*7*	*10*	*15*	*50*	

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

Spread Sheet Comparing Pennsylvania LEED™ Projects (LEED 2.0)

Project	Cambri a Office Bldg.	Central Admn. Bldg.	Clearview Elem. School	PA DEP Lab	Heinz History Center	DEP SE Regional Office	McGowan Inst.
Credits							
SS1: Site Selection	0	1	1	1	1	1	1
SS2: Development Density & Community Connectivity	0	0	0	0	1	1	0
SS3: Brownfield Redevelopment	0	0	0	0	1	1	1
SS4.1: Alternative Transportation, Public Transportation Access	1	0	0	1	1	1	1
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	1	1	1	1	1	1	1
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1	0	0	1	0	0	0
SS4.4: Alternative Transportation, Parking Capacity	0	1	1	1	1	1	1
SS5.1: Site Development, Protect of Restore Habitat	0	0	0	0	0	0	1
SS5.2: Site Development, Maximize Open Space	1	1	1	1	0	0	1
SS6.1: Stormwater Design, Quantity Control	1	1	0	0	0	1	1
SS6.2: Stormwater Design, Quality Control	0	0	0	0	0	0	0
SS7.1: Heat Island Effect, Non-Roof	0	0	0	0	1	1	0
SS7.2: Heat Island Effect, Roof	1	0	1	0	0	1	1
SS8: Light Pollution Reduction	0	1	0	1	0	1	0
Total - SS	***6***	***6***	***5***	***7***	***7***	***10***	***9***
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	0	1	1	1	1	1
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	0	1	1	1	1	1
WE2: Innovative Wastewater Technologies	0	0	0	0	0	1	1
WE3.1: Water Use Reduction, 20% Reduction	1	1	1	1	0	1	1
WE3.2: Water Use Reduction, 30% Reduction	1	0	1	1	0	1	1
Total - WE	***4***	***1***	***4***	***4***	***2***	***5***	***5***
Total - SS, WE	***10***	***7***	***9***	***11***	***9***	***15***	***14***

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

C

Continuation Line

D

C

Continuation Line

New House	PA DEP District office	PNC Firstside Center	Shuster Hall	Plaza - PPL Center	WS Cumby Office		Percent of projects that pursued credits
						Total	
1	1	1	1	1	1	12	92.31%
0	0	1	0	1	0	4	30.77%
0	0	1	0	0	0	4	30.77%
1	0	1	0	1	1	9	69.23%
1	1	1	0	1	1	12	92.31%
0	0	1	0	1	0	4	30.77%
0	0	1	1	0	1	9	69.23%
0	1	0	1	0	0	3	23.08%
0	1	1	1	1	1	10	76.92%
0	1	0	0	0	1	6	46.15%
0	0	1	0	1	1	3	23.08%
1	0	1	1	1	1	7	53.85%
1	1	0	0	1	0	7	53.85%
0	0	1	1	0	0	5	38.46%
5	***6***	***11***	***6***	***9***	***8***	***95***	
1	1	1	1	1	1	12	92.31%
1	1	0	1	1	1	11	84.62%
0	1	0	1	0	0	4	30.77%
0	1	0	1	1	1	10	76.92%
0	1	0	1	1	1	9	69.23%
2	***5***	***1***	***5***	***4***	***4***	***46***	
7	***11***	***12***	***11***	***13***	***12***	***141***	

D

Spread Sheet Comparing Pennsylvania LEED™ Projects (LEED-NC 2.1)

Project	Lower Windsor Township	Pennsyl. Housing Finance Agency	South. York County Lib.	David L L Conv. Center	Swarthmore College	DEP California Office Bldg	US Steel Research/ Tech Center
Credits							
SS1: Site Selection	1	1	1	0	1	0	1
SS2: Development Density & Community Connectivity	0	1	0	1	0	0	0
SS3: Brownfield Redevelopment	0	0	0	1	0	0	1
SS4.1: Alternative Transportation, Public Transportation Access	0	1	1	1	1	0	1
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	0	1	1	1	1	1	1
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	0	1	0	0	0	0	0
SS4.4: Alternative Transportation, Parking Capacity	1	0	1	1	1	1	1
SS5.1: Site Development, Protect of Restore Habitat	0	0	0	0	1	0	0
SS5.2: Site Development, Maximize Open Space	1	0	1	0	1	1	0
SS6.1: Stormwater Design, Quantity Control	1	1	0	0	1	0	0
SS6.2: Stormwater Design, Quality Control	0	0	0	0	0	0	0
SS7.1: Heat Island Effect, Non-Roof	1	1	0	1	1	0	0
SS7.2: Heat Island Effect, Roof	0	1	0	0	1	1	1
SS8: Light Pollution Reduction	1	1	1	1	0	1	0
Total - SS	***6***	***9***	***6***	***7***	***9***	***5***	***6***
WE1.1: Water Efficient Landscaping, Reduce by 50%	1	1	1	1	1	1	1
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	1	1	1	1	1	1	1
WE2: Innovative Wastewater Technologies	1	1	0	1	0	0	0
WE3.1: Water Use Reduction, 20% Reduction	1	1	1	1	0	1	1
WE3.2: Water Use Reduction, 30% Reduction	1	1	1	1	0	1	1
Total - WE	***5***	***5***	***4***	***5***	***2***	***4***	***4***
Total - SS, WE	***11***	***14***	***10***	***12***	***11***	***9***	***10***

Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

A

Continuation Line

B

A

Hender. House	Posner Center	Total	Percent of projects that pursued credits
1	1	7	77.78%
0	0	2	22.22%
0	0	2	22.22%
1	1	7	77.78%
1	1	8	88.89%
0	0	1	11.11%
0	0	6	66.67%
1	1	3	33.33%
1	1	6	66.67%
0	1	4	44.44%
0	1	1	11.11%
0	1	5	55.56%
0	1	5	55.56%
0	0	5	55.56%
5	***9***	***62***	
1	1	9	100.00%
1	0	8	88.89%
0	0	3	33.33%
1	0	7	77.78%
1	0	7	77.78%
4	***1***	***34***	
9	***10***	***96***	

Continuation Line

B

APPENDIX D

Percent Distribution of SS and WE Credits

PERCENT DISTRIBUTION OF SUSTAINABLE SITES CREDIT IN MI, OH, IL, WI, MN, IA, PA AND NY (LEED-NC 2.1)

Credit	MI (7 bldgs)	OH (2 bldgs)	IL (4 bldgs)	WI (1 bldg)	MN -	IA -	PA (9 bldgs)	NY (5 bldgs)	Total (28 bldgs)
SS1: Site Selection	57.14%	100.00%	100.00%	0.00%	-	-	77.78%	80.00%	75.00%
SS2: Development Density & Community Connectivity	28.57%	0.00%	25.00%	0.00%	-	-	22.22%	0.00%	17.86%
SS3: Brownfield Redevelopment	42.86%	0.00%	0.00%	0.00%	-	-	22.22%	0.00%	17.86%
SS4.1: Alternative Transportation, Public Transportation Access	71.43%	50.00%	75.00%	0.00%	-	-	77.78%	40.00%	64.29%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	71.43%	100.00%	50.00%	100.00%	-	-	88.89%	100.00%	82.14%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	28.57%	0.00%	25.00%	0.00%	-	-	11.11%	40.00%	21.43%
SS4.4: Alternative Transportation, Parking Capacity	57.14%	50.00%	25.00%	0.00%	-	-	66.67%	80.00%	57.14%
SS5.1: Site Development, Protect of Restore Habitat	42.86%	0.00%	25.00%	100.00%	-	-	33.33%	60.00%	39.29%
SS5.2: Site Development, Maximize Open Space	42.86%	50.00%	50.00%	100.00%	-	-	66.67%	80.00%	60.71%
SS6.1: Stormwater Design, Quantity Control	28.57%	50.00%	25.00%	100.00%	-	-	44.44%	40.00%	39.29%
SS6.2: Stormwater Design, Quality Control	42.86%	50.00%	25.00%	100.00%	-	-	11.11%	40.00%	32.14%
SS7.1: Heat Island Effect, Non-Roof	71.43%	50.00%	75.00%	0.00%	-	-	55.56%	80.00%	64.29%
SS7.2: Heat Island Effect, Roof	57.14%	0.00%	75.00%	0.00%	-	-	55.56%	20.00%	46.43%
SS8: Light Pollution Reduction	42.86%	100.00%	50.00%	100.00%	-	-	55.56%	40.00%	53.57%

Table developed by this research, Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

PERCENT DISTRIBUTION OF WATER EFFICIENCY CREDIT IN MI, OH, IL, WI, MN, IA, PA AND NY (LEED-NC 2.1)

Credit	MI (7 bldgs)	OH (2 bldgs)	IL (4 bldgs)	WI (1 bldg)	MN -	IA -	PA (9 bldgs)	NY (5 bldgs)	Total (28 bldgs)
WE1.1: Water Efficient Landscaping, Reduce by 50%	100.00%	50.00%	75.00%	100.00%	-	-	100.00%	80.00%	89.29%
WE1.2: Water Efficient Landscaping, No Potable Use or No Irrigation	71.43%	50.00%	50.00%	100.00%	-	-	88.89%	80.00%	75.00%
WE2: Innovative Wastewater Technologies	28.57%	50.00%	0.00%	0.00%	-	-	33.33%	20.00%	25.00%
WE3.1: Water Use Reduction, 20% Reduction	57.14%	100.00%	50.00%	0.00%	-	-	77.78%	40.00%	60.71%
WE3.2: Water Use Reduction, 30% Reduction	57.14%	50.00%	25.00%	0.00%			77.78%	40.00%	53.57%

Table developed by this research, Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

PERCENT DISTRIBUTION OF SUSTAINABLE SITES CREDIT IN MI, OH, IL, WI, MN, IA, PA AND NY (LEED-NC 2.0)

Credit	MI (8 bldgs)	OH (2 bldgs)	IL (2 bldgs)	WI (3 bldgs)	MN (1 bldg)	IA (1 bldg)	PA (13 bldgs)	NY (5 bldgs)	Total (35 bldgs)
SS1: Site Selection	75.00%	50.00%	100.00%	66.67%	0.00%	100.00%	92.31%	60.00%	77.14%
SS2: Development Density & Community Connectivity	12.50%	50.00%	0.00%	0.00%	0.00%	0.00%	30.77%	60.00%	25.71%
SS3: Brownfield Redevelopment	12.50%	50.00%	0.00%	0.00%	0.00%	0.00%	30.77%	0.00%	17.14%
SS4.1: Alternative Transportation, Public Transportation Access	50.00%	50.00%	100.00%	33.33%	0.00%	0.00%	69.23%	80.00%	60.00%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	87.50%	0.00%	100.00%	100.00%	0.00%	100.00%	92.31%	80.00%	82.86%

PERCENT DISTRIBUTION OF SUSTAINABLE SITES CREDIT IN MI, OH, IL, WI, MN, IA, PA AND NY (LEED-NC 2.0)

Credit	MI (8 bldgs)	OH (2 bldgs)	IL (2 bldgs)	WI (3 bldgs)	MN (1 bldg)	IA (1 bldg)	PA (13 bldgs)	NY (5 bldgs)	Total (35 bldgs)
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	50.00%	0.00%	100.00%	33.33%	0.00%	100.00%	30.77%	40.00%	40.00%
SS4.4: Alternative Transportation, Parking Capacity	62.50%	0.00%	0.00%	66.67%	0.00%	100.00%	69.23%	80.00%	60.00%
SS5.1: Site Development, Protect of Restore Habitat	62.50%	50.00%	50.00%	66.67%	0.00%	100.00%	23.08%	0.00%	37.14%
SS5.2: Site Development, Maximize Open Space	62.50%	50.00%	50.00%	100.00%	100.00%	100.00%	76.92%	20.00%	65.71%
SS6.1: Stormwater Design, Quantity Control	50.00%	50.00%	50.00%	66.67%	100.00%	0.00%	46.15%	20.00%	45.71%
SS6.2: Stormwater Design, Quality Control	37.50%	50.00%	50.00%	66.67%	100.00%	0.00%	23.08%	20.00%	34.29%
SS7.1: Heat Island Effect, Non-Roof	50.00%	50.00%	50.00%	33.33%	0.00%	100.00%	53.85%	100.00%	57.14%
SS7.2: Heat Island Effect, Roof	62.50%	100.00%	100.00%	33.33%	0.00%	100.00%	53.85%	60.00%	60.00%
SS8: Light Pollution Reduction	62.50%	100.00%	50.00%	100.00%	100.00%	100.00%	38.46%	60.00%	60.00%

Table developed by this research, Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

PERCENT DISTRIBUTION OF SUSTAINABLE SITES CREDIT IN MI, OH, IL, WI, MN, IA, PA AND NY (LEED-NC 2.1)

Credit	MI	OH	IL	WI	MN	IA	PA	NY	Total
	(7 bldgs)	(2 bldgs)	(4 bldgs)	(1 bldg)	-	-	(9 bldgs)	(5 bldgs)	(28 bldgs)
SS1: Site Selection	57.14%	100.00%	100.00%	0.00%	-	-	77.78%	80.00%	75.00%
SS2: Development Density & Community Connectivity	28.57%	0.00%	25.00%	0.00%	-	-	22.22%	0.00%	17.86%
SS3: Brownfield Redevelopment	42.86%	0.00%	0.00%	0.00%	-	-	22.22%	0.00%	17.86%
SS4.1: Alternative Transportation, Public Transportation Access	71.43%	50.00%	75.00%	0.00%	-	-	77.78%	40.00%	64.29%
SS4.2: Alternative Transportation, Bicycle Storage & Changing Rooms	71.43%	100.00%	50.00%	100.00%	-	-	88.89%	100.00%	82.14%
SS4.3: Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	28.57%	0.00%	25.00%	0.00%	-	-	11.11%	40.00%	21.43%
SS4.4: Alternative Transportation, Parking Capacity	57.14%	50.00%	25.00%	0.00%	-	-	66.67%	80.00%	57.14%
SS5.1: Site Development, Protect of Restore Habitat	42.86%	0.00%	25.00%	100.00%	-	-	33.33%	60.00%	39.29%
SS5.2: Site Development, Maximize Open Space	42.86%	50.00%	50.00%	100.00%	-	-	66.67%	80.00%	60.71%
SS6.1: Stormwater Design, Quantity Control	28.57%	50.00%	25.00%	100.00%	-	-	44.44%	40.00%	39.29%
SS6.2: Stormwater Design, Quality Control	42.86%	50.00%	25.00%	100.00%	-	-	11.11%	40.00%	32.14%
SS7.1: Heat Island Effect, Non-Roof	71.43%	50.00%	75.00%	0.00%	-	-	55.56%	80.00%	64.29%
SS7.2: Heat Island Effect, Roof	57.14%	0.00%	75.00%	0.00%	-	-	55.56%	20.00%	46.43%
SS8: Light Pollution Reduction	42.86%	100.00%	50.00%	100.00%	-	-	55.56%	40.00%	53.57%

Table developed by this research, Source: http://www.usgbc.org/LEED/Project/project_list.asp (Visited: April 20, 2006)

APPENDIX E

Collaborative Work Session Work Sheet

Below, is a sample of the work sheet used for the collaborative work session held for the research titled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006] conducted by the Construction Management and Landscape Architecture Programs in the School of Planning, Design and Construction at Michigan State University. Similar work sheets were developed for each LEED SS and WE credit. These sheets included the intent of the credit and questions for the work session groups to discuss and organize their conclusions.

Sample Collaborative Session Work Sheet

SS Credit 1: Site Selection *The intent of this credit is to avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site [USGBC-2].*

Refer to separate summary of LEED-NC 2.2 in Work Session packet for summary of requirements.

Evaluate the standard in the context of public institution projects for the Great Lakes region / cold climates.

What organizational benefits / concerns do you foresee in pursuing this credit-standard?

Rank environmental benefits ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Rank health benefits ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Rank difficulties associated with:

Cost ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Political issues ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Practicality in implementing ☐ High ☐ Medium ☐ Low ☐ None

Please explain (what was your rationale for the score given?):

Design, technical and, political strategies that could be used for compliance with this credit-standard

Explain:

What situational criteria might influence use of this credit-standard?

Explain:

Do you recommend use of this credit-standard for public sector projects in Great Lakes region and under what circumstances?

Explain:

Cost

High Cost, Less Overall Benefit	High Cost, High Overall Benefit
Low Cost, Less Overall Benefit	Low Cost, High Overall Benefit

Overall Benefit

APPENDIX F

Case Studies Questionnaire

This appendix includes the questionnaire used for the four case studies conducted for the research titled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006], by the Construction Management and Landscape Architecture Programs in the School of Planning, Design and Construction at Michigan State University. The interviews with owners were aimed at gathering information about the decision-making parameters that influence pursuing or not pursuing LEED SS and WE credits and to gain insight into the organizational benefits / concerns that a project team expresses in the decision-making process to pursue or not to pursue the LEED credits.

Q1. Is the attached list of credits on USGBC website correct? ☐ Yes ☐ No

Q2. Your project was certified under which LEED™ standard? ☐ LEED 2.0 ☐ LEED-NC 2.1

For each LEED Site and Water related credit answer the questions in each column (This is an Excel Spreadsheet, use arrow keys to scroll)

LEED™ credit-standard	**Prereq 1 (Erosion and Sedimentation Control)**	**SS1 (Site Selection)**	**SS2 (Urban Redevelopment)**	**SS3 (Brownfield Redevelopment)**	**SS4.1 (Alternative Transportation - Public Transportation Access)**
Q3. Did you obtain this LEED™ credit-standard?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Q4. Who made the decision to obtain or not to obtain this LEED™ credit-standard?	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other	☐ Designer ☐ Owner ☐ Project Team ☐ Other
Q5. In the decision making process to pursue this LEED™ credit-standard, what organizational benefits or concerns were expressed?					
	If the LEED™ credit-standard below was obtained, please answer the questions below.				
LEED™ credit-standard	**Prereq 1 (Erosion and Sedimentation Control)**	**SS1 (Site Selection)**	**SS2 (Urban Redevelopment)**	**SS3 (Brownfield Redevelopment)**	**SS4.1 (Alternative Transportation - Public Transportation Access)**

Q6a. Were cost increases associated with required documentation significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q6b. If yes, please explain					
Q6c. If known, indicate % increase.					
Q7a. Were cost increases associated with designing, planning or engineering significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q7b. If yes, please explain					
Q7c. If known, indicate % increase.					
Q8a. Were cost increases associated with material purchase significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q8b. If yes, please explain					
Q8c. If known, indicate % increase.					

Q9a. Were cost increases associated with construction labor significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q9b. If yes, please explain					
Q9c. If known, indicate % increase.					
Q10a. Were cost increases associated with construction project management significant?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q10b. If yes, please explain					
Q10c. If known, indicate % increase.					
Q11a. Are you aware of the technical strategies used for compliance with this LEED™ credit-standard?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q11b. If Yes, please explain					

Q12. Were these technical strategies helpful in obtaining this LEED™ credit?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q13. Would you recommend these strategies be used by others?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q14a. Would you recommend that other governmental/ institutional owners pursue this credit-standard?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q14b. If Yes, please explain					
Q15a. Did you anticipate the institutional outcomes of complying with this credit-standard to be positive or negative?	☐ Positive ☐ Negative	☐ Positive ☐ Negative	☐ Positive ☐ Negative	☐ Positive ☐ Negative	☐ Positive ☐ Negative
Q15b. Please explain					
Q16a. Did this LEED™ credit-standard impact contractual/ bidding processes?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A

Q16b. If Yes, please explain					
Q17. Which subcontracted trade/s was/ were impacted by this credit-standard? Check all that apply.	☐ Landscaping Cont. ☐ Earthwork Cont. ☐ Site Utility Cont. ☐ Plumbing Cont. ☐ Roofing Cont. ☐ Paving Cont. ☐ Const.Mngr/Contractor ☐ Site Concrete Cont. ☐ Other ☐ Don't Know	☐ Landscaping Cont. ☐ Earthwork Cont. ☐ Site Utility Cont. ☐ Plumbing Cont. ☐ Roofing Cont. ☐ Paving Cont. ☐ Const.Mngr/Contractor ☐ Site Concrete Cont. ☐ Other ☐ Don't Know	☐ Landscaping Cont. ☐ Earthwork Cont. ☐ Site Utility Cont. ☐ Plumbing Cont. ☐ Roofing Cont. ☐ Paving Cont. ☐ Const.Mngr/Contractor ☐ Site Concrete Cont. ☐ Other ☐ Don't Know	☐ Landscaping Cont. ☐ Earthwork Cont. ☐ Site Utility Cont. ☐ Plumbing Cont. ☐ Roofing Cont. ☐ Paving Cont. ☐ Const.Mngr/Contractor ☐ Site Concrete Cont. ☐ Other ☐ Don't Know	☐ Landscaping Cont. ☐ Earthwork Cont. ☐ Site Utility Cont. ☐ Plumbing Cont. ☐ Roofing Cont. ☐ Paving Cont. ☐ Const.Mngr/Contractor ☐ Site Concrete Cont. ☐ Other ☐ Don't Know
Q18. Who prepared the LEED™ Letter Templates for this credit-standard?	☐ Engineer ☐ Architect ☐ Planner ☐ Landscape Architect ☐ Contractor ☐ Subcontractor ☐ Separate LEED Consult	☐ Engineer ☐ Architect ☐ Planner ☐ Landscape Architect ☐ Contractor ☐ Subcontractor ☐ Separate LEED Consult	☐ Engineer ☐ Architect ☐ Planner ☐ Landscape Architect ☐ Contractor ☐ Subcontractor ☐ Separate LEED Consult	☐ Engineer ☐ Architect ☐ Planner ☐ Landscape Architect ☐ Contractor ☐ Subcontractor ☐ Separate LEED Consult	☐ Engineer ☐ Architect ☐ Planner ☐ Landscape Architect ☐ Contractor ☐ Subcontractor ☐ Separate LEED Consult
Q19a. If this credit was obtained, were the organizational benefits/ concerns realized?	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A	☐ Yes ☐ No ☐ Don't Know ☐ N/A
Q19b. Explain					

<u>THE ABOVE RESPONSES WILL BE USED FOR THE FOLLOW-UP INTERVIEW REGARDING YOUR PROJECT</u>

APPENDIX G

Identification of Attributes from Collaborative Work Session, Case Studies and Literature Review

Introduction

This appendix presents the attributes identified from the literature, collaborative work session data and owner's responses from the case study projects conducted for the research titled "Promoting Healthy Environments through Application of LEED Site Planning Standards to Cold Climate Institutional Settings" [Mrozowski et al. 2006]. For each credit, first, the important attributes found by the researcher are stated. Then the intent of the credit is provided, as stated in the LEED-NC 2.2 Reference Guide. The collaborative work session responses are described in a paraphrased format and the attributes suggested by the work session responses are listed. Then, the interview responses are described in a paraphrased format and the attributes indicated by the case studies are listed. Attributes identified from the literature described in chapter two are then listed. Finally, the attributes are integrated and a matrix is presented for each credit, showing the relation of the attributes to the objectives of sustainable construction – environment, community and economic issues as identified by [USGBC-2], [Presley and Meade 2004] and [ASTM 2004] and the relation is represented by '•'. The table demonstrates the source of identification of various attributes. CWS indicate attributes identified from the collaborative work session and CS indicate attributes identified from the case studies. The highlighted portions in all the tables indicate attributes with low confidence level as seen in the 'discussion' column in all of the credits.

Sustainable Sites (SS) Credits

SS Prerequisite 1: Construction Activity Pollution Prevention (Formerly - Erosion and Sedimentation Control) **Analysis:** The researcher found the important attributes for SS Prerequisite 1 to be – prevents loss of topsoil during construction, prevents sedimentation of storm waters or receiving streams, prevents air pollution and has no cost/ potential cost decrease. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation [USGBC-2].

Work Session: All work groups concluded this was a relatively straightforward prerequisite and highly recommended its adoption. Overall the groups in the quadrant analysis indicated this credit had high benefit (environmental) and low cost. The work groups indicated that this credit was usually being met in most communities, and reflected good practice, but that details of the newly referenced EPA standard should be evaluated. Several work groups expressed concern that project parties need to be informed of this credit at project inception and that erosion control measures be adequately maintained during construction. Table below shows the work session responses obtained for SS Prerequisite 1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Makes project managers consciously think of this. Concerns: Behavior of excavators; need contractors committed to this. Need effective monitoring of the site activity; need full understanding through all actors	2
	Benefits: Certified Storm Water Operator 1. Phased Site Const. – Reducing site exposure over the duration of the project – concern: contractor efficiencies 2. Need a plan but practices are not always enforced 3. Local vs. EPA requirements – Rural may be less stringent or there may be no standard	3

	Benefit to the host community and project neighbors.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
	Technical are more or less laid out in the standards, technically is feasible and well understood Political: awareness and enforcement varies across jurisdictions	2
	Consistent codes in the GL Region. Monitoring Compliance – Incentives or fines for violations are a potential strategy	3
	Not so much a political issue yet, but water mgt. is growing in concern within the great lakes basin. Training of people. Maintaining the implemented system.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
		4

Work Session Responses for SS Prerequisite 1

Work session responses suggest the following attributes for SS Prerequisite 1:

Requires designers to evaluate EPA standards v/s local codes
No cost increase
High environmental benefits
Medium health benefits
Benefits the host community and project neighbors
Reduces site exposure over the duration of the project
Requires high maintenance of implemented system during construction
Requires effective monitoring of the site activity

Attributes Identified for SS Prerequisite 1 from Work Session

Case Studies: For Case Study 1, protection of an adjacent vernal pond through sedimentation and erosion controls was important. Throughout, the project science departments monitored water quality. For Case Studies 2 and 3, sedimentation and erosion control measures were implemented in order to achieve this credit in accordance with the standards. For Case Study 4, this credit is being pursued since it is a requirement. Erosion and sedimentation control is progressive and included: initial use of silt fencing, stormwater structures collectors were protected, temporary paving of some site areas and placement of gravel over the entire site. The paving and gravel not only prevent erosion and sediments from flowing off the site, but also provide a firm construction base and prevent dust. Water from excavations is being filtered through filter/bladder bags to prevent soil from entering the storm water system.

For all the four case study projects, respondents indicated that there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor and construction project management for complying with this credit. Except for Case Study 3, no other case study project indicated cost increases associated with required documentation for complying with this credit. Institutional outcomes of complying with this credit were indicated as positive and all four projects recommended use of this credit by other governmental/ institutional owners.

The interview responses suggest the following attributes for SS Prerequisite 1:

Prevents loss of topsoil during construction
Prevents sedimentation of storm waters or receiving streams
Prevents air pollution
Requires effective monitoring of the site activity
Cost associated with required documentation varies (three case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase)
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Prerequisite 1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Prerequisite 1:

Reduces pollution from construction activities [USGBC-2]
Prevents loss of topsoil during construction [USGBC-2]
Prevents sedimentation of storm waters or receiving streams [USGBC-2]
Prevents air pollution [USGBC-2]
Evaluates EPA standards v/s local codes [USGBC-2]
No cost / potential cost decrease [SWA 2004]
Achieved through standard practice (increased design efforts but minimal construction first costs) [Eijadi et al. 2002]
Addresses environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]

Attributes Identified for SS Prerequisite 1 from Literature Review

Matrix Showing Attributes Identified for SS Prerequisite 1:

SS Prerequisite 1: Construction Activity Pollution Prevention

Attribute	Environ-ment	Community	Economic	Source of identification	Discussion
Reduces pollution from construction activities	•	•		[USGBC-2]	
Prevents loss of topsoil during construction	•			[USGBC-2], CS	
Prevents sedimentation of storm waters or receiving streams	•			[USGBC-2], CS	
Prevents air pollution	•	•		[USGBC-2], CS	
Requires designer to evaluate EPA stds v/s local codes	•			[USGBC-2], CWS	
No cost / potential cost decrease			•	[SWA 2004], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al. 2002]	
Benefits the host community and project neighbors	•	•		CWS	
Reduces site exposure over the duration of the project	•			CWS	
Requires high maintenance of implemented system during construction	•		•	CWS	
Requires effective monitoring of the site activity	•		•	CWS, CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	CWS concluded high environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded medium health benefits
Cost associated with required documentation varies			•	CS	Three case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase

Attributes related to SS Prerequisite 1

SS Credit 1: Site Selection Analysis:

The researcher found the important attributes for SS Credit 1 to be – pursuing subject to site availability, reduces sprawl, avoids development of inappropriate sites and minimizes disruption of the environmentally sensitive areas. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site [USGBC-2]

Work Session: The work groups indicated that this credit offered high environmental benefits, but the ability to implement it would be situational. Work groups connected the use of this credit to larger urban planning issues, regional planning, sprawl and land availability. The work groups were split on whether costs of this credit would be low or high depending on specific project conditions. Table below shows the work session responses obtained for SS Credit 1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?	Should be complying with on any site. Mitigation for wetland. Very high political, health (environmental and human), social, economic difficulties.	1
	Benefits: Great PR, reduces public criticism of what you are doing; Concerns: could constrain your land choices, depending upon the availability of land (e.g., Ann Arbor, East Lansing)	2
	Encourages urban infill & density – encourages the reduction on consumption of land and destruction of habitat.	3
	High community affects – large issue relative to regional community planning patterns. Chicago example = if going for LEED certification the approval process is speeded up. Environmental protection and land use policy impacts.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain	Design strategies—"best practices" guidelines that makes mandatory priority of this item; scale must be at community level; alternative strategies that address quality of life in its broadest definition. Municipal strategies and zoning policies must be adjusted to accommodate greater public/community input. A tax on "carbon" and a smart growth boundary may be the most effective strategy for encouraging while site selection.	1
		2

	IDEA: FQA Floristic Qualitative Assessment – Conducted – Anything over an established threshold would not be developed – this could be used as an alternative compliance path or added requirement for great lakes states – FQA benchmarks have been established for up to 40 states.	3
		4
What situational criteria might influence use of this credit-standard? Explain	Combine with above community/regional scale needed. Holistic approach with focus on broad quality of life issues.	1
	Somewhat situational, achieve it if you can. Other state laws provide some of these protections Availability of site, condition of the site (configuration)	2
		3
	Political land use policy and jurisdiction complicate a solid assessment.	4

Work Session Responses for SS Prerequisite 1

Work session responses suggest the following attributes for SS Credit 1:

Subject to site availability
Requires designers to determine zoning requirements of the local community and the community master plan
Reduces sprawl
High environmental benefits
Medium health benefits

Attributes Identified for SS Credit 1 from Work Session

Case Studies: Case Studies 2 and 3 project site do not fall in any of the prohibited areas as described in the standard. Case Study 4 project site is a previously developed/ disturbed site and is not one of the prohibited sites identified by the standard.

For all the three case study projects, the respondents indicated that there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor and construction project management for complying with this credit. Except for Case Study 3, no other case study project indicated cost increases associated with required documentation for complying with this credit. Institutional outcomes of complying with this credit were indicated as positive and the three projects recommended use of this credit by other governmental/ institutional owners.

The interview responses suggest the following attributes for SS Credit 1:

Avoids development of inappropriate sites
Subject to site availability
Minimizes disruption of the environmentally sensitive areas
Cost associated with required documentation varies (two case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase)
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Credit 1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 1:

Avoids development of inappropriate sites [USGBC-2]
Reduces environmental impact from the location of a building on a site [USGBC-2]
Subject to site availability [USGBC-2]
Requires designers to determine zoning requirements of the local community and the community master plan [USGBC-2]
Minimizes disruption of the environmentally sensitive areas [USGBC-2]
Encourages designers to incorporate site features into the design [USGBC-2]
Limits development footprint [USGBC-2]
Reduces sprawl [USGBC-2]
No cost / potential cost decrease [SWA 2004] and [FPC 2001]
Achieved through standard practice (increased design efforts but minimal construction first costs) [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 1 from Literature Review

Matrix Showing Attributes Identified for SS Credit 1:

SS Credit 1: Site Selection

Attribute	Environ-ment	Comm-unity	Econ-omic	Source of identification	Discussion
Avoids development of inappropriate sites	•	•		[USGBC-2], CS	
Reduces environmental impact from the location of a building on a site	•			[USGBC-2]	
Subject to site availability	•			[USGBC-2], CWS, CS	
Requires designers to determine zoning requirements of local community & the community master plan; Reduces sprawl	•	•		[USGBC-2], CWS	
Minimizes disruption of the environmentally sensitive areas	•			[USGBC-2], CS	
Encourages designers to incorporate site features into the design	•			[USGBC-2]	
Limits development footprint	•			[USGBC-2]	
Achieved through standard practice (increased design effort but minimal construction first costs)			•	[Eijadi et al. 2002]	
No cost increase associated with designing, planning or engineering; material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const. proj. mgmt.			•	CS	
No cost / Potential cost decrease			•	[SWA 2004], [FPC 2001]	CWS groups were split on whether costs of this credit would be low or high depending on specific project conditions.
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits
Cost associated with required documentation varies			•	CS	Two case study projects had no cost increase associated with required documentation whereas one had minor cost increase

Attributes related to SS Credit 1

SS Credit 2: Development Density & Community Connectivity Analysis:

The researcher found the important attributes for SS Credit 2 to be – increases density of community, reduces sprawl and pursuing subject to availability of previously developed site. These attributes were identified by collaborative work session and supported by the literature.

Intent of the Credit: Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources [USGBC-2].

Work Session: The work groups generally agreed that implementing this credit would yield high environmental and health benefits due to decreased land use and reduced sprawl. Its use was seen as situation dependent in that overall location of an agency complex may or may not support the use of this credit. The credit was viewed as encouraging walking and bicycling due to its urban nature. The use of this credit was subject to land availability and overall planning. Some concern was expressed for campus settings where property lines are not defined. Costs to implement this credit were seen as high due to perceived requirement for multistory buildings and working with existing infrastructure and site utilities. Table below shows the work session responses obtained for SS Credit 2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?	Easier to meet in community settings where property lines help define density; on campus, the lack of property lines may require a different way to define the standard.	1
	Benefit: Many benefits are seen. Environmental and lifestyle benefits. Support fight versus sprawl, urban redevelopment and mixed use; may support city strategies for increased densification (e.g., infill on strip commercial)	2

	Encourages urban redevelopment and infill – uses existing infrastructure – health and wellness i.e. more transportation options – providing service areas within development may enable achievement of credit	3
	Keeps development compact, emphasizes pedestrian circulation, reduces unnecessary extension of infrastructure, and minimizes auto demand.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain	Strategies will include alterations to the master plan for a campus compliance	1
		2
		3
		4
What situational criteria might influence use of this credit-standard? Explain	Donor influence, state/federal regulations, energy costs will significantly affect institutional settings; technology will mediate some of the costs due to energy through improved communication.	1
		2
		3
		4

Work Session Responses for SS Credit 2

Work session responses suggest the following attributes for SS Credit 2:

Subject to availability of previously developed site
Increases density of community
Reduces sprawl
High costs
High environmental benefits
High health benefits
Decreases land use
Encourages walking and bicycling
Easier to meet in community settings where property lines help define density
Reduces unnecessary extension of infrastructure
Minimizes auto demand
Supports urban redevelopment and mixed use
Keeps development compact

Attributes Identified for SS Credit 2 from Work Session

Case Studies: Project criteria of all four projects were inconsistent with the standard.

Interview responses suggested no attributes for SS Credit 2.

Literature Review:

Literature Review indicates the following attributes for SS Credit 2:

Channels development to urban areas with existing infrastructure [USGBC-2]
Protects greenfields and preserves habitat and natural resources [USGBC-2]
Subject to availability of previously developed site [USGBC-2]
Increases density of community [USGBC-2]
Subject to distance of site from residential zone or neighborhood [USGBC-2]
Subject to distance of site from basic services [USGBC-2]

Subject to availability of pedestrian access between the building and services [USGBC-2]
Reduces sprawl [USGBC-2]
No cost / potential cost decrease [SWA 2004]
Achieved through standard practice (increased design efforts but minimal construction first costs) [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 2 from Literature Review

Matrix Showing Attributes Identified for SS Credit 2:

SS Credit 2: Development Density & Community Connectivity

Attribute	Environ-ment	Comm-unity	Econ-omic	Source of identification	Discussion
Channels development to urban areas with existing infrastructure	•			[USGBC-2]	
Protects greenfields and preserves habitat and natural resources	•			[USGBC-2]	
Subject to availability of previously developed site	•			[USGBC-2], CWS	
Increases density of community; Reduces sprawl	•	•		[USGBC-2], CWS	
Subject to distance of site from residential zone or neighborhood	•			[USGBC-2]	
Subject to distance of site from basic services	•			[USGBC-2]	
Subject to availability of pedestrian access between the building and services	•			[USGBC-2]	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al. 2002]	
Decreases land use	•	•		CWS	
Encourages walking and bicycling		•		CWS	
Easier to meet in community settings where property lines help define density	•	•		CWS	
Reduces unnecessary extension of infrastructure	•		•	CWS	
Minimizes auto demand; Keeps development compact	•	•		CWS	
Supports urban redevelopment and mixed use	•	•		CWS	
Cost varies			•	[SWA 2004], CWS	[SWA 2004] concluded no cost / potential cost decrease to achieve this credit. CWS concluded high costs to achieve this credit
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 2

SS Credit 3: Brownfield Redevelopment Analysis:

The researcher found the important attributes for SS Credit 3 to be – pursuing subject to availability of 'brownfield' site and reduces greenfield development. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Rehabilitate damaged sites where development is complicated by environmental contamination, reducing pressure on undeveloped land [USGBC-2].

Work Session: The work groups indicated that although this credit had high potential environmental and health benefit it also carried high costs. Implementing this credit is situational, and depends on availability of sites and the particular site conditions. Work groups felt this credit could be mandated for state agencies, but not school districts or other public owners. Table below shows the work session responses obtained for SS Credit 3.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Good public relations "doing the right thing"; enhancing property values	2
	Development incentives – Potential existing Transportation and Infrastructure – reduces Greenfield development - Concerns – cost and public safety perception	3
	Noble cause especially in an urban context. PR. Synergistic community benefits – catalyst for other redevelopment.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
		4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Great planning ethos, but tax paying citizenry is getting leary of the cost.	4

Work Session Responses for SS Credit 3

Work session responses suggest the following attributes for SS Credit 3:

Subject to availability of "brownfield" site
Reduces greenfield development
High costs
High environmental benefits
High health benefits
Enhances property value
Encourages use of existing transportation and infrastructure

Attributes Identified for SS Credit 3 from Work Session

Case Studies: Since none of the four sites was classified as "brownfield", SS Credit 3 was not available to them.

The interview responses suggest the following attributes for SS Credit 3:

Subject to availability of "brownfield" site

Attribute Identified for SS Credit 3 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 3:

Rehabilitates damaged sites [USGBC-2]
Subject to availability of "brownfield" site [USGBC-2]
Reduces greenfield development [USGBC-2]
No cost / potential cost decrease [SWA 2004]
High costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]

Attributes Identified for SS Credit 3 from Literature Review

Matrix Showing Attributes Identified for SS Credit 3:

SS Credit 3: Brownfield Redevelopment

Attribute	Environment	Community	Economic	Source of identification	Discussion
Rehabilitates damaged sites	•			[USGBC-2]	
Subject to availability of "brownfield" site	•			[USGBC-2], CWS, CS	
Reduces greenfield development	•			[USGBC-2], CWS	
Enhances property value			•	CWS	
Encourages use of existing transportation and infrastructure	•	•		CWS	
Cost varies			•	[SWA 2004], CWS	[SWA 2004] concluded no cost / potential cost decrease to achieve this credit. [Eijadi et al. 2002] and CWS concluded high costs to achieve this credit
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded high health benefits

Attributes related to SS Credit 3

SS Credit 4.1: Alternative Transportation: Public Transportation Access Analysis:

The researcher found the important attributes for SS Credit 4.1 to be – encourages building occupants to use mass transit, minimizes parking lots, reduces automobile use and air pollution and has no cost/ potential cost decrease. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce pollution and land development impacts from automobile use [USGBC-2].

Work Session: Although this credit was viewed as situational because it is dependent on availability of public transportation, all work groups indicated that for the right site this credit had no cost associated with it and high health and environmental benefit. Public sector owners should be encouraged to select sites with available public transportation. Additionally public sector owners may have the ability to work with public bus systems to alter routes to accommodate this credit. Table below shows the work session responses obtained for SS Credit 4.1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Equity benefit (hire people who don't have cars); reduce pollution and parking lots costs; some more walking behavior in employees	2
	Amenity to building occupants & employers – Concerns: Transit system is not in place and needs to be expanded or building needs to follow transit master plan	3
	Should be a requirement for any state building. Makes sense to keep with population growth.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Need to create reasonable options that promote use of bus. What to do on the off day you need to get to the doctor, store, etc.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	promotions, incentives	4

Work Session Responses for SS Credit 4.1

Work session responses suggest the following attributes for SS Credit 4.1:

Subject to availability of public transportation system
Encourages building occupants to use mass transit
Minimizes parking lots
Reduces automobile use and air pollution
No cost / potential cost decrease
High environmental benefits
High health benefits

Attributes Identified for SS Credit 4.1 from Work Session

Case Studies: Three bus lines within ¼ mile of the project site serve Case Study 2 project site. Case Study 4 is located across the street from the main campus bus hub, and adjacent to numerous bus routes. The respondents indicated there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. The interview responses suggest the following attributes for SS 4.1:

Subject to distance of building from mass transit
Subject to availability of public transportation system
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Credit 4.1 from Case Studies

Literature Review: Literature Review indicates the following attributes for SS Credit 4.1:

Subject to distance of building from mass transit [USGBC-2]
Subject to transportation needs of building occupants [USGBC-2]
Subject to availability of sidewalks, paths and walkways to existing mass transit stops [USGBC-2]
Encourages building occupants to use mass transit [USGBC-2]
Minimizes parking lots [USGBC-2]
Reduces automobile use and air pollution [USGBC-2]
No cost / potential cost decrease [SWA 2004] and [FPC 2001]
Achieved through standard practice (increased design efforts but minimal construction first costs) [Eijadi et al. 2002]
Addresses global environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 4.1 from Literature Review

Matrix Showing Attributes Identified for SS Credit 4.1:

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to distance of building from mass transit	•			[USGBC-2], CS	
Subject to transportation needs of building occupants		•		[USGBC-2]	
Subject to availability of public transportation system	•	•		CWS, CS	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			[USGBC-2]	
Encourages building occupants to use mass transit		•		[USGBC-2], CWS	
Minimizes parking lots	•	•		[USGBC-2], CWS	
Reduces automobile use, air pollution	•	•		[USGBC-2], CWS	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al. 2002]	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj. mgmt.			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 4.1

SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms

Analysis:

The researcher found the important attributes for SS Credit 4.2 to be – reduces automobile use and air pollution and minimizes parking lots. These attributes were identified by collaborative work session and supported by the literature.

Intent of the Credit: Reduce pollution and land development impacts from automobile use [USGBC-2].

Work Session: All four workgroups indicated this credit offered high environmental and health benefits with relatively low to moderate costs for new buildings. Work groups indicated some concerns over costs associated with lost square footage to accommodate shower facilities or bike storage. All work groups indicated this credit should be recommended for public sector owner projects. Table below shows the work session responses obtained for SS Credit 4.2.

<table>
<tr><th>Question</th><th>Response</th><th>Group #</th></tr>
<tr><td rowspan="4">What organizational benefits / concerns do you foresee in pursuing this credit-standard?</td><td>Decreased conflicts with automobiles, noise pollution, decreased space requirements secondary to road and parking requirements of autos on campus; increased health of student/ faculty/ staff/ administrators with subsequent decreases on health care costs/ insurance. Positive enabling and environmental aspects would be expected.</td><td>1</td></tr>
<tr><td>Benefits: good PR, healthier employees, lower health costs, inspiration to others
Concerns: financial costs (square footage and plumbing)</td><td>2</td></tr>
<tr><td></td><td>3</td></tr>
<tr><td>Less dependence on the automobile. Potential to consume program space.</td><td>4</td></tr>
</table>

Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain	Broader, more regional approaches to transportation systems, particularly bicycle and pedestrian paths, must be considered and encouraged beyond the campus boundaries of an institution; on-campus master plans must be adapted to accommodate increased commuting and recreation bicycle travel from off campus sites and from campus to campus sites. Adaptation of regional transportation systems, like CATA, Indian Trails, and Amtrak must occur in routes, scheduling, and vehicle structures would encourage greater demands for alternative transportation on campus.	1
	Need some research on the benefits of this in terms of greater health outcomes (e.g., amongst employees)	2
		3
	Need regional access system so people can actually bike to work and then use the shower, otherwise you provide the shower alone and simply buy the credit.	4
What situational criteria might influence use of this credit-standard? Explain	Cost of transportation/energy in the near future. Bike repair shop availability on campus. Institutional policy that provides incentives for bicycle and pedestrian travel on campus by encouraging greater "healthy living" practices by employees.	1
		2
		3
		4

Work Session Responses for SS Credit 4.2

Work session responses suggest the following attributes for SS Credit 4.2:

Subject to space available for shower facilities
Reduces automobile use and air pollution
Minimizes parking lots
Low to moderate costs
High environmental benefits
High health benefits
Reduces noise pollution
High financial costs (square footage and plumbing)

Attributes Identified for SS Credit 4.2 from Work Session

Case Studies: None of the case study projects pursued this credit because of concerns over space allocations for shower rooms. Additionally, since shower facilities pose liabilities risk, Case Study 3 did not provide shower facilities. However, Case Study 4 is considering this credit for its registered building and will provide shower rooms since they ended up with space in basement that could be used for shower rooms without affecting program space. Some additional costs are anticipated for construction/ plumbing of these rooms.

The interview responses suggest the following attributes for SS Credit 4.2:

Subject to space available for shower facilities
High financial costs (square footage and plumbing),
May affect program space

Attributes Identified for SS Credit 4.2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 4.2:

Subject to space available for shower facilities [USGBC-2]
Provides secure bicycle storage areas for cyclists [USGBC-2]
Reduces automobile use and air pollution [USGBC-2]
Minimizes parking lots [USGBC-2]
High costs [SWA 2004]
Low to moderate costs [FPC 2001]
Minor construction costs [Eijadi et al. 2002]
Addresses global environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 4.2 from Literature Review

Matrix Showing Attributes Identified for SS Credit 4.2:

SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to space available for shower facilities			•	[USGBC-2], CWS, CS	
Provides secure bicycle storage areas for cyclists		•		[USGBC-2]	
Reduces automobile use, air pollution	•	•	•	[USGBC-2], CWS	
Minimizes parking lots	•	•	•	[USGBC-2], CWS	
Reduces noise pollution		•		CWS	
High financial costs (square footage and plumbing)			•	CWS, CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] concluded high costs to achieve this credit, [Eijadi et al. 2002] concluded minor construction cost, [FPC 2001] and CWS concluded low to moderate costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 4.2

SS Credit 4.3: Alternative Transportation: Low Emitting & Fuel Efficient Vehicles

Analysis:

The researcher found the important attributes for SS Credit 4.3 to be – reduces air pollution and automobile use. These attributes were identified by collaborative work session and supported by the literature.

Intent of the Credit: Reduce pollution and land development impacts from automobile use [USGBC-2].

Work Session: Work groups did not think the environmental or health benefits were as high with this credit. At the same time, they generally indicated that the costs to implement this credit were relatively low. Option two (providing dedicated parking spaces for low emitting/fuel efficient vehicles) was seen as the easier option to implement. The groups were mixed on whether this credit should be recommended for public sector owners. However, in the quadrant analysis two of three groups indicated low cost/high overall benefit. Table below shows the work session responses obtained for SS Credit 4.3.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Incentivize alternative fuel vehicles purchased; lower air pollution and emissions Concerns: Can impact upon employees as a whole (lacking parking); also some equity issues works against people who can't afford a Prius	2
		3
	Option 2 is easier – no brainier. Is 3% a great impact?	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Could a campus purchase fuel-efficient vehicles for fleet and then claim this credit for any building built on campus? Is it somewhat exclusive – how much to purchase a hybrid car?	4
What situational		1

criteria might influence use of this credit-standard? Explain		2
		3
		4

Work Session Responses for SS Credit 4.3

Work session responses suggest the following attributes for SS Credit 4.3:

Reduces air pollution, automobile use
Low costs
Medium environmental benefits
Low health benefits

Attributes Identified for SS Credit 4.3 from Work Session

Case Studies: Because of high infrastructure cost associated for complying with this credit, none of the case study projects pursued this credit.

The interview responses suggest the following attributes for SS Credit 4.3:

High infrastructure cost

Attribute Identified for SS Credit 4.3 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 4.3:

Provides low-emitting and fuel efficient vehicles for 3% of full time equivalent occupants [USGBC-2]
Provides preferred parking for low-emitting and fuel efficient vehicles [USGBC-2]
Provides alternative-fuel refueling stations [USGBC-2]
Reduces air pollution and automobile use [USGBC-2]
Higher initial costs for alternative vehicles [USGBC-2]
Low costs [SWA 2004]
Significant construction costs [Eijadi et al. 2002]
Addresses global environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attribute Identified for SS Credit 4.3 from Literature Review

Matrix Showing Attributes Identified for SS Credit 4.3:

SS Credit 4.3: Alternative Transportation: Low Emitting & Fuel Efficient Vehicles

Attribute	Environment	Community	Economic	Source of identification	Discussion
Provides low-emitting and fuel efficient vehicles for 3% of full time equivalent occupants	•	•		[USGBC-2]	
Provides preferred parking for low-emitting and fuel efficient vehicles	•	•		[USGBC-2]	
Provides alternative-fuel refueling stations	•	•		[USGBC-2]	
Reduces air pollution, automobile use	•	•		[USGBC-2], CWS	
Higher initial costs for alternative vehicles			•	[USGBC-2]	
High infrastructure cost			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] and CWS concluded low costs to achieve this credit, [Eijadi et al. 2002] concluded significant construction cost
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded low health benefits

Attributes related to SS Credit 4.3

SS Credit 4.4: Alternative Transportation: Parking Capacity Analysis:

The researcher found the important attributes for SS Credit 4.4 to be – minimizes parking lot/ garage size, provides parking space for carpools or vanpools, encourages use of public transportation, reduces amount of impervious surface, reduces stormwater runoff, low costs and reduces air pollution. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce pollution and land development impacts from single occupancy vehicle use [USGBC-2].

Work Session: Work groups recommended adopting this credit for public sector projects. Costs to implement this credit were seen as low, or as less than standard design. The credit was seen, as have minimal technical difficulties. Benefits cited included reduced storm water due to reduced impervious surfaces. In general, the work group participants did not rank the environmental or health benefits as high as with other credits.

Table below shows the work session responses obtained for SS Credit 4.4.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefit: lower impervious surface cover; if carpooling occurs lower emissions and better air quality; encourages use of public transportation (with lower emissions again); makes a community more amenable for walking	2
		3
	Less pervious pavement, less storm water runoff, better visual environment. Need to take the life style issue into our thinking – how to deal with issues of what we do on the off day or working mother, or other unique situations.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	We are cramming more people into less space and more often developers are now asking for more parking than the local zoning. Mixed-use projects are better because it balances out demand.	4
What situational		1

criteria might influence use of this credit-standard? Explain	In existing neighborhoods might be opposition from under sizing parking (as will park on street or in neighborhoods); on other hand we dislike parking lot	2
		3
	Government is pushing for less parking, whereas developers want more. What about promotional days.	4

Work Session Responses for SS Credit 4.4

Work session responses suggest the following attributes for SS Credit 4.4:

Encourages use of public transportation
Reduces amount of impervious surface, reduces stormwater runoff
Low costs
Medium environmental benefits
Low health benefits
Reduces air pollution
Makes community more amenable for walking

Attributes Identified for SS Credit 4.4 from Work Session

Case Studies: For Case Study 1, parking is provided only for service vehicles and group buses. No new parking was provided because on- campus students could walk and off-campus students could ride buses. Green space conservation and cost savings were the motivating factors for achieving this credit. The respondents indicated that there were no significant cost increases associated with designing, planning or engineering; construction labor; documentation and construction project management for complying with this credit. However, respondents indicated that there was decrease in material purchase cost since the parking space was reduced and the building had a small footprint. Case Studies 2 and 3 did not pursue this credit because of parking space requirement for the program. Case Study 4 may achieve this credit.

The interview responses suggest the following attributes for SS Credit 4.4:

Minimizes parking lot/ garage size
Provides parking space for carpools or vanpools
Encourages use of public transportation
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase

No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Credit 4.4 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 4.4:

Minimizes parking lot/ garage size [USGBC-2]
Provides parking space for carpools or vanpools [USGBC-2]
Subject to location of project site [USGBC-2]
Subject to number of cars likely to drive to the site [USGBC-2]
Encourages use of public transportation [USGBC-2]
Reduces amount of impervious surface, reduces stormwater runoff [USGBC-2]
Reduces air pollution [USGBC-2]
Low costs [SWA 2004] and [Eijadi et al. 2002]
Addresses global environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 4.4 from Literature Review

Matrix Showing Attributes Identified for SS Credit 4.4:

SS Credit 4.4: Alternative Transportation: Parking Capacity

Attribute	Environment	Community	Economic	Source of identification	Discussion
Minimizes parking lot/ garage size	•	•	•	[USGBC-2], CS	
Provides parking space for carpools or vanpools	•	•		[USGBC-2], CS	
Subject to location of project site	•			[USGBC-2]	
Subject to number of cars likely to drive to the site	•	•		[USGBC-2]	
Encourages use of public transportation	•	•		[USGBC-2], CWS, CS	
Reduces amount of impervious surface, reduces stormwater runoff	•			[USGBC-2], CWS	
Low costs			•	[SWA 2004], [Eijadi et al. 2002], CWS	
Reduces air pollution	•	•		[USGBC-2], CWS	
Makes community more amenable for walking		•		CWS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [USGBC-2] and [Mrozowski et al. 2006] concluded health impacts, CWS concluded low health benefits

Attributes related to SS Credit 4.4

SS Credit 5.1: Site Development: Protect or Restore Habitat (Formerly - Reduced Site Disturbance: Development Footprint) **Analysis:**

The researcher found the important attributes for SS Credit 5.1 to be – conserves existing natural areas and restores damaged areas, maintains existing natural ecosystem and reduces infrastructure construction. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity [USGBC-2].

Work Session: Most work groups viewed this credit as situational. Moderate technical difficulties with implementation were identified as concerns based on building configuration, height etc. The work groups recommend use of this credit but they generally indicated that better urban/regional planning might be more effective. Work groups also indicated that differences in urban and rural developments would affect the ability to use this credit. Table table shows the work session responses obtained for SS Credit 5.1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: enhanced water quality	2
	Landscape management/stewardship plan is required to effectively implement. Align with regional strategy – neighbors may not like your weeds, having in place a master plan that insures a long term commitment to open space	3
	Easy to get on Greenfield site but not on urban site. Does not encourage density, compact design.	4
Design, technical and, political strategies that could be used for		1
	Technically could be hard to meet the dimensions in Option 1. (Multi story buildings in particular)	2
		3

compliance with this credit-standard. Explain	This is not a substitute to good urban planning/design. Intent is good, can your get there on all projects. Potentially do it on a regional/ community planning level where the bigger planning issues are addressed, but on a project by project basis where things get chopped up.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Urban vs. rural will vary.	4

Work Session Responses for SS Credit 5.1

Work session responses suggest the following attributes for SS Credit 5.1:

Maintains existing natural ecosystem
Medium costs
High environmental benefits
Medium health benefits
Requires effective implementation of landscape management
Enhances water quality

Attributes Identified for SS Credit 5.1 from Work Session

Case Studies: For Case Study 1, this credit was achieved by restoring and maintaining natural vegetation. Excavated earth was deposited to form berms rather than being hauled from the site. This credit was achieved to preserve space and these berms in combination with existing vegetation help to provide some degree of visual and acoustical isolation from the adjacent major roadway. The respondents indicated that there was no significant cost increase associated with material purchase; documentation and construction project management for complying with this credit and the cost of designing, planning or engineering was neutral due to lack of utility connections and less excavation. Respondents indicated that there were cost savings in terms of construction labor, but the workers had to work in tight space. Being urbanized sites, Case Studies 2 and 3 did not pursue this credit. Case Study 4 will not pursue this credit because of site configuration limitations.

The interview responses suggest the following attributes for SS Credit 5.1:

Conserves existing natural areas and restores damaged areas
Maintains existing natural ecosystem
Reduces infrastructure construction
Provides better visual impact
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Credit 5.1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 5.1:

Conserves existing natural areas and restores damaged areas [USGBC-2]
Limits construction on greenfield site or previously developed site [USGBC-2]
Reduces building footprint [USGBC-2]
Maintains existing natural ecosystem [USGBC-2]
Reduces infrastructure construction [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Medium costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 5.1 from Literature Review

Matrix Showing Attributes Identified for SS Credit 5.1:

SS Credit 5.1: Site Development: Protect or Restore Habitat

Attribute	Environment	Community	Economic	Source of identification	Discussion
Conserves existing natural areas and restores damaged areas	•			[USGBC-2], CS	
Limits construction on greenfield site or previously developed site	•			[USGBC-2]	
Reduces building footprint	•			[USGBC-2]	
Maintains existing natural ecosystem	•			[USGBC-2], CWS, CS	
Reduces infrastructure construction	•		•	[USGBC-2], CS	
Requires effective implementation of landscape management	•			CWS	
Enhances water quality	•	•		CWS	
Provides better visual impact		•		CS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj mgmt			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] and [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] and CWS concluded medium cost
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impacts varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits

Attributes related to SS Credit 5.1

SS Credit 5.2: Site Development: Maximize Open Space Analysis:

The researcher found the important attributes for SS Credit 5.2 to be – reduces development footprint, provides vegetated open space, minimizes site disruption, increases amount of daylighting and reduces heat island effects. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Provide a high ratio of open space to development footprint to promote biodiversity [USGBC-2].

Work Session: Although project open space was seen as a positive for occupants, this credit was believed to potentially promote sprawl and was not highly recommended for adoption by public agencies. Some increased costs were associated with multistory design solutions potentially necessary in meeting the credit. Work groups indicated that good overall urban design solutions might be a better approach. Although generally work groups seemed to indicate some environmental and health benefits, the costs and potential sprawl pressures seemed to outweigh them in the quadrant analysis. Table table shows the work session responses obtained for SS Credit 5.2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: to employees / occupiers of the building; increases water infiltration, reduction of heat island effect, more opportunities for day lighting for employees Concerns: tension with the emphasis on density; could be offset by building form (multi story) or regionally provided open space	2
		3
	Intent is to push taller buildings, but does it create a mix of uses and synergy, and a reason to be there. More is not necessarily better, how you do it matters.	4
Design, technical and, political strategies that could		1
		2
		3

be used for compliance with this credit-standard. Explain	LEED should stick with the technical stuff (water efficiency, energy, etc.) not urban design, planning aspects. Some kind of credit at a regional level. No good substitute for good urban design.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Coupled with good solid comprehensive coordinated urban design maybe.	4

Work Session Responses for SS Credit 5.2

Work session responses suggest the following attributes for SS Credit 5.2:

Increase amount of daylighting
Reduces heat island effects
High costs
High environmental benefits
Medium health benefits
Promotes sprawl
Increases water infiltration

Attributes Identified for SS Credit 5.2 from Work Session

Case Studies: Case Study 1 site is relatively large which allowed for use of this credit. Maintaining existing vegetation, the vernal pond and open space were all used to provide distance, sound and visual separation from the adjacent major roadway. The respondents indicated that there was no significant cost increase associated with material purchase; documentation and construction project management for complying with this credit and the cost of designing, planning or engineering was neutral due to lack of utility connections and less excavation. Respondents indicated that there were cost savings in terms of construction labor, but the workers had to work in tight space. Case Study 2 has been developed in an area with no local zoning requirements for open space. Open space, equal to the building footprint, has been provided adjacent to the building. In addition, the university has designated open space for the life of the building. Being an urbanized site, Case Study 3 did not pursue this credit. Case Study 4 may achieve this credit. Open space definition in MSU includes parking space.

The interview responses suggest the following attributes for SS Credit 5.2:

Reduces development footprint
Provides vegetated open space
Minimizes site disruption
Provides better visual impact
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with material purchase
No cost increase associated with construction labor
No cost increase associated with construction project management

Attributes Identified for SS Credit 5.2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 5.2:

Reduces development footprint [USGBC-2]
Provides vegetated open space [USGBC-2]
Minimizes site disruption [USGBC-2]
Increases amount of daylighting [USGBC-2]
Reduces heat island effects [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Medium costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 5.2 from Literature Review

Matrix Showing Attributes Identified for SS Credit 5.2:

SS Credit 5.2: Site Development: Maximize Open Space

Attribute	Environment	Community	Economic	Source of identification	Discussion
Reduces development footprint	•			[USGBC-2], CS	
Provides vegetated open space	•			[USGBC-2], CS	
Minimizes site disruption	•			[USGBC-2], CS	
Increases amount of daylighting		•		[USGBC-2], CWS	
Reduces heat island effects	•	•		[USGBC-2], CWS	
Promotes sprawl	•	•		CWS	
Increases water infiltration	•			CWS	
Provides better visual impact		•		CS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project mgmt			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] and [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded medium cost and CWS concluded high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits

Attributes related to SS Credit 5.2

SS Credit 6.1: Stormwater Design: Quantity Control (Formerly - Storm water Management: Rate and Quantity) **Analysis:**

The researcher found the important attribute for SS Credit 6.1 to be – requires careful design and maintenance of system. This attribute was identified by collaborative work session and supported by the literature.

Intent of the Credit: Limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants [USGBC-2]

Work Session: Work session participants indicated that meeting this credit would yield high environmental benefits and had low costs associated with implementation. This credit was highly recommended for adoption by public agencies. Some technical concerns were expressed with design and maintenance of systems used to implement this credit. The need for careful integrated planning was expressed. Overall public sector owners recommended this credit for adoption. Table below shows the work session responses obtained for SS Credit 6.1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?	Opportunity for teaching/learning for students and faculty on campus. Improve water quality and eliminate fines from non-compliance. Sometimes finding enough space on campus is a problem—it requires up parking space	1
	Benefits: better stream water quality; better fish habitat; could prevent nasty lawsuits arising from flooded downstream neighbors; Concerns: The reductions seem rather arbitrary (if you are 51 must reduce to 37%); technical nature of analysis could lead to improper numbers	2
	Recharge Aquifer – counties and municipalities vary in their level of control. Is it necessary to fully store the 2 year event – design for two year slow, cleanse cool and infiltrate. Owners need to be educated – visible systems	3
		4
Design, technical and, political	Balancing energy needs with water needs—e.g., cisterns, solar powered pumps—through demonstration projects.	1

strategies that could be used for compliance with this credit-standard. Explain	Integrated design process is necessary; need to have up front planning for this. Stormwater needs a high level of management that may be possible at the site level; e.g., county drain commissioners really need to know what they are doing	2
	High	3
	Would it be better to manage storm water at the watershed level, not project-by-project that actually increases the amount of time heavy flows are moving through the river/stream and eroding more.	4
What situational criteria might influence use of this credit-standard? Explain	Regulations. Available fresh-water supplies.	1
		2
		3
	Focusing on infiltration is good.	4

Work Session Responses for SS Credit 6.1

Work session responses suggest the following attributes for SS Credit 6.1:

Requires careful design and maintenance of system
Low costs
High environmental benefits
Medium health benefits

Attributes Identified for SS Credit 6.1 from Work Session

Case Studies: None of the case study projects pursued this credit. Because of the high cost associated with cistern/ greywater system, Case Study 4 will not pursue this credit. The interview responses suggest the following attributes for SS Credit 6.1:

High equipment purchase cost

Attributes Identified for SS Credit 6.1 from Case Studies

Literature Review: Literature Review indicates the following attributes for SS Credit 6.1:

Limits disruption of natural hydrology [USGBC-2]
Increases on-site infiltration [USGBC-2]
Minimizes impervious surfaces [USGBC-2]
Decrease in the volume of stormwater runoff [USGBC-2]
Requires careful design and maintenance of system [USGBC-2]
Either no cost increase or high costs [SWA 2004]
No cost increase [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 6.1 from Literature Review

Matrix Showing Attributes Identified for SS Credit 6.1:

SS Credit 6.1: Stormwater Design: Quantity Control

Attribute	Environment	Community	Economic	Source of identification	Discussion
Limits disruption of natural hydrology	•			[USGBC-2]	
Increases on-site infiltration	•			[USGBC-2]	
Minimizes impervious surfaces	•			[USGBC-2]	
Decrease in the volume of stormwater runoff	•			[USGBC-2]	
Requires careful design and maintenance of system	•			[USGBC-2], CWS	
High equipment purchase cost			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] concluded either no cost increase or high cost, [Eijadi et al. 2002] concluded no cost increase and CWS concluded low costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits

Attributes related to SS Credit 6.1

SS Credit 6.2: Stormwater Design: Quality Control (Formerly - Storm water Management: Treatment) **Analysis:**

The researcher found the important attributes for SS Credit 6.2 to be – reduces or eliminates water pollution, minimizes impervious surfaces, increases on-site infiltration, eliminates sources of contaminants, removes pollutants from stormwater runoff and decreases stormwater runoff. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Limit disruption and pollution of natural water flows by managing stormwater runoff [USGBC-2].

Work Session: Work groups ranked the environmental benefits from meeting this credit as high, but indicated cost increases were associated with the credit. Participants indicated that not all sites could support the use of this credit. Porous pavements, green roofs and flow through planters were seen as potential strategies, for helping to meet this credit. This credit was viewed as connected to SS Credit 6.1. Generally, it was recommended that credit be adopted for public sector projects depending on project conditions. Table below shows the work session responses obtained for SS Credit 6.2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?	see SS Credit 6.1	1
	Benefits: methods given will improve water quality by increased infiltration and removal of suspended solids and other contaminants Concerns: scale seems low for dealing with water quality (regional issue); lack of data on BMPs (whether they work or not); lack of baseline data for the monitoring reports in some locations; TMDL data can help	2
	Porous pavements – interlocking infill concrete pavers i.e. turf stone installed over materials with fines – office, industrial, parks, ball stadium, hospitals $4 to 5 @ SF – better for cold climate, snow removal – rubber edge blade	3
		4
Design, technical and, political strategies that		1
		2

could be used for compliance with this credit-standard. Explain		3
	Is it more problematic in urban setting however, green roofs will hold most of the water that it receives? Flow through planters. Infiltration beyond 15' of the building.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
		4

Work Session Responses for SS Credit 6.2

Work session responses suggest the following attributes for SS Credit 6.2:

Reduces or eliminates water pollution
Increases on-site infiltration
Eliminates sources of contaminants
Removes pollutants from stormwater runoff
High costs
High environmental benefits
High health benefits

Attributes Identified for SS Credit 6.2 from Work Session

Case Studies: For Case Study 1, bioswales were used to channel and filter water runoff from roof areas into the vernal pond. Reduced paving for parking areas also helped to decrease stormwater runoff. The respondents indicated that there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. The other case study projects did not pursue this credit. Because of the high cost associated with cistern/ greywater system, Case Study 4 will not pursue this credit.

The interview responses suggest the following attributes for SS Credit 6.2:

Minimizes impervious surfaces
Increases on-site infiltration
Decreases stormwater runoff
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
No cost increase associated with material purchase
High equipment purchase cost

Attributes Identified for SS Credit 6.2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 6.2:

Reduces or eliminates water pollution [USGBC-2]
Minimizes impervious surfaces [USGBC-2]
Increases on-site infiltration [USGBC-2]
Eliminates sources of contaminants [USGBC-2]
Removes pollutants from stormwater runoff [USGBC-2]
Decreases stormwater runoff [USGBC-2]
Moderate cost [SWA 2004]
No cost increase [FPC 2001]
Significant costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 6.2 from Literature Review

Matrix Showing Attributes Identified for SS Credit 6.2:

SS Credit 6.2: Stormwater Design: Quality Control

Attribute	Environment	Community	Economic	Source of identification	Discussion
Reduces or eliminates water pollution	•	•		[USGBC-2], CWS	
Minimizes impervious surfaces	•			[USGBC-2], CS	
Increases on-site infiltration	•			[USGBC-2], CWS, CS	
Eliminates sources of contaminants	•			[USGBC-2], CWS	
Removes pollutants from stormwater runoff	•			[USGBC-2], CWS	
Decreases stormwater runoff	•			[USGBC-2], CS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
High equipment purchase cost			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] concluded moderate cost, [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded significant cost and CWS concluded high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 6.2

SS Credit 7.1: Heat Island Effect: Non-Roof Analysis:

The researcher found the important attributes for SS Credit 7.1 to be – reduces heat islands, limits the amount of impervious hardscape areas and provides shading for hard surfaced areas. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat [USGBC-2].

Work Session: Health and environmental benefits were seen as moderate with this credit and costs increases were seen as moderate to high for northern climates. Establishing tree canopies was seen as difficult for larger parking facilities, and cost of reflective pavements was seen as an increase over standard pavements. Work groups indicated that the use of this credit would be situational. Table below shows the work session responses obtained for SS Credit 7.1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?	Snow removal issues in winter with certain pavement.	1
	Concern: 5 year rule for shade can be difficult to achieve; very difficult to quantify benefits (harder to tell than BMP) Benefits: does reduce heat	2
	Porous paving is encouraged – trees are difficult to implement - SR index is good for concrete but is expensive	3
	Seasonal issues do they apply to our climate – sometimes especially in urban.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain	One must consider how the extremes of climate here affect the benefits of different strategies, including pavement snow maintenance.	1
		2
		3
	Adding more complexity/detail to parking areas = smaller areas, greater reflectivity pavement may cost more.	4
What situational criteria might	Regulations may affect storm water availability	1
	Encourage solar reflexive parking wherever surface parking	2

influence use of this credit-standard? Explain		3
		4

Work Session Responses for SS Credit 7.1

Work session responses suggest the following attributes for SS Credit 7.1:

Reduces heat islands
Provides shading for hard surfaced areas
Moderate to high costs
Medium environmental benefits
Medium health benefits
Has issues with snow removal in winter with certain pavement

Attributes Identified for SS Credit 7.1 from Work Session

Case Studies: Case Study 1 achieved this credit by reducing parking pavement, maintaining and restoring natural vegetation to provide shading for hard surfaced areas and using white flagstone in sunny hard surfaced areas. Because of high value of trees, natural vegetation was restored inspite of some debate about value of some species. The respondents indicated that there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. Case Study 2 did not pursue this credit. Case Study 3 used reflective white Portland cement concrete for sunny hard surfaced exterior areas to achieve this credit. The respondents indicated that there were minor cost increases for documentation required for this credit and cost increases for material purchase, the cost of Portland Cement Concrete being approximately double than asphalt cost. Case Study 4 provided a combination of reflective concrete sidewalks and shade to achieve this credit.

The interview responses suggest the following attributes for SS Credit 7.1:

Limits the amount of impervious hardscape areas
Provides shading for hard surfaced areas
Cost increase associated with required documentation varies (one of the case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase)

No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
Cost increase associated with material purchase varies (one of the case study projects experienced no cost increase and the other project had high material purchase cost)

Attributes Identified for SS Credit 7.1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 7.1:

Reduces heat islands [USGBC-2]
Minimizes impact on microclimate and human and wildlife habitat [USGBC-2]
Limits the amount of impervious hardscape areas [USGBC-2]
Provides shading for hard surfaced areas [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Minor costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 7.1 from Literature Review

Matrix Showing Attributes Identified for SS Credit 7.1:

SS Credit 7.1: Heat Island Effect: Non-Roof

Attribute	Environment	Community	Economic	Source of identification	Discussion
Reduces heat islands	•	•		[USGBC-2], CWS	
Minimizes impact on microclimate and human and wildlife habitat	•	•		[USGBC-2]	
Limits the amount of impervious hardscape areas	•			USGBC-2], CS	
Provides shading for hard surfaced areas	•			[USGBC-2], CWS, CS	
Has issues with snow removal in winter with certain pavement	•			CWS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj mgmt			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] and [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded minor cost and CWS concluded moderate to high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium environmental benefit
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits
Cost increase associated with required documentation varies			•	CS	One of the case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase
Cost increase associated with material purchase varies			•	CS	One of the case study projects experienced no cost increase, & the other project had high material purchase cost

Attributes related to SS Credit 7.1

SS Credit 7.2: Heat Island Effect: Roof Analysis:

The researcher found the important attribute for SS Credit 7.2 to be – reduces heat islands. This attribute was identified by collaborative work session and supported by the literature.

Intent of the Credit: Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat [USGBC-2].

Work Session: Costs increases associated with green roofs were seen as high, however the use of reflective roof coverings was seen as practical to implement. The work groups although generally favoring the use of this credit, did not overwhelmingly recommend its adoption by public sector owners. Table below shows the work session responses obtained for SS Credit 7.2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
		2
	Every Roof Material is practical to consider – vegetated is more practical for synergies	3
	Perception that it is too over the edge, too costly, and not what we are used to seeing.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
		4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Need more data to get acceptability.	4

Work Session Responses for SS Credit 7.2

Work session responses suggest the following attributes for SS Credit 7.2:

Reduces heat islands
Low or high costs
High environmental benefits
High health benefits

Attributes Identified for SS Credit 7.2 from Work Session

Case Studies: For Case Study 2, an Energy Star rated roofing product that has an emissivity of at least 0.9 has covered 95.58% of the total roof area. Case Study 3 used reflective roof material to achieve this credit. The respondents indicated that except for documentation costs, there was no significant cost increase associated with designing, planning or engineering; material purchase; construction labor; and construction project management for complying with this credit. For Case Study 4, light/ reflective roof material is being used to achieve this credit. The respondents indicated that because of high cost, green roof is not being installed.

The interview responses suggest the following attributes for SS Credit 7.2:

Minor cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
No cost increase associated with material purchase
High cost for installing green roof

Attributes Identified for SS Credit 7.2 from Case Studies

Literature Review: Literature Review indicates the following attributes for SS Credit 7.2:

Reduces heat islands [USGBC-2]
Minimizes impact on microclimate and human and wildlife habitat [USGBC-2]
Green roofs provide insulating benefits, aesthetic appeal and lower maintenance than standard roofs [USGBC-2]
Garden roofs reduce stormwater volumes [USGBC-2]
No cost increase or high costs [SWA 2004]
No cost increase [FPC 2001]
Significant costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for SS Credit 7.2 from Literature Review

Matrix Showing Attributes Identified for SS Credit 7.2:

SS Credit 7.2: Heat Island Effect: Roof

Attribute	Environment	Community	Economic	Source of identification	Discussion
Reduces heat islands	•			[USGBC-2], CWS	
Minimizes impact on microclimate and human and wildlife habitat	•	•		[USGBC-2]	
Green roofs provide insulating benefits, aesthetic appeal and lower maintenance than standard roofs	•	•	•	[USGBC-2]	
Garden roofs reduce stormwater volumes	•			[USGBC-2]	
Minor cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
High cost for installing green roof			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] concluded either no cost increase or high cost, [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded significant cost and CWS concluded low or high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Attributes related to SS Credit 7.2

SS Credit 8: Light Pollution Reduction Analysis:

The researcher found the important attributes for SS Credit 8 to be – no cost/ potential cost decrease and some concern about public safety in campus settings. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments [USGBC-2].

Work Session: Public sector owners generally recommended this credit for adoption. Environmental benefits were seen as moderate. The work groups did not see a strong health benefit from use of the credit and some concern was expresses over public safety for general walkways in campus settings. Careful overall site lighting design is necessary when using this credit. Table below shows the work session responses obtained for SS Credit 8.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
		2
	Municipalities have varying comfort levels, fairly easy achieve and not costly	3
	Generally good overall but not applicable everywhere such as recycle district. Best reason to do it is reduced energy consumption.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Using less energy, better environment. Don't know the impact to safety – do the reduce percentages maintain a safe environment?	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Contextual component to this thing.	4

Work Session Responses for SS Credit 8

Work session responses suggest the following attributes for SS Credit 8:

No cost/ potential cost decrease
Medium environmental benefits
Low health benefits
Some concern about public safety in campus settings

Attributes Identified for SS Credit 8 from Work Session

Case Studies: Case Study 1 campus lighting standards were consistent with this credit. Limited site lighting was installed. Safety is achieved by use of lighting bollards and safety pylons. The respondents indicated that there were no significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. For Case Study 2, project's exterior lighting has been designed in accordance with the referenced IESNA guidelines. No new site lighting has been provided since the building is on existing campus. Case Study 3 did not pursue this credit because high light level was needed for safety purpose. For Case Study 4, general university lighting standards comply with this credit.

The interview responses suggest the following attributes for SS Credit 8:

Some concern about public safety in campus settings
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
No cost increase associated with material purchase

Attributes Identified for SS Credit 8 from Case Studies

Literature Review: Literature Review indicates the following attributes for SS Credit 8:

Minimizes light trespass from the building and site [USGBC-2]
Reduces sky-glow to increase night sky access [USGBC-2]
Improves night time visibility through glare reduction [USGBC-2]
Reduces development impact on nocturnal environments [USGBC-2]
No cost / potential cost decrease [SWA 2004], [FPC 2001] and [Eijadi et al. 2004]
Addresses local/ regional environmental impacts [Eijadi et al. 2004]
No health impacts [Eijadi et al. 2002]

Attributes Identified for SS Credit 8 from Literature Review

Matrix Showing Attributes Identified for SS Credit 8:

SS Credit 8: Light Pollution Reduction

Attribute	Environment	Community	Economic	Source of identification	Discussion
Minimizes light trespass from the building and site	•	•		[USGBC-2]	
Reduces sky-glow to increase night sky access	•	•		[USGBC-2]	
Improves night time visibility through glare reduction	•	•		[USGBC-2]	
Reduces development impact on nocturnal environments	•	•		[USGBC-2]	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], [Eijadi et al. 2004] and CWS	
Some concern about public safety in campus settings		•		CWS, CS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project mgmt			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded low health benefits

Attributes related to SS Credit 8

Water Efficiency (WE) Credits

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50% Analysis:

The researcher found the important attribute for WE Credit 1.1 to be – encourages use of native or adaptive plants. This attribute was identified by collaborative work session and case studies and supported by the literature.

Intent of the Credit: Limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation [USGBC-2].

Work Session: Saving water was seen to have a strong environmental benefit, and therefore the groups recommended the adoption of this credit by public sector owners. Careful landscape design was seen as an important element. Because use of this credit is likely to lead to nontraditional plant selections, it is possible that approval agencies and the public will need to be educated in how and what is being accomplished. Costs to implement were seen as low by the workgroups. Table below shows the work session responses obtained for WE Credit 1.1.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Concern with water conservation will come to MI. Good for PR, also potential economic/fiscal benefits for firm/agency. (Reducing costs of irrigation, etc.) Reducing treatment requirements/infrastructure to deal with water/stormwater	2
	Reduced water use and cost & systems maintenance – Concern: credit still encourages irrigation, can maintain urban landscape to support wildlife and clean air in water and landscape challenged area's	3
	Basic benefits due to our climate. Need to understand native community = impacts water requirements. In many instances, a native plant requires as much water as a non-native – depending on the species. Long-term maintenance can become a larger issue = control burns.	4

Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
	Hire an appropriate LA; use non-potable sources/capture rainwater; technical approaches exist to do this.	2
		3
	Separate municipal filtration system would be innovative = purple pipe for grey water.	4
What situational criteria might influence use of this credit-standard? Explain		1
	Soil types affect this, climate issues.	2
		3
	Water utilization in the Midwest is changing and time will place more pressure on this issue.	4

Work Session Responses for WE Credit 1.1

Work session responses suggest the following attributes for WE Credit 1.1:

Encourages use of native or adaptive plants
No cost increase
High environmental benefits
Medium health benefits
Requires careful landscape design

Attributes Identified for WE Credit 1.1 from Work Session

Case Studies: Case Study 1 used largely native species, which require limited water to achieve this credit. No supplementary irrigation was required. Because of lot of shade and cool environment, water use was minimal. The respondents indicated that there was no significant cost increase associated with material purchase; construction labor; documentation and construction project management for complying with this credit. Since landscaping was done by students, there was no contracting and thus saved money for designing, planning or engineering. Case Study 2 did not pursue this credit. For Case Study 3, captured rainwater and indigenous plants were used to achieve this credit. The respondents indicated that there was no significant cost increase associated with designing, planning or engineering; construction labor; and construction project management for complying with this credit. However, cost of material purchase was indicated as high because of the pump required for water treatment. There was minor increase in documentation cost. For Case Study 4, a drip irrigation system is being installed to achieve this credit.

The interview responses suggest the following attributes for WE Credit 1.1:

Encourages use of native or adaptive plants
Cost increase associated with required documentation varies (one of the case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase)
No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
Cost increase associated with material purchase varies (one of the case study projects experienced no cost increase and the other project had high material purchase cost)

Attributes Identified for WE Credit 1.1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for WE Credit 1.1:

Limits or eliminates the use of potable water or other natural surface or subsurface water [USGBC-2]
Encourages use of captured rainwater [USGBC-2]
Encourages use of recycled wastewater [USGBC-2]
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses [USGBC-2]
Encourages use of native or adaptive plants [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Significant costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for WE Credit 1.1 from Literature Review

Matrix Showing Attributes Identified for WE Credit 1.1:

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%

Attribute	Environ-ment	Comm-unity	Eco-nomic	Source of identification	Discussion
Limits or eliminates the use of potable water or other natural surface or subsurface water	•			[USGBC-2]	
Encourages use of captured rainwater	•			[USGBC-2]	
Encourages use of recycled wastewater	•			[USGBC-2]	
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses	•			[USGBC-2]	
Encourages use of native or adaptive plants	•			[USGBC-2], CWS, CS	
Requires careful landscape design	•			CWS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
Cost varies				Literature Review, CWS	[SWA 2004] , [FPC 2001] and CWS concluded no cost increase, [Eijadi et al. 2002] concluded significant cost
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits
Cost increase associated with required documentation varies			•	CS	One of the case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase
Cost increase associated with material purchase varies			•	CS	One of the case study projects experienced no cost increase, and the other project had high material purchase cost

Attributes related to WE Credit 1.1

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation Analysis:

The researcher found the important attributes for WE Credit 1.2 to be – does not encourage use of supplementary irrigation and encourages use of native or adaptive plants. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation [USGBC-2].

Work Session: Costs to implement this credit were seen as high, and the environmental benefits were seen as moderate by the work groups. This credit was not highly recommended for adoption by public sector owners. Workgroups questioned the cost effectiveness for a single building project, but instead favored a community wide approach. Some opportunities may exist in campus settings. Table below shows the work session responses obtained for WE Credit 1.2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
		2
	SEE WEc1.1	3
		4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Need a community/shared grey water reservoir = purple pipe. Less cost for sewage treatment facility. How to get over project size threshold to make it viable – share waste water treatment facility amongst neighbors. Tax increment finance mechanism, city capture a % of taxes and reimburse land owner over time. How to cover the upfront gap.	4
What situational		1

criteria might influence use of this credit-standard? Explain	Ability to do on-site storage of rain water usually necessary	2
		3
	Site size, amount of water collection required for little irrigation area.	4

Work Session Responses for WE Credit 1.2

Work session responses suggest the following attributes for WE Credit 1.2:

Encourages use of native or adaptive plants
High costs
Medium environmental benefits
Low health benefits

Attributes Identified for WE Credit 1.2 from Work Session

Case Studies: Case Study 1 connected with WE 1.1 and used native species, which require limited water to achieve this credit. No supplementary irrigation was required. Because of lot of shade and cool environment, water use was minimal. The respondents indicated that there were no significant cost increases associated with material purchase; construction labor; documentation and construction project management for complying with this credit. Since landscaping was done by students, there was no contracting and thus saved money for designing, planning or engineering. Case Studies 2 and 3 did not pursue this credit. Case Study 4 may achieve this credit.

The interview responses suggest the following attributes for WE Credit 1.2:

Does not encourage use of supplementary irrigation
Encourages use of native or adaptive plants
No cost increase associated with required documentation
No cost increase associated with designing, planning or engineering
No cost increase associated with construction labor
No cost increase associated with construction project management
No cost increase associated with material purchase

Attributes Identified for WE Credit 1.2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for WE Credit 1.2:

Limits or eliminates the use of potable water or other natural surface or subsurface water [USGBC-2]
Encourages use of captured rainwater [USGBC-2]
Encourages use of recycled wastewater [USGBC-2]
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses for irrigation [USGBC-2]
Encourages installing landscaping that does not require permanent irrigation systems [USGBC-2]
Does not encourage use of supplementary irrigation [USGBC-2]
Encourages use native or adaptive plants [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Minor costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]
Addresses health impacts [Mrozowski et al. 2006]

Attributes Identified for WE Credit 1.2 from Literature Review

Matrix Showing Attributes Identified for WE Credit 1.2:

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation

Attribute	Environment	Community	Economic	Source of identification	Discussion
Limits or eliminates the use of potable water or other natural surface or subsurface water	•			[USGBC-2]	
Encourages use of captured rainwater	•			[USGBC-2]	
Encourages use of recycled wastewater	•			[USGBC-2]	
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses for irrigation	•			[USGBC-2]	
Encourages installing landscaping that does not require permanent irrigation systems	•			[USGBC-2]	
Does not encourage use of supplementary irrigation	•			[USGBC-2], CS	
Encourages use of native or adaptive plants	•			[USGBC-2], CWS, CS	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] and [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded minor costs and CWS concluded high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded low health benefits

Attributes related to WE Credit 1.2

WE Credit 2: Innovative Wastewater Technologies Analysis:

The researcher found the important attributes for WE Credit 2 to be – encourages use of high-efficiency/ dry fixtures and encourages treating wastewater on-site. These attributes were identified by collaborative work session and/ or case studies and supported by the literature.

Intent of the Credit: Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge [USGBC-2].

Work Session: The work groups favored adoption of this credit by public sector owners. Option One use of water conserving fixtures was seen as relatively easy to implement and with low cost. Option 2 was viewed as having high cost. The work groups saw moderate to high environmental benefit of using this credit. Table below shows the work session responses obtained for WE Credit 2.

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
	Benefits: Reduction in water use; offsetting utility costs	2
		3
	Option 2 = high initial investment, tough to justify payback.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard.Explain		1
	Opportunity for ID credit here also	2
		3
	Development credits for option 2.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
		4

Work Session Responses for WE Credit 2

Work session responses suggest the following attributes for WE Credit 2:

Encourages use of high-efficiency/ dry fixtures
Encourages treating wastewater on-site
Low or high costs
Medium to high environmental benefits
Medium health benefits

Attributes Identified for WE Credit 2 from Work Session

Case Studies: Case Study 1 installed composting toilet and grey water systems to achieve this credit. Because of lot of shade and cool environment, water use was minimal. Respondents indicated that there were significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. They do not recommend use of this credit by governmental/ institutional owners because of the high cost associated with this credit. The other case study projects did not pursue this credit because of high cost.

The interview responses suggest the following attributes for WE Credit 2:

Encourages use of high-efficiency/ dry fixtures
Encourages treating wastewater on-site
High cost increase associated with required documentation
High cost increase associated with designing, planning or engineering
High cost increase associated with construction labor
High cost increase associated with construction project management
High cost increase associated with material purchase

Attributes Identified for WE Credit 2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for WE Credit 2:

Reduces generation of wastewater and potable water demand [USGBC-2]
Increases the local aquifer recharge [USGBC-2]
Uses high-efficiency/ dry fixtures [USGBC-2]
Encourages reuse of stormwater or graywater [USGBC-2]
Encourages treating wastewater on-site [USGBC-2]
No cost increase [FPC 2001]
Significant costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]

Attributes Identified for WE Credit 2 from Literature Review

Matrix Showing Attributes Identified for WE Credit 2:

WE Credit 2: Innovative Wastewater Technologies

Attribute	Environment	Community	Economic	Source of identification	Discussion
Reduces generation of wastewater and potable water demand	•			[USGBC-2]	
Increases the local aquifer recharge	•			[USGBC-2]	
Encourages use of high-efficiency/ dry fixtures	•		•	[USGBC-2], CWS, CS	
Encourages reuse of stormwater or graywater	•			[USGBC-2]	
Encourages treating wastewater on-site	•		•	[USGBC-2], CWS, CS	
High cost associated with required documentation			•	CS	
High cost associated with designing, planning or engineering			•	CS	
High cost associated with material purchase			•	CS	
High cost associated with construction labor			•	CS	
High cost associated with construction project management			•	CS	
Cost varies			•	Literature Review, CWS	[FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded significant costs and CWS concluded low or high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium to high environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded medium health benefits

Attributes related to WE Credit 2

WE Credit 3.1: Water Use Reduction: 20% Reduction Analysis:

The researcher found the important attribute for WE Credit 3.1 to be – encourages use of high-efficiency/ dry fixtures. This attribute was identified by collaborative work session and case studies and supported by the literature.

Intent of the Credit: Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems [USGBC-2].

Work Session: The work groups favored adoption of this credit by public sector owners. Use of water conserving fixtures was seen as relatively easy to implement and with low cost. The work groups saw moderate to high environmental benefit of using this credit. They generally saw this credit closely connected with WE Credit 2. Table below shows the work session responses obtained for WE Credit 3.1.

Question	Response	Group #
What organizational benefits / impacts do you foresee in pursuing this credit-standard?		1
		2
	Concern: Available fixtures that work – Maintenance practices - Local or regional regulation limitations	3
	Less water in = less costs – however water is still cheap. Easier to get with simple fixture choices. Need more benchmarking/research on long-term benefits to push for greater implementation.	4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
		4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	Owner vs. lease/rent – easier to an owner/occupant whereas additional cost could put it out of reach for a lease/rent situation.	4

Work Session Responses for WE Credit 3.1

Work session responses suggest the following attributes for WE Credit 3.1:

Encourages use of high-efficiency/ dry fixtures
Moderate costs
Medium environmental benefits
Medium health benefits

Attributes Identified for WE Credit 3.1 from Work Session

Case Studies: Case Study 1 installed composting toilet and grey water systems to achieve this credit. The respondents indicated that there were significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. They do not recommend use of this credit by governmental/ institutional owners because of the high cost associated with this credit. For Case Study 2, this credit has been achieved by installing waterless urinals and 0.5 gpf lavatory aerators. For Case Study 4, waterless urinals and low flow fixtures are being used to meet this credit. These are generally already used in new construction across campus.

The interview responses suggest the following attributes for WE Credit 3.1:

Encourages use of high-efficiency/ dry fixtures
High cost increase associated with required documentation
High cost increase associated with designing, planning or engineering
High cost increase associated with construction labor
High cost increase associated with construction project management
High cost increase associated with material purchase

Attributes Identified for WE Credit 3.1 from Case Studies

Literature Review:

Literature Review indicates the following attributes for WE Credit 3.1:

Maximizes water efficiency within buildings [USGBC-2]
Reduces burden on municipal water and wastewater systems [USGBC-2]
Encourages use of high-efficiency/ dry fixtures [USGBC-2]
Encourages reuse of stormwater or graywater [USGBC-2]
No cost increase [SWA 2004] and [FPC 2001]
Minor costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]

Attributes Identified for WE Credit 3.1 from Literature Review

Matrix Showing Attributes Identified for WE Credit 3.1:

WE Credit 3.1: Water Use Reduction: 20% Reduction

Attribute	Environment	Community	Economic	Source of identification	Discussion
Maximizes water efficiency within buildings	•			[USGBC-2]	
Reduces burden on municipal water and wastewater systems	•			[USGBC-2]	
Encourages use of high-efficiency/ dry fixtures	•		•	[USGBC-2], CWS, CS	
Encourages reuse of stormwater or graywater	•			[USGBC-2]	
High cost associated with required documentation			•	CS	
High cost associated with designing, planning or engineering			•	CS	
High cost associated with material purchase			•	CS	
High cost associated with construction labor			•	CS	
High cost associated with construction project mgmt			•	CS	
Cost varies	•			Literature Review, CWS	[SWA 2004] and [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded minor costs and CWS concluded moderate costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded medium health benefits

Attributes related to WE Credit 3.1

WE Credit 3.2: Water Use Reduction: 30% Reduction Analysis:

The researcher found the important attribute for WE Credit 3.2 to be – encourages use of high-efficiency/ dry fixtures. This attribute was identified by collaborative work session and case studies and supported by the literature.

Intent of the Credit: Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems [USGBC-2].

Work Session: This credit was closely associated with WE 3.1 and the workgroups did not seem to differentiate between them. Only one work group submitted the work sheet separately from WE 3.1.and its responses were similar to those for WE 3.1. No quadrant analyses were submitted. Table below shows the work session responses obtained for WE Credit 3.2

Question	Response	Group #
What organizational benefits / concerns do you foresee in pursuing this credit-standard?		1
		2
		3
		4
Design, technical and, political strategies that could be used for compliance with this credit-standard. Explain		1
		2
		3
	Tax increment.	4
What situational criteria might influence use of this credit-standard? Explain		1
		2
		3
	project size, utility cost, need to pump uphill,	4

Work Session Responses for WE Credit 3.2

Work session responses suggest the following attributes for WE Credit 3.2:

Encourages use of high-efficiency/ dry fixtures
High costs
Medium environmental benefits
Low health benefits

Attributes Identified for WE Credit 3.2 from Work Session

Case Studies: Case Study 1 installed composting toilet and grey water systems to achieve this credit. The respondents indicated that there were significant cost increases associated with designing, planning or engineering; material purchase; construction labor; documentation and construction project management for complying with this credit. They do not recommend use of this credit by governmental/ institutional owners because of the high cost associated with this credit. For Case Study 2, this credit has been achieved by installing waterless urinals and 0.5 gpf lavatory aerators. Case Study 3 did not pursue this credit and Case Study 4 may achieve this credit.

The interview responses suggest the following attributes for WE Credit 3.2:

Encourages use of high-efficiency/ dry fixtures
High cost increase associated with required documentation
High cost increase associated with designing, planning or engineering
High cost increase associated with construction labor
High cost increase associated with construction project management
High cost increase associated with material purchase

Attributes Identified for WE Credit 3.2 from Case Studies

Literature Review:

Literature Review indicates the following attributes for SS Credit 3.2:

Maximizes water efficiency within buildings [USGBC-2]
Reduces burden on municipal water and wastewater systems [USGBC-2]
Encourages use of high-efficiency/ dry fixtures [USGBC-2]
Encourages reuse of stormwater or graywater [USGBC-2]
Moderate costs [SWA 2004]
No cost increase [FPC 2001]
Significant costs [Eijadi et al. 2002]
Addresses local/ regional environmental impacts [Eijadi et al. 2002]
No health impacts [Eijadi et al. 2002]

Attributes Identified for WE Credit 3.2 from Literature Review

Matrix Showing Attributes Identified for WE Credit 3.2:

WE Credit 3.2: Water Use Reduction: 30% Reduction

Attribute	Environment	Community	Economic	Source of identification	Discussion
Maximizes water efficiency within buildings	•			[USGBC-2]	
Reduces burden on municipal water and wastewater systems	•			[USGBC-2]	
Encourages use of high-efficiency/ dry fixtures	•		•	[USGBC-2], CWS, CS	
Encourages reuse of stormwater or graywater	•			[USGBC-2]	
High cost associated with required documentation			•	CS	
High cost associated with designing, planning or engineering			•	CS	
High cost associated with material purchase			•	CS	
High cost associated with construction labor			•	CS	
High cost associated with construction project mgmt			•	CS	
Cost varies	•			Literature Review, CWS	[SWA 2004] concluded moderate costs, [FPC 2001] concluded no cost increase, [Eijadi et al. 2002] concluded significant costs and CWS concluded high costs
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded medium environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, CWS concluded low health benefits

Attributes related to WE Credit 3.2

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APPENDIX H

'Proof of Concept' Package

Introduction

This research developed a decision-making framework for aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites (SS) and Water Efficiency (WE) credits for their projects. This conceptual framework could be incorporated with a decision-support system or a software program to automate the methodology for selecting LEED credits for a project. Development of a working computer program is beyond the scope of this thesis.

The researcher identified decision-making attributes (characteristics), which influence a decision whether or not to use specific LEED SS and WE credits, through literature review, data collected at a collaborative work session of design professionals held at Michigan State University, and interviews of four case study projects, to address use of SS and WE credits of LEED. The researcher identified and presented these attributes, relevant to each credit according to their relation with the three global objectives of sustainable construction – Environment, Community and Economic. Example attributes identified for SS Credit 4.1: Alternative Transportation, Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50% are illustrated in Tables 1 and 2 of this review package.

The graphic depicting the framework for assisting institutional owners in deciding the use of specific LEED-NC 2.2 Sustainable Sites (SS) and Water Efficiency (WE) credits for their projects and its description are presented below, followed by five questions regarding aspects of the framework.

Framework

Figure 1 shows the conceptual framework developed for assisting institutional owners in deciding to select LEED SS and WE credits for their projects. The framework consists of three main inputs required from the owner. The first is '**List all SS and WE credits**', the second input is represented by the module '**Conceptual design and decision-making parameters**' and the third is '**Owner's system of values**'. Below is a description of each module used in the framework.

Process 1: List all SS and WE Credits

This is the first step in the framework. Here, the owner is required to list all the SS and WE prerequisite and credits.

Process 2: Conceptual design and decision-making parameters

The second input required from the owner consists of the conceptual design and decision-making parameters that could influence pursuing or not pursuing specific credits. The relevant parameters that describe the conceptual design are described, such as the site selected is not a brownfield site. Then the decision-making parameters are described. For instance, environmental benefits of pursuing LEED SS and WE credits could be the determining factor in deciding to pursue certain credits. The owner might want to use credits that yield high environmental benefits and have low cost of implementation. Such conceptual design and decision-making parameters are required in this module.

Process 3: Knowledge Base

'Knowledge Base' helps in eliminating the credits that are clearly infeasible for the project. For instance, if a brownfield site is not available, SS Credit 3: Brownfield Redevelopment, cannot be achieved.

Process 4: Data Base

'Data Base' is the list of attributes identified for each LEED SS and WE credit by the author in this research. These are decision-making attributes (characteristics), which influence a decision whether or not to use specific LEED SS and WE credits. Table 1 gives an illustration of the example attributes identified for SS Credit 4.1: Alternative Transportation, Public Transportation Access and Table 2 shows the example attributes identified for WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%. The source of identification of each attribute is also shown in the tables. CWS indicate attributes identified from the collaborative work session and CS indicate attributes identified from the case studies. Each attribute is presented according to its relation with the three objectives of sustainable construction – Environment, Community and Economic and the relation is represented by '•'. The highlighted portions in both the tables indicate attributes with low confidence level as seen in the 'discussion' column in both the credits.

Process 5: Credit Choice Generator

'Credit Choice Generator' with the help of Knowledge Base, Data Base and the information provided by the owner generates a list of potential credits.

For instance, in the first step all the LEED SS and WE credits are listed. In the 'Conceptual design and decision-making parameters' module, the owner states that he/ she wants to use credits that yield high environmental benefits and have low cost of implementation. The 'Credit Choice Generator' will integrate information provided by the owner, information from Knowledge Base and Data Base and generate a list of potential credits that yield high environmental benefits and have low cost of implementation. Assuming that the site selected is not a brownfield site, then SS credit 3: Brownfield Redevelopment, will be pruned from the set even though it meets the owner's requirements. The 'Credit Choice Generator' will then generate this list of potential credits: SS Prerequisite 1, SS 1, SS 2, SS 4.1, SS 4.2, SS 5.1, SS 5.2, SS 6.1, SS 6.2, SS 7.2 and WE 1.1, since all of these credits yield high environmental benefits and have low cost of implementation.

Process 6: Owner's system of values

The next step in the framework is to evaluate the potential credits such that a ranking can be developed according to the utility of the credit for a specific project. Based on 'Owner's system of values', which is the third input required from the owner, first the owner weights each attribute of sustainability according to the subjective importance or utility which that attribute holds for the owner.

Process 7: Value Extractor

The module 'Value Extractor' extracts weightings for sustainability attributes from the owner. Then, values for each of the sustainability attributes are determined for each credit from other sources such as project team, architect, engineer, landscape architect, designer, etc. and a normalized value between zero and one is calculated for each attribute value.

Process 8: Evaluate each credit

In the module 'Evaluate each credit' after weights have been established and values calculated for each attribute for a particular credit, the weights and normalized values are multiplied and summed to create an index of subjective utility for that credit.

Process 9: Amalgamator

The next step in the framework is the 'Amalgamator' module, which amalgamates the owner's weightings with the attribute values for each credit and sorts them, resulting in a relative ranking of the potential credits.

Process 10: List of selected credits

In the module 'List of selected credits' which represents the output of the entire process, the owner can review the credits recommended by the framework and select credits from the list.

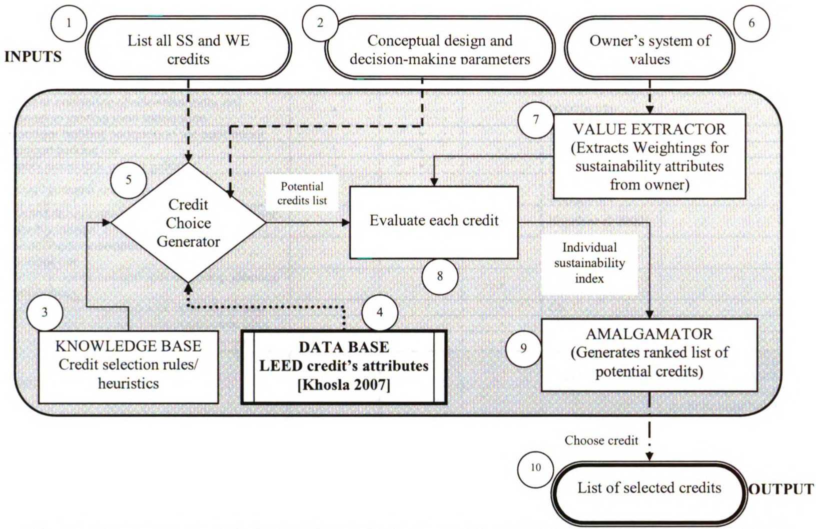

Figure 1: Framework to Assist Institutional Owners in Deciding to Select LEED SS and WE Credits for their Projects

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Source of identification	Discussion
Subject to distance of building from mass transit	•			[USGBC-2], CS	
Subject to transportation needs of building occupants		•		[USGBC-2]	
Subject to availability of public transportation system	•	•		CWS, CS	
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			[USGBC-2]	
Encourages building occupants to use mass transit		•		[USGBC-2], CWS	
Minimizes parking lots	•	•		[USGBC-2], CWS	
Reduces automobile use, air pollution	•	•		[USGBC-2], CWS	
No cost / potential cost decrease			•	[SWA 2004], [FPC 2001], CWS	
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	[Eijadi et al. 2002]	
No cost increase associated with required documentation			•	CS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with material purchase			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with const proj. mgmt.			•	CS	
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded global environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		Literature Review, CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded high health benefits

Table 1: Attributes related to SS Credit 4.1

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%

Attribute	Environ-ment	Comm-unity	Econ-omic	Source of identification	Discussion
Limits or eliminates the use of potable water or other natural surface or subsurface water	•			[USGBC-2]	
Encourages use of captured rainwater	•			[USGBC-2]	
Encourages use of recycled wastewater	•			[USGBC-2]	
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses	•			[USGBC-2]	
Encourages use of native or adaptive plants	•			[USGBC-2], CWS, CS	
Requires careful landscape design	•			CWS	
No cost increase associated with designing, planning or engineering			•	CS	
No cost increase associated with construction labor			•	CS	
No cost increase associated with construction project management			•	CS	
Cost varies			•	Literature Review, CWS	[SWA 2004] , [FPC 2001] and CWS concluded no cost increase, [Eijadi et al. 2002] concluded significant cost
Addresses environmental impacts	•			[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded local/ regional environmental impacts, CWS concluded high environmental benefits
Health impact varies		•		[Eijadi et al. 2002], CWS	[Eijadi et al. 2002] concluded no health impacts, [Mrozowski et al. 2006] concluded health impacts, CWS concluded medium health benefits
Cost increase associated with required documentation varies			•	CS	One of the case study projects had no cost increase associated with required documentation whereas one case study project had minor cost increase
Cost increase associated with material purchase varies			•	CS	One of the case study projects experienced no cost increase, and the other project had high material purchase cost

Table 2: Attributes related to WE Credit 1.1

Questions regarding aspects of the framework

1. When considering the introduction, the framework graphic and the narrative description of each step, how well do you feel you understand the intent, structure and the intended use of the framework?

    a. Do you need any additional discussion / background?

Response:

2. How useful is the framework in aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites and Water Efficiency credits for their projects. Explain.

Response:

3. Are there additional steps or processes, which you can suggest as key in deciding to use Sustainable Sites and Water Efficiency credits. Explain.

Response:

4. When considering SS Credit 4.1: Alternative Transportation: Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%, are the attributes identified by the research comprehensive or are there other important attributes you would suggest or are there some indicated which should be deleted.

Response:

5. Do you have any additional suggestions about the content and form of the framework?

Response:

Proof of Concept Responses			
No.	**Questions**	**Owner 1**	**Owner 2**
1)	When considering the introduction, the framework graphic and the narrative description of each step, how well do you feel you understand the intent, structure and the intended use of the framework? a. Do you need any additional discussion / background?	I understand it well. The flowchart is a good approximation of the decision-process that our building planning committee used in our deliberations.	The framework, introduction and the description looked good. The Credit Choice Generator, Value Extractor, Evaluate Each Credit, Amalgamator is the gut of the framework where you decide whether or not you are going for the credit. But owners system of values may differ since weighted values come from a variety of sources. There are varieties of folks in MSU – Department of Police and Safety may have different views for assigning weights to attributes of a certain credit than the Department of Grounds Maintenance.
2)	How useful is the framework in aiding institutional owners as they consider use of specific LEED-NC 2.2 Sustainable Sites and Water Efficiency credits for their projects. Explain.	It's very useful.	This framework formalizes the process, which some folks may need. We worked the same way without the framework and got input from everybody. It's a good framework to decide whether or not to pursue certain credits.
3)	Are there additional steps or processes, which you can suggest as key in deciding to use Sustainable Sites and Water Efficiency credits. Explain.	No, I don't think so.	No. You have explained the framework very well.
4)	When considering SS Credit 4.1: Alternative Transportation: Public Transportation Access and WE Credit 1.1: Water Efficient Landscaping, Reduce by 50%, are the attributes identified by the research comprehensive or are there other important attributes you would suggest or are there some indicated which should be deleted.	Being an educational institution, we had an additional "value" attribute for outreach and community education for the water efficient landscaping because we believed that the gardens around the Bunker Interpretive Center would serve as demonstration gardens in addition to their role in water conservation.	Attributes are covered fairly well. I do not think any important attributes are missed out.
5)	Do you have any additional suggestions about the content and form of the framework?	No. Thank you for the chance to participate in the original research and in the validation of the conceptual framework.	It is a good framework to choose which credits to pursue or not.

APPENDIX I

Demonstrative Case Study Attribute Weightings

SS Prerequisite 1: Construction Activity Pollution Prevention

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Reduces pollution from construction activities	•	•		7	0.75	5.25
Prevents loss of topsoil during construction	•			5	0.5	2.5
Prevents sedimentation of storm waters or receiving streams	•			5	0.5	2.5
Prevents air pollution	•	•		7	0.75	5.25
Requires designer to evaluate EPA stds v/s local codes	•			5	0.5	2.5
No cost / potential cost decrease			•	7	0.75	5.25
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	7	0.75	5.25
Benefits the host community and project neighbors	•	•		7	0.75	5.25
Reduces site exposure over the duration of the project	•			5	0.5	2.5
Requires high maintenance of implemented system during construction	•		•	3	0.25	0.75
Requires effective monitoring of the site activity	•		•	3	0.25	0.75
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction project management			•	7	0.75	5.25
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		5	0.5	2.5
Cost associated with required documentation varies			•	5	0.5	2.5
Sustainability Index for SS Prerequisite 1 =						**69.0**
Demonstrative Case Study: Average Sustainability Index for SS Prerequisite 1 =						**69.0/18 = 3.83**

SS Credit 1: Site Selection

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Avoids development of inappropriate sites	•	•		7	0.75	5.25
Reduces environmental impact from the location of a building on a site	•			5	0.5	2.5
Subject to site availability	•			3	0.25	0.75
Requires designers to determine zoning requirements of local community & the community master plan; Reduces sprawl	•	•		7	0.75	5.25
Minimizes disruption of the environmentally sensitive areas	•			5	0.5	2.5
Encourages designers to incorporate site features into the design	•			3	0.25	0.75
Limits development footprint	•			5	0.5	2.5
Achieved through standard practice (increased design effort but minimal construction first costs)			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering; material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with const. proj. mgmt.			•	7	0.75	5.25
No cost / Potential cost decrease			•	7	0.75	5.25
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		5	0.5	2.5
Cost associated with required documentation varies			•	5	0.5	2.5
Sustainability Index for SS Credit 1 =						**56.0**
Demonstrative Case Study: Average Sustainability Index for SS Credit 1 =						**56.0/15 = 3.73**

SS Credit 2: Development Density & Community Connectivity

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Channels development to urban areas with existing infrastructure	•			5	0.5	2.5
Protects greenfields and preserves habitat and natural resources	•			5	0.5	2.5
Subject to availability of previously developed site	•			3	0.25	0.75
Increases density of community; Reduces sprawl	•	•		7	0.75	5.25
Subject to distance of site from residential zone or neighborhood	•			3	0.25	0.75
Subject to distance of site from basic services	•			3	0.25	0.75
Subject to availability of pedestrian access between the building and services	•			3	0.25	0.75
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	7	0.75	5.25
Decreases land use	•	•		7	0.75	5.25
Encourages walking and bicycling		•		7	0.75	5.25
Easier to meet in community settings where property lines help define density	•	•		7	0.75	5.25
Reduces unnecessary extension of infrastructure	•		•	7	0.75	5.25
Minimizes auto demand; Keeps development compact	•	•		7	0.75	5.25
Supports urban redevelopment and mixed use	•	•		7	0.75	5.25
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 2 =						**63.0**
Demonstrative Case Study: Average Sustainability Index for SS Credit 2 =						**63.0/17 = 3.71**

SS Credit 4.1: Alternative Transportation: Public Transportation Access

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Subject to distance of building from mass transit	•			3	0.25	0.75
Subject to transportation needs of building occupants		•		3	0.25	0.75
Subject to availability of public transportation system	•	•		3	0.25	0.75
Subject to availability of sidewalks, paths and walkways to existing mass transit stops	•			3	0.25	0.75
Encourages building occupants to use mass transit		•		3	0.25	0.75
Minimizes parking lots	•	•		7	0.75	5.25
Reduces automobile use, air pollution	•	•		7	0.75	5.25
No cost / potential cost decrease			•	7	0.75	5.25
Achieved through standard practice (increased design efforts but minimal construction first costs)			•	7	0.75	5.25
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with const proj. mgmt.			•	7	0.75	5.25
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 4.1 =						**61.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 4.1 =						**61.5/16 = 3.84**

SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Subject to space available for shower facilities			•	3	0.25	0.75
Provides secure bicycle storage areas for cyclists		•		3	0.25	0.75
Reduces automobile use, air pollution	•	•	•	7	0.75	5.25
Minimizes parking lots	•	•	•	7	0.75	5.25
Reduces noise pollution		•		3	0.25	0.75
High financial costs (square footage and plumbing)			•	3	0.25	0.75
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 4.2 =						**26.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 4.2 =						**26.5/9 = 2.94**

SS Credit 4.4: Alternative Transportation: Parking Capacity

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Minimizes parking lot/ garage size	•	•	•	7	0.75	5.25
Provides parking space for carpools or vanpools	•	•		5	0.5	2.5
Subject to location of project site	•			3	0.25	0.75
Subject to number of cars likely to drive to the site	•	•		3	0.25	0.75
Encourages use of public transportation	•	•		7	0.75	5.25
Reduces amount of impervious surface and stormwater runoff	•			5	0.5	2.5
Low costs			•	7	0.75	5.25
Reduces air pollution	•	•		7	0.75	5.25
Makes community more amenable for walking		•		5	0.5	2.5
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with const proj. management			•	7	0.75	5.25
Addresses environmental impacts	•			5	0.5	2.5
Health impact varies		•		3	0.25	0.75
Sustainability Index for SS Credit 4.4 =						**59.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 4.4 =						**59.5/16 = 3.72**

SS Credit 5.1: Site Development: Protect or Restore Habitat

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Conserves existing natural areas and restores damaged areas	•			5	0.5	2.5
Limits construction on greenfield site or previously developed site	•			5	0.5	2.5
Reduces building footprint	•			5	0.5	2.5
Maintains existing natural ecosystem	•			5	0.5	2.5
Reduces infrastructure construction	•		•	7	0.75	5.25
Requires effective implementation of landscape management	•			3	0.25	0.75
Enhances water quality	•	•		7	0.75	5.25
Provides better visual impact		•		3	0.25	0.75
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with const proj mgmt			•	7	0.75	5.25
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impacts varies		•		5	0.5	2.5
Sustainability Index for SS Credit 5.1 =						**58.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 5.1 =						**58.5/16 = 3.66**

SS Credit 5.2: Site Development: Maximize Open Space

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Reduces development footprint	•			5	0.5	2.5
Provides vegetated open space	•			5	0.5	2.5
Minimizes site disruption	•			5	0.5	2.5
Increases amount of daylighting		•		5	0.5	2.5
Reduces heat island effects	•	•		7	0.75	5.25
Promotes sprawl	•	•		7	0.75	5.25
Increases water infiltration	•			5	0.5	2.5
Provides better visual impact		•		3	0.25	0.75
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engg			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction project mgmt			•	7	0.75	5.25
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		5	0.5	2.5
Sustainability Index for SS Credit 5.2 =						**60.25**
Demonstrative Case Study: Average Sustainability Index for SS Credit 5.2 =						**60.25/16 = 3.77**

SS Credit 6.1: Stormwater Design: Quantity Control

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Limits disruption of natural hydrology	•			5	0.5	2.5
Increases on-site infiltration	•			5	0.5	2.5
Minimizes impervious surfaces	•			5	0.5	2.5
Decrease in the volume of stormwater runoff	•			5	0.5	2.5
Requires careful design and maintenance of system	•			5	0.5	2.5
High equipment purchase cost			•	3	0.25	0.75
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		5	0.5	2.5
Sustainability Index for SS Credit 6.1 =						**23.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 6.1 =						**23.5/9 = 2.61**

SS Credit 6.2: Stormwater Design: Quality Control

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Reduces or eliminates water pollution	•	•		7	0.75	5.25
Minimizes impervious surfaces, Increases on-site infiltration	•			5	0.5	2.5
Eliminates sources of contaminants, Decrease stormwater runoff	•			7	0.75	5.25
Removes pollutants from stormwater runoff	•			5	0.5	2.5
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engg			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction proj. management			•	7	0.75	5.25
High equipment purchase cost			•	3	0.25	0.75
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 6.2 =						**55.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 6.2 =						**55.5/13 = 4.27**

SS Credit 7.2: Heat Island Effect: Roof

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Reduces heat islands	•			5	0.5	2.5
Minimizes impact on microclimate & human & wildlife habitat	•	•		7	0.75	5.25
Green roofs provide insulating benefits, aesthetic appeal and lower maintenance than standard roofs	•	•	•	3	0.25	0.75
Garden roofs reduce stormwater volumes	•			3	0.25	0.75
Minor cost increase associated with required documentation			•	5	0.5	2.5
No cost increase associated with designing, planning or engg			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction proj. management			•	7	0.75	5.25
High cost for installing green roof			•	3	0.25	0.75
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		7	0.75	5.25
Sustainability Index for SS Credit 7.2 =						**46.5**
Demonstrative Case Study: Average Sustainability Index for SS Credit 7.2 =						**46.5/13 = 3.57**

SS Credit 8: Light Pollution Reduction

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Minimizes light trespass from the building and site	•	•		7	0.75	5.25
Reduces sky-glow to increase night sky access	•	•		7	0.75	5.25
Improves night time visibility through glare reduction	•	•		7	0.75	5.25
Reduces development impact on nocturnal environments	•	•		7	0.75	5.25
No cost / potential cost decrease			•	7	0.75	5.25
Some concern about public safety in campus settings		•		5	0.5	2.5
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engg			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction project mgmt			•	7	0.75	5.25
Addresses environmental impacts	•			5	0.5	2.5
Health impact varies		•		3	0.25	0.75
Sustainability Index for SS Credit 8 =						**58.25**
Demonstrative Case Study: Average Sustainability Index for SS Credit 8 =						**58.25/13 = 4.48**

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Limits or eliminates the use of potable water or other natural surface or subsurface water	•			5	0.5	2.5
Encourages use of captured rainwater	•			5	0.5	2.5
Encourages use of recycled wastewater	•			5	0.5	2.5
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses	•			5	0.5	2.5
Encourages use of native or adaptive plants	•			5	0.5	2.5
Requires careful landscape design	•			3	0.25	0.75
No cost increase associated with designing, planning or engg			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction proj. management			•	7	0.75	5.25
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			7	0.75	5.25
Health impact varies		•		5	0.5	2.5
Cost increase associated with required documentation varies			•	5	0.5	2.5
Cost increase associated with material purchase varies			•	5	0.5	2.5
Sustainability Index for WE Credit 1.1 =						**44.25**
Demonstrative Case Study: Average Sustainability Index for WE Credit 1.1 =						**44.25/14 = 3.16**

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Limits or eliminates the use of potable water or other natural surface or subsurface water	•			5	0.5	2.5
Encourages use of captured rainwater	•			5	0.5	2.5
Encourages use of recycled wastewater	•			5	0.5	2.5
Encourages use of water treated and conveyed by a public agency specifically for non-potable uses for irrigation	•			5	0.5	2.5
Encourages installing landscaping that does not require permanent irrigation systems	•			5	0.5	2.5
Does not encourage use of supplementary irrigation	•			5	0.5	2.5
Encourages use of native or adaptive plants	•			5	0.5	2.5
No cost increase associated with required documentation			•	7	0.75	5.25
No cost increase associated with designing, planning or engineering			•	7	0.75	5.25
No cost increase associated with material purchase			•	7	0.75	5.25
No cost increase associated with construction labor			•	7	0.75	5.25
No cost increase associated with construction project management			•	7	0.75	5.25
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			5	0.5	2.5
Health impact varies		•		3	0.25	0.75
Sustainability Index for WE Credit 1.2 =						**49.5**
Demonstrative Case Study: Average Sustainability Index for WE Credit 1.2 =						**49.5/15 = 3.30**

WE Credit 2: Innovative Wastewater Technologies

Attribute	Environment	Community	Economic	Weights	Value	Weights x Value
Reduces generation of wastewater and potable water demand	•			5	0.5	2.5
Increases the local aquifer recharge	•			5	0.5	2.5
Encourages use of high-efficiency/ dry fixtures	•		•	5	0.5	2.5
Encourages reuse of stormwater or graywater	•			5	0.5	2.5
Encourages treating wastewater on-site	•		•	5	0.5	2.5
High cost associated with required documentation			•	3	0.25	0.75
High cost associated with designing, planning or engineering			•	3	0.25	0.75
High cost associated with material purchase			•	3	0.25	0.75
High cost associated with construction labor			•	3	0.25	0.75
High cost associated with construction project management			•	3	0.25	0.75
Cost varies			•	5	0.5	2.5
Addresses environmental impacts	•			5	0.5	2.5
Health impact varies		•		5	0.5	2.5
Sustainability Index for WE Credit 2 =						**23.75**
Demonstrative Case Study: Average Sustainability Index for WE Credit 2 =						**23.75/13 = 1.83**

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