TURNING A CORNER: Kansas State University Seeks to Meaningfully Address Green Building and the Sustainable Use of Energy and Resources on Campus and in the Broader Community

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INTRODUCTION

Kansas State University (KSU) is a land-grant institution, with nine colleges and 23,000 students. The 668-acre main campus is located within the City of Manhattan, Kansas, which has a population of approximately 45,000. Through a bottom-up process the university has been seeking to integrate sustainability in student life, curriculum, operations, research, and engagement.

KEYWORDS

college sustainability, collaborative design, energy efficiency, stormwater management, solar power, green roofs, material re-use

OVERVIEW OF K-STATE'S EFFORTS TOWARD SUSTAINABILITY

KSU's effort to enhance sustainability started in the university's Facilities Planning Department and was achieved primarily through an advisory committee on campus planning, its stewardship subcommittee, and a consortium of faculty and other partners. The effort now underway to integrate sustainability into all facets of the university began with the 2004 adoption of the fifth major Campus Master Plan in the university's 145-year history.

The guiding principles of the master planning process were: 1) reflect the mission of Kansas State University in the physical environment, 2) design for a pedestrian-oriented campus, 3) create positive linkages to the community, 4) account for the long-term impact of planning decisions, and 5) respect the natural systems of the campus fabric. Throughout the process of developing the master plan, environmental impacts and sustainability were considered to be significant issues. The master plan included general guidance to frame decision making processes for open space, buildings, circulation/parking, and infrastructure.

Early in 2007 KSU's Campus Planning and Development Advisory Committee (CPDA) established a Stewardship Subcommittee with a four-part charge. First, propose strategies, principles, or guidelines for environmental stewardship to be included in the KSU Campus Master Plan. Second, suggest methods to educate the campus to be stewards of the environment—for example, methods to improve existing buildings within the context of sustainability, methods to understand and utilize lifecycle cost analysis when developing program statements for potential capital improvements, and methods

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to determine potential ways to fund stewardship activities. Third, propose the inclusion of the preservation and historical presence in the principles of stewardship. Fourth, suggest a framework for organizing interested parties across campus to promote stewardship.

KSU's Stewardship Subcommittee

The Stewardship Subcommittee is composed of university faculty and staff with a wide range of perspectives. The subcommittee began articulating the key areas of concern as curriculum, operations, research, and engagement. The subcommittee's first accomplishments were to: 1) identify opportunities presented by using best practices to create sustainable buildings when new buildings were to be constructed; 2) help preserve existing historic buildings while making them more efficient; and 3) implement several service-learning projects that set an example for the university in creating energy and environmentally conserving landscapes and structures.

The potential to build new buildings to meet LEED standards was documented in a white paper entitled "Green Building Guidelines and LEED Attainment."

Recommendations presented in the Stewardship Subcommittee's "Green Building" white paper include:

1. KSU should be a sustainability leader in terms of our peer institutions.
2a. Adopt the USGBC's LEED Green Building rating system as the general structure and framework for documenting the achievement of green buildings.
2b. Establish LEED basic certification equivalence as a project goal for all new construction. LEED equivalence should be written into all RFPs (the basis of contracts with Architecture, Engineering, Landscape Architecture, and Landscape Design/Horticulture firms).
2c. Publish project management and budgeting guidelines for design and construction to ensure successful, cost effective LEED and/or sustainable sites equivalence.
3. Identify legitimate, high payback green features for each project. Establish a project management and budgeting process that ensures early consideration and visibility for cost-effective green features and resists sacrificing green features in order to cover project costs overruns.
4. Ensure that the KSU Comptroller is on board with cost-effective green building.
5. Ensure informed decisions by undertaking LCCA/NPV (net present value) analysis for all green features and comparing costs and benefits to other competing uses for project funds.
6. Move toward a carbon-neutral campus by assessing where KSU can reduce its carbon footprint and determine the best ways to save energy, water and other resources. Where carbon reductions are not possible to achieve a carbon-neutral campus purchase renewable energy credits.

The potential of preserving existing buildings and adapting them to be more energy and water efficient was also documented. Preservation is an important aspect of implementing sustainability initiatives for KSU's main campus because a high percentage of buildings in use today are older and historic buildings. Seventy-two percent of the gross square footage of main campus buildings was built before 1960, and fifty-five percent of the gross square footage was built before 1940 (KBOR 2007, p. 3).

During the spring of 2008, the Stewardship Subcommittee identified potential ways to administer a comprehensive approach to sustainability within the university, building upon earlier efforts to promote sustainability at KSU (KSU 2006; 2007a; 2007b; and 2008a). The subcommittee recommended hiring or appointing an individual to an administrative position who would report directly to the president or one of the vice-presidents of the university. A director of sustainability was subsequently appointed and the director's charge was defined (KSU 2008b).

As noted in a May 12, 2008 KSU news release, the university has multiple initiatives underway to encourage the campus to become more sustainable in terms of its use of energy, water, and other resources. KSU administrators, recognizing the need for university-wide leadership of these initiatives, tasked the new director of sustainability with developing a university-wide approach for addressing sustainability at KSU. Since that time, the director has provided leadership and oversight to existing initiatives such as campus recycling and composting, design and construction of green buildings on campus, multi-modal campus and community transportation needs, and campus energy conservation and renewable energy efforts. In addition, working with other faculty and staff at KSU, the director encourages interdisciplinary research and sharing of ideas and accomplishments along with service-learning work that engages the broader community in regard to sustainability. The Consortium for Environmental Stewardship and Sustainability has been an important player in encouraging such efforts.

Consortium for Environmental Stewardship and Sustainability (CESAS)

CESAS is a network of partner organizations choosing to work collaboratively to advance sustainability and sustainable development. The Consortium brings together cooperative groups focused on sustainability that integrate and connect multidisciplinary research and education efforts in the areas of science, engineering, economics, and social science. KSU Chemistry Professor Larry Erickson is the primary coordinator for CESAS. Partners include units of academic institutions in Kansas, Thailand, and the Russian Federation, industry, units of government, and other organizations.

Since sustainable development requires appropriate consideration of both present and future needs, the foundation is the concept of a "Triple Bottom Line" where economic, social, and environmental values are all vital to decision making. While integrating the social and economic research is crucial, sustainability begins with science.

The primary target areas for CESAS research include: 1) Renewable Energy (e.g., solar, wind, biofuels); 2) Water (e.g., quality, resources, usage); 3) Materials, Products, Process Design (e.g., green chemistry, architecture, design); 4) Land Management (e.g., erosion, urban sprawl, protection); 5) Agriculture (e.g., crops, animal production, environmental management); and 6) Development of Policy (e.g., water, wind energy, triple bottom line metrics).

Primary objectives of CESAS include:

- Encourage scientific, social, and policy research in sustainability.
- Educate students and the public in environmental stewardship and sustainability.
- Provide a forum and administrative structure for dialogue and multidisciplinary efforts to work cooperatively to advance sustainability efforts.
- Promote communication, outreach, and service between the academic community and other stakeholders (business, government, social groups, and citizens) to enable efficient progress toward the development of a sustainable society.
- Introduce new curricula in environmental conservation and sustainability policy, planning/design, implementation, and evaluation. Develop new sustainability courses and seminars.
- Develop frameworks for assessing triple bottom-line implications in sustainable development.

CESAS-supported activities include the development of a Targeted Excellence proposal for an integrated research and outreach program in "Rural Systems Sustainability," development of an annual "Dialogue on Sustainability" (held each summer at KSU), an "International Dialogue on Civic Discourse Sustainability" (held in the Russian Federation in August 2007), a January 2008 Intersession course on Renewable Energy, Food, and Sustainability, an EPA-supported workshop on Brownfield Redevelopment (held on September 9–11, 2008 at KSU's Manhattan campus), and various seminars, distance education courses, and a reading club (http://www-proxy.engg.ksu.edu/chsr/sustainability/).

Working closely with the director of sustainability KSU, CESAS, university administrators, and continuing education conference planners have hosted two well-attended sustainability conferences at KSU (the first held in January 2009, the second in January 2010, with a third planned for March 2011). These conferences have brought together representatives from education and the private sector to discuss sustainability needs, opportunities, strategies, and projects in the region and state.

In addition to CESAS-supported activities, it is important to note two water- and energy-related research and outreach centers and recent energy efficiency action items occurring on the KSU campus. In regard to green building design and construction, the School of Leadership Studies Building was recently dedicated on campus and is described in some detail below.

Kansas Center for Agricultural Resources and the Environment

The Kansas Center for Agricultural Resources and the Environment (KCARE) was established to coordinate and enhance research, extension, and teaching activities pertaining to environmental issues related to agriculture. Areas of emphasis include air and water quality, soil and water conservation, waste management, and sustainable agriculture.

Faculty from many KSU departments and colleges contribute to efforts to protect air and water quality, improve soil and stormwater management, minimize and reuse materials previously considered to be "waste," and increase conservation of energy and water in both rural and urban landscapes.

Kansas State University's Center for Sustainable Energy

The Center for Sustainable Energy began to take shape in 2007 after receiving a $750,000 Targeted Excellence grant from KSU's Provost's Office. The center was established in an attempt to bring together all renewable and sustainable energy related research activities at the university. The center has three primary goals: to research and develop sustainable energy systems and lower greenhouse gas emissions; to educate those on and off campus about sustainable energy; and to facilitate the adoption of new technology by industrial users. It is expected that the Center for Sustainable Energy will improve collaborative research efforts across departments, ensuring that KSU efficiently uses its resources to help solve energy issues. As described in an October 2007 news release, center activities have initially focused on the conversion of biomass to biofuels and related products. "Center researchers also are looking at new plants for fuel and the most sustainable way to manage crops. Part of that research has to do with water and the amount of carbon and other nutrients retained in the soil" (KSU 2007b).

Basic and applied research, education, and a range of outreach activities continue to be important components of the Center for Sustainable Energy, with more than 30 faculty from across campus involved, including the colleges of Agriculture, Arts and Sciences, and Engineering (KSU 2010a).

Improved Energy Efficiency at KSU: Investing in Campus Infrastructure

Along with its commitment to a sustainability officer, K-State has made energy efficiency a major focus of both its sustainability and budget management efforts. With typical annual utility expenditures around $15 million and, as noted previously, an aging campus, there are very significant potential savings from energy efficiency on the KSU campus. Managing campus in a time of serious budget cuts has renewed a focus on reducing utility expenditures by the administration, while acknowledging the benefits in terms of reduced environmental impact. Shortly after creating the new director of sustainability position, the university entered into conversations with multiple energy service companies to investigate its energy efficiency options. These included both an energy service contracting organization (ESCO) and a consulting company specializing in development of campus behavior-based energy efficiency programs. The conversations have led to significant energy efficiency investments.

The ESCO efforts entail a two-phase performance contracting relationship with Johnson Controls. As with a typical energy performance contract, investments through these contracts must pay for themselves with energy savings over a reasonable period of time. However, other factors were also important in selecting the major focus areas for the projects. In this way, the utility budget has been leveraged through performance contracting in order to fund infrastructure improvements with substantial justifications other than energy savings that would not have otherwise been funded. This is an important motivating factor for university administrators in entering into the contracts.

Lighting was a major priority for the Phase I Johnson Control contract. Existing external campus sidewalk lighting was not only energy intensive, but the lighting systems had become obsolete and replacement parts were no longer readily available. Faced with the need to continue a uniform campus aesthetic, but with no funding to replace all sidewalk lighting, an ESCO performance contract was an excellent opportunity. This led to examination of the entire campus external lighting arena, and identification of retrofits with $61,000 in projected annual savings, almost one percent of campus electricity consumption (KSU 2010b).

Water was the other major priority for Phase I. Water rates from City of Manhattan water services have increased substantially in recent years due to city infrastructure investments, putting pressure on an already strained utilities budget. The Phase I contract involves drilling wells on campus to source non-potable water for use in the central power plant (steam, chilled water) as well as for irrigation throughout campus. This represents a majority of water use on campus, and will represent very significant savings to the university.

The Phase II contract has recently been signed and will be implemented in the first half of 2011. The major priorities associated with Phase II include upgrades to central power plant chillers as well as comprehensive replacement of fume hoods with energy efficient models. Both of these priorities are motivated by concerns in addition to energy savings. The power plant chillers are quite old and have become unreliable. Failure of one or more during peak cooling demand in the heat of summer could very significantly damage other infrastructure, and negatively impact university activities. Their replacement is a matter of preventing these dire consequences as much as energy savings. Similarly, the fume-hood ducts in the campus chemistry building have significant leaks, a major safety concern. Replacing fume-hoods in this building will allow for replacement of this damaged ducting as well, an expense that would be much more difficult to bear without bundling with an ESCO project.

Improved Energy Efficiency at KSU—Managing Infrastructure and Behavior-based Savings

The other line of effort related to energy efficiency in the past two years has been in terms of improved management of existing infrastructure and encouraging responsible behavior by campus users.

KSU was approached in late 2008 by an energy services company that focuses on creating behavior-based energy conservation programs for campuses. KSU officials offered an RFP for services of this kind and then entered into negotiations with this firm. Through research during the negotiating process by campus facilities personnel and the director of sustainability, it was concluded that it would be preferable to invest in internal capacity to address behavior-based change and efficient management of campus infrastructure rather than outsource these services.

The director of sustainability and associate vice president of facilities then partnered to create a new job position titled “director of energy and environment.” This position is a new director-level position under the associate vice president and is charged with “developing a university-wide approach for energy conservation” through “building control enhancements” as well as “behavioral- and technological-based energy conservation” (KSU 2010c). The search process for this position opened in January of 2010 and was filled in July of 2010. The new director of energy and environment was formerly one of the primary Johnson Controls engineers involved in KSU campus energy audits and development of Phase I and II performance contracts. As a result, this individual was intimately familiar with campus infrastructure upon his hiring. In addition, KSU has recently hired an energy manager with specialized knowledge in building controls to complement the skills of the director of energy and environment.

Initial efforts of this small but growing team are to install building-level metering in significant portions of campus as well as a sophisticated central control room for monitoring, analyzing, and managing campus utility systems. This team has partnered with the director of sustainability to develop an energy efficiency competition with KSU rival—the University of Kansas—in the second round of the nationally recognized Kansas Take Charge Challenge (New York Times 2010). The competition begins on January 1, 2011 and ends on September 30, 2011. Together, the energy manager and director of sustainability will lead a team of undergraduate interns in the development of an educational and promotional campaign to support this competition and address the larger goal of achieving behavior-based energy savings on campus. Dr. Noel Shulz, wife of KSU President Dr. Kirk Shulz and Paslay professor of electrical and computer engineering, is co-chair of this competition. The president and first lady will be key assets in encouraging the campus community toward energy efficient behavior.

As revealed above, KSU has taken great strides in proactively addressing energy efficiency on campus in the past two years. These efforts have only just begun, but they are already bearing fruit.

School of Leadership Studies Green Building Design and Construction

The KSU School of Leadership Studies* dedicated a new Center for Leadership Studies in April 2010 (see note 1). The building was designed with the expectation of LEED certification at the silver level* (see note 2). The building is two stories tall with a total of 36,000 square feet of classrooms, offices, meeting spaces, faculty and staff support spaces, and a small café. The building design took advantage of multiple green design approaches including material selections, indoor air quality, and daylighting. However, there are three exemplary areas of sustainable design described herein: site design, energy and water efficiency, and construction waste diversion.

Sustainable Sites

The building site, formerly a parking lot, was selected because it was in the campus core and provided the opportunity to increase density while maintaining an excellent relationship with the natural features of a creek and open space to the north and east of the site. Fifty-nine percent of the site was preserved for open and/or vegetated space, and this resulted in a more pervious site than the parking lot. As a result of site design strategies there is expected to be a 27 percent reduction in the rate and 32 percent reduction in the quantity of stormwater flowing into nearby waterways.

Despite the good intentions and meaningful attempt to relate the building to the stream (a second-floor patio looks out upon Campus Creek, and an outdoor amphitheater also provides visual connections to the riparian corridor), a small cluster of 45–55-foot tall chinkapin oak (*Quercus muehlenbergii*) were removed at the northeast corner of the site. This was unfortunate since these trees can live for 150–200 years, and prior to their removal, offered cooling shade, interconnected root systems, aesthetic beauty, and a connection to other native plants in the Flint Hills Ecoregion; however, new trees were added for no net loss in the total number of trees on the site, post-construction (see note 3).

Energy and Water Efficiency

Energy and water efficiency were two areas of significant accomplishment in the design and construction of the building. The energy use is expected to be 37 percent less, and water use is expected to be 45 percent less than baseline codes. Lighting was designed to include monitoring sensors and to allow multiple levels of control by occupants.

The campus uses a central system for steam and chilled water, but it was determined that changes would need to be made to that system (particularly in the type of refrigerant used in the chillers) if LEED Certification was to be achieved. Funding for major changes to the central system was not available so the design team chose to use a separate HVAC system in the Leadership Studies Building. All occupied spaces are served by DX/electric cooled variable air volume (VAV) rooftop air handling units with electric generated humidity and a natural gas-fired heat exchanger. Each building level is served by a dedicated rooftop unit. Interior HVAC zones are served with pinch-off VAV boxes and exterior zones are served with fan-powered VAV boxes with electric re-heat coils.

Construction Waste Minimization and Diversion

Close management of construction activities resulted in achieving diversion of more than 95 percent of the construction waste from landfills. Such efforts have the potential to help reduce the consumption of energy and water both directly and indirectly. Per the U.S. Green Building Council, recycling of construction and demolition debris reduces the demand for virgin resources and, in turn, reduces environmental impacts from resource extraction, processing, and transportation. Thus, the benefits of waste diversion at the project site include reducing both material waste and land and water pollution.

Sustainability Strategies Related to the Design Process

The key strategies for sustainability were established by kicking off the project with an "eco-charrette."

*On December 14, 2010, the USGBC notified the project team that the KSU School of Leadership Studies has achieved LEED Gold certification.

Left: Leadership Studies Building at night showing its relationship to adjacent streets and the Campus Creek corridor. Right: Leadership Studies Building interior: entry court/foyer. (Photos courtesy of Opus.)

The charrette brought a broad range of team members together to evaluate potential strategies, weigh in on associated costs, and discuss other impacts. Led by the Opus design-build team, charrette participants included KSU facilities and maintenance staff; KSU faculty members, administrators, and students; civil, mechanical, and electrical engineers; and architecture and landscape architecture professionals. From this wide group it was possible to weigh the costs and benefits of each sustainability category and thus establish priorities. The result was an initial LEED checklist of objectives to meet the desired rating level and a clear sense about how to move forward on the design.

The authors perceive that the inclusivity created by both the design/build process and the programming and design participants had a positive impact on the design quality and on user satisfaction with the completed building. This building is an example of the tremendous potential of green design as a model for campus construction. The School of Leadership Studies was able to serve as a positive example of how well-designed and sustainable buildings can enhance and inform the campus community.

Challenges and Lessons Learned

One lesson learned was that the act of documenting various aspects of the construction process increased the project team's awareness of taking proper measures to insure a successful outcome. For example, insuring indoor air quality during construction requires close watch over the shipping, receiving, storing, and installation of HVAC equipment and ductwork to make sure that construction dust does not contaminate these items. Routine photography of items arriving and being stored at the site raised awareness and cooperation amongst the work crew of the need to minimize and control dust.

Opus and KSU initially believed that the credit toward "Heat Island Effect—Roofs" could be achieved; however, not enough surface area could be reflective to earn the credit if the roof design were to meet the university's standard criteria. Campus standards for shingled roofs required a manufacturer that did not comply with the solar reflectance criteria needed. This was an area where an aesthetic tradition took precedence over this particular LEED credit. The project team appreciated the campus' challenges with stocking replacement shingle inventory and maintaining a consistent appearance across the campus. The team designed a highly reflective white TPO membrane material over the "flat" roof areas, and created a campus standard grey asphalt composition shingle roof along hipped portions of the roof. In the end, while this approach did not provide the amount of reflective roofing needed to earn the credit, the design contributed to the goal of reflecting solar radiation and reducing the heat island effect. The TPO color and hip configuration thus address "the spirit" of LEED and meet KSU's shingle roof requirement. This particular challenge shows that it takes planning and cooperation among many different stakeholders to reach success, even if success does not earn a LEED credit for a particular negotiated design effort.

A few strategies that did not prove to be cost effective were the use of solar panels and wind turbines for generating electricity, use of geothermal for the HVAC system, and greywater systems for toilets. Solar panels and wind turbines only provide energy when the sun is shining and the wind is blowing, so a redundant backup system, battery, or another energy storage device must be provided. For geothermal systems, if the high initial costs of drilling into the rocky soil conditions of the site could be absorbed, the small site did not offer the physical area needed for the storage tubes. These challenges reminded the project team that site constraints, prioritization, and limited budgets may take precedence, and as much as designers, engineers, and the client would like to achieve success in all areas, some energy efficient features must be left for a different time and place.

The formal credit toward providing daylight and views was not achieved, but the effort spent toward daylighting resulted in a better building. By using full glass walls at perimeter corridors at the second floor and orienting classrooms to the exterior walls, daylighting and views were provided for all building users except those in the Town Hall auditorium. The interior placement of this auditorium was necessary due to the limits the size of the site placed on the building configuration. So while the project team could not achieve the formal credit for this attribute, the effort to provide its benefits for as many building users as possible was taken.

Leadership Studies Building interior: conference room and entry court/foyer. (Photo courtesy of Opus.)

Project Funding

The project was privately funded through gifts and used a design-build project delivery system. The programming and schematic design process used to conceptualize the building and develop the design through the construction documents phase included students, faculty, staff, and administrators at various levels within the university.

Project Team

Opus Design Build, LLC (construction): Oscar Healy, senior director of construction; Justin Duff, project manager

Opus AE Group, Inc. (architecture): Gary Schuberth, project designer/architect; Dan Young-Dixon, sustainability; Julie Ward, LEED coordinator; Jennifer Koehler, interior designer

Lankford & Associates, Inc. (MEP engineering): Greg Fendler, electrical engineer; Don Erisman, mechanical engineer

Metro-Air (HVAC design-builders): Justin Gunter, Engineer

Innovative Solutions, Inc. (commissioning): Don Erisman, commissioning agent

Schwab-Eaton, Inc. (civil engineering and landscape architecture): Leon Brown, civil engineer; Gary Schooley, landscape architect

Kansas State University Team Members included: Mary Tolar, Director, School of Leadership Studies (SLS); Susan Scott, Founding Director and Senior Advisor, SLS; Lori Kniffin, Ambassadors President (student), now SLS Building Manager; Eric Schmidt, architectural engineering major/leadership studies minor and Ambassador (student); Mike Smith, Vice President, KSU Foundation; Mike Holen, Dean, College of Education; Ruth Dyer, Associate Provost; Ned Gatewood, Facilities Architect; Mark George, Facilities Planning; Dea Brokesh, Facilities Landscape Architect; Susan Benz (Benz Resource Group), KSU Foundation Project Manager; Barbara Anderson, Associate Professor; Ben Champion, Director of Sustainability; and Sue Pray, SLS Administrative Officer.

Notes

1. In Fall 2010 Opus received a Design-Build Project of the Year award as well as the Design-Build Honor Award for Buildings under $10 million from the Design-Build Institute of America for their work on the School of Leadership Studies Building at KSU. The firm was selected because they were

seen as successfully creating a team atmosphere resulting in a building with excellent attributes. Key to Opus's success with the design-build approach is their decades-long partnership between the Opus AE Group (architects and engineers) and Opus Design Building (the project managers and builders). Opus has completed nearly six million square feet of LEED projects and nearly five million square feet of projects using "sustainable strategies."

2. Opus submitted the School of Leadership Studies Building for LEED certification, and are under final review of 42 points on the LEED rating scale. Thirty-nine points are needed for Gold. There is the chance they could not be awarded all points. Thus, the LEED Silver level is a conservative estimate of how the building will be certified.
3. Lee R. Skabelund's Fall 2007 Landscape Architecture Specialization Studio helped raise critical issues related to Campus Creek corridor and tree protection and stormwater management, helping the project team to remain focused on these important issues during the planning/design and construction process.

GREEN BUILDING TEACHING, RESEARCH, AND OUTREACH AT KSU

While the previous section highlights organizational approaches to the governance of sustainability, it should be noted that many steps are being taken toward promoting a community of sustainable effort at other scales and levels. These steps, in the form of projects of varying scopes, reinforce both the institutional goals and the broad tenets of sustainability. Viewed as a whole, these initiatives share significant characteristics. First, they are without exception interdisciplinary in nature, involving dedicated efforts from several departments, as well as faculty, students, and professionals. It is well understood that true sustainability is not the provenance of only one profession, but necessarily requires a multifaceted approach. Second, the lessons learned from each project extend beyond its specific requirements, increasing the knowledge base and expertise of both active participants and others. In essence, the value of the project is as much a vehicle for outreach as in fulfilling its specific requirements. Finally, as pedagogical efforts, these projects fulfill the primary responsibility of the university—to invest emerging professionals and scholars with the tools to successfully navigate the challenges of their lives and careers. Sustainability is an important component of almost every professional endeavor today, and it is anticipated that the demands of responsible resource management, ecological mediation, and economic viability will continue to be addressed in the future.

KSU Case Study Examples

In the following pages of this paper, case study examples are presented to highlight three projects implemented at KSU between 2007 and 2009. These include the International Student Center Rain-Garden Demonstration Project (an award-winning project at state, regional, and national levels), the Seaton Hall Green Roof Research and Demonstration Project, and KSU's Project Solar House.

KSU's International Student Center (ISC) Rain-Garden

Undertaken outside of regular coursework, this service-learning project engaged students and faculty in a collaborative design-build effort on campus. The larger purpose of the project is to help restore the natural hydrologic cycle along the Campus Creek riparian corridor while educating students, faculty, staff, administrators, and campus visitors about low-impact stormwater management solutions. This purpose was accomplished by designing and constructing a rain-garden that captures and uses rooftop and surface water runoff, and does so in a simple, elegant manner.

An October 2006 Campus Creek Watershed planning/design charrette, which proceeded the design and implementation of the ISC Rain-Garden, involved roughly 125 students, faculty, and staff as well as KSU landscape architecture alumni and local engineering professionals. Beginning in March 2007, the rain-garden was constructed by more than 60 students, faculty, and other volunteers. Assistance for the ISC Rain-Garden project was provided by local businesses, suppliers, and professionals, with more than 400 hours of volunteer time offered during implementation of the rain-garden (not including many hours of planning/design time). The rain-garden was tested by very heavy rains in May 2007—with over ten inches of rain falling during the thirty-day period following the first day of planting on April 28, 2007. Rain-garden construction was completed in June 2007, with final plantings installed and a permeable flagstone pathway laid with assistance from a summer-

Left: International Student Center Rain-Garden (May 22, 2010 lrs). Right: Seaton Hall Green Roof (September 3, 2010 lrs).

studio landscape architecture class. Working closely with KSU Grounds and ISC staff, the rain-garden is being maintained by faculty and students. The ISC Rain-Garden has received several awards, including national recognition (see note).

The rain-garden is seen as a model for stormwater management in the community, and it is frequently visited by groups and individuals. In August 2008, a Rain-Garden planning/design handbook was published to assist planners/designers, engineers, landowners, and community members in understanding the process of implementing and managing this type of living and evolving stormwater management feature.

The three phases of the project are summarized in the following paragraphs.

Phase 1: KSU Stormwater Management Charrette and ISC Rain-Garden Planning/Design

During Fall 2006, the Kansas State University Campus Creek Planning/Design Charrette involved students, faculty, staff, and professionals in the task of considering ecologically sound ways to treat stormwater that falls on the campus. In the process, many ideas for rain-gardens, bio-retention cells, streambank improvements, and other stormwater best management practices (BMPs) were generated.

Watershed analyses, water quality monitoring, and contextual site assessment work were undertaken through a Natural Systems & Site Analysis course. Planning and design ideas identified were subsequently reviewed by faculty with a keen interest in stormwater management, and, over time, it is expected that implementation plans will be developed for various parts of the Campus Creek Watershed.

From late December 2006 to early March 2007 detailed plans were developed for a demonstration rain-garden just west of the Taiwan Wing at KSU's International Student Center. This location was selected given the tendency for stormwater to collect and sit atop the highly-compacted clay soils, which were covered at the time with turfgrass (including a mix of Bermuda grass, fescue, and bluegrass). Working with staff at the ISC, contacts at the Kansas Department of Health and Environment (KDHE), faculty in KSU's Department of Landscape Architecture/Regional and Community Planning, landscape architects at KSU Facilities, and the KSU Landscape Committee, a final design was prepared and refined by KSU faculty and students. The plan was given a nod of approval by KSU Facilities staff.

The planning/design charrette was supported by a budget of $5,000—provided by a KDHE-sponsored WaterLINK service-learning grant. An additional $10,000 KDHE Clean Water Neighbor Grant helped initiate work on detailed rain-garden design and set the stage for its spring 2007 implementation. Subsequent WaterLINK grants helped support additional work at the rain-garden, including the design, fabrication, and installation of sculptural rain-bowls below the roof scuppers (fall 2007 to spring 2008).

In tandem with the two-cell rain-garden, adjacent perennial beds, permeable pathways, and other nearby plantings, the rain-bowls were designed to slow and infiltrate stormwater falling onto or flowing into the area. Working concurrently with limestone splash-pads and the vegetation-filled rain-garden pools, the three evedure silicon bronze rain-bowls dissipate energy from rooftop runoff. Additionally, the rain-bowls provide water for small-scale, supplemental uses (including old-fashioned hand-to-plant irrigation when vegetation is transplanted and hand-washing during weeding and other garden work).

Outreach was an important component of this initial phase of the KSU Stormwater Management project. Many innovative ways to address urban stormwater runoff were demonstrated to campus administrators, staff, faculty, and students during the charrette. Local planners, designers, engineers, other professionals, and community leaders were informed of the project via e-mail, phone, and in face-to-face meetings. A number of designers and engineers attended lectures presented by stormwater management experts and participated in the charrette. City of Manhattan planning and engineering staff and other professionals expressed interest in learning more about the project, and many conversations were spawned by this and other university outreach efforts relating to stormwater management and water quality protection.

As an example of the influence of both the 2006 charrette and implementation of the ISC Rain-Garden, KSU Facilities is presently in the process of implementing a series of innovative stormwater practices at the university's new child care center (scheduled for completion in spring 2011). At the child care center, porous paving parking lots will be connected to several large bioretention areas. Additionally, a series of rain-gardens and the collection of rooftop runoff in a large underground cistern are all part of this state and federally funded project. Success at the ISC Rain-Garden helped spur this new, much larger project effort. As a result of these activities, the negative impacts of rapid, pipe-to-stream stormwater runoff are beginning to be addressed on campus. In light of these and other anticipated actions, it is hoped that stream banks on campus can be stabilized and water quality improved.

The list of complementary water quality protection efforts at KSU is very long, and these efforts include projects in both agricultural and urban/small town settings. Suffice it to say that KSU faculty, staff, and students are deeply committed to help local communities throughout the region, state, nation, and world improve the way we care for vital surface and groundwater resources.

Phase 2: ISC Rain-Garden Design and Construction

During Spring and Summer 2007, this collaborative design-build project engaged students, faculty, staff, and professionals in the task of implementing a two-cell rain-garden at the International Student Center. Specific design and construction activities included: preparing detailed rain-garden designs, reviewing these designs with knowledgeable faculty and students, refining designs, and preparing final construction documents; researching and coordinating purchases, donations, and transport of all necessary equipment, tools, and materials (including lay-out stakes, lumber, weed-barrier fabric, salvaged and purchased limestone, gravel, topsoil, mulch, hundreds of plants, and other materials such as micorrhizal inoculum and aluminum sulfate); excavating, rototilling, and grading the two shallow rain-garden basins with assistance of a hired student with experience in operating a "bobcat" earth-mover; removing weeds, roots, and sod/turf grass and relocating/transplanting four existing shrubs; placement of nine large limestone slabs to relate the garden to the ISC's eight-foot grid and to serve as stepping stones through the garden; preparation of the base areas for the two pathways on the north and south sides of the rain-garden; placement and settling/compaction of washed filter stone (gravel) to support the salvaged cut pavers along the formal path (north) and the flagstone along the informal flagstone path (south); laying filter fabric beneath the cut pavers and flagstone pathways; setting heavy salvaged edging stones, reused metal edging, and filler gravel; placing three large, flat limestone splash-pads below roof scuppers; repairing storm-damaged areas after heavy rainfall damaged unfinished areas of the flagstone path and the adjacent water-directing berm; coordinating the spraying of weeds and Bermuda grass by KSU Grounds staff; placing plant protection (including fencing around a black chokeberry after it was pruned by rabbits); planting a combination of moist rain-garden, dry fringe (shady to full sun), woodland, ornamental perennials, and woody plants during five different planting days (many of the species planted are native to the Flint Hills Eco-region); ordering, hauling, and placing five loads of donated mulch; watering plants from rooftop runoff (and by hose as needed); regularly weeding the garden during the early establishment period; soliciting donations; coordinating volunteers; taking photos; and tracking purchases, budgets and project costs; designing and coordinating the fabrication of an interpretive sign / recognition plaque; and (in Fall 2007 and Spring 2008) designing and coordinating the creation and installation of three (54, 75.6, and 113.5 pound) rain-bowls for the garden.

Phase 3: ISC Rain-Garden Maintenance and Monitoring

Immediately following creation of the rain-garden, spot treatment of weeds using herbicides was selectively used to keep invasive grasses near the rain-garden in check during the first growing season. Future treatments using chemicals were deemed unnecessary as the use of hardwood mulch and composting leaves helped minimize the growth of weeds and made weeding easy to perform.

Rain-garden maintenance is done in collaboration with landscape architecture faculty and students, along with other student volunteers. Volunteers include KSU Environmental Issues and Ethics students who choose to assist with weeding each spring. Weeding out woody plant seedlings typically occurs several times during summer and fall. KSU Grounds staff assist with maintenance and weed control.

Maintenance costs are modest (primarily requiring volunteer labor, with some paid support offered several times a year by KSU Grounds staff). Nevertheless, the time spent to care for the rain-garden is likely greater than the time that would otherwise be required to run a mower across a lawn in this area.

As a result of their active involvement in the project, KSU Facilities and Grounds desire to see additional water-sensitive design projects implemented on campus, but recognize that with decreasing budgets it may be a challenge to address ongoing weeding, clipping, and clean-up needs.

Monitoring of vegetative health indicates that native plants often grow nearly two times the height they would in more stressful, natural conditions. Visual observations indicate that most storm events less than approximately two inches collect and infiltrate all rainwater and other precipitation falling on the Taiwan Wing, the rain-garden, and the garden's watershed. Four soil density probes and four infiltration tests were completed in April 2008 and provided an idea of soil conditions within and immediately down slope of the KSU ISC rain-garden at that point in time. Additional infiltration testing may be done in the coming years to see how quickly water infiltrates into the rain-garden. Bulk density tests may also be done to see if densities decrease over time (which should occur if compaction/foot traffic is minimized and as the native grasses and forbs mature).

Ongoing monitoring will help the project team learn which plants are best suited for the particular site conditions and show how infiltration rates and soil densities change over time, thus providing important information for future rain-garden and bioretention designs within the Flint Hills Eco-region.

Challenges and constraints in regard to maintenance and monitoring

This was, as far as project designers were aware, the first rain-garden designed and implemented on campus or within the city and so they did not have any local models from which to learn. Designers drew upon ideas from across the country (including award-winning projects posted at www.asla.org, and from Topeka (especially Jackson Street), and Kansas City (especially the Missouri Discovery Center).

Initially, KSU Grounds personnel were skeptical about the ability of the very heavy clay soils to infiltrate water. After breaking up the soil and getting plants established (which only took two months in 2007) the soil readily infiltrates and plants evapotranspire stormwater runoff quite rapidly. After large storm events, stormwater seldom remains in the two basins for more than a few hours and there is rarely water in the upper, wetter basin for more than a day. Mosquitoes typically need four to five days to breed and hatch, so properly functioning rain-gardens do not contribute to producing these pesky insects.

Weed species transported by birds, wind, gravity, water, and other forces are the major maintenance challenge. Designers of the ISC Rain-Garden knew that a large amount of honeysuckle, buckthorn, and other fruit- and seed-bearing woody species nearby and across campus would be transported into the area and thus decided to place weed barrier (filter fabric) beneath the porous pathways on the north and south sides of the rain-garden. This has made it easier to weed honeysuckle, buckthorn, and other woody plants from these pathways. However, finding time and personnel to regularly monitor and weed (before weeds go to seed) can be a challenge. Managers should budget at least a few hours a week during the first growing season to monitor and maintain a rain-garden; watering and weeding a rain-garden on a regular basis during the first two growing seasons will save a great deal of time down the road.

Trying to understand what all the different plants look like at different stages is also a challenge (and a great learning opportunity for all involved). This is particularly true when we seek to create more complex and dynamic systems—which is exactly what was initiated at the ISC Rain-Garden. Initially, volunteers removed Carolina Geranium (*Geranium carolinianum*), thinking it was a weed. After a rain-garden tour a student who graduated from KSU-Horticulture checked on the plant and informed volunteers that the plant is native to this part of Kansas, so it is no longer weeded out.

Lessons learned in regard to maintenance and monitoring

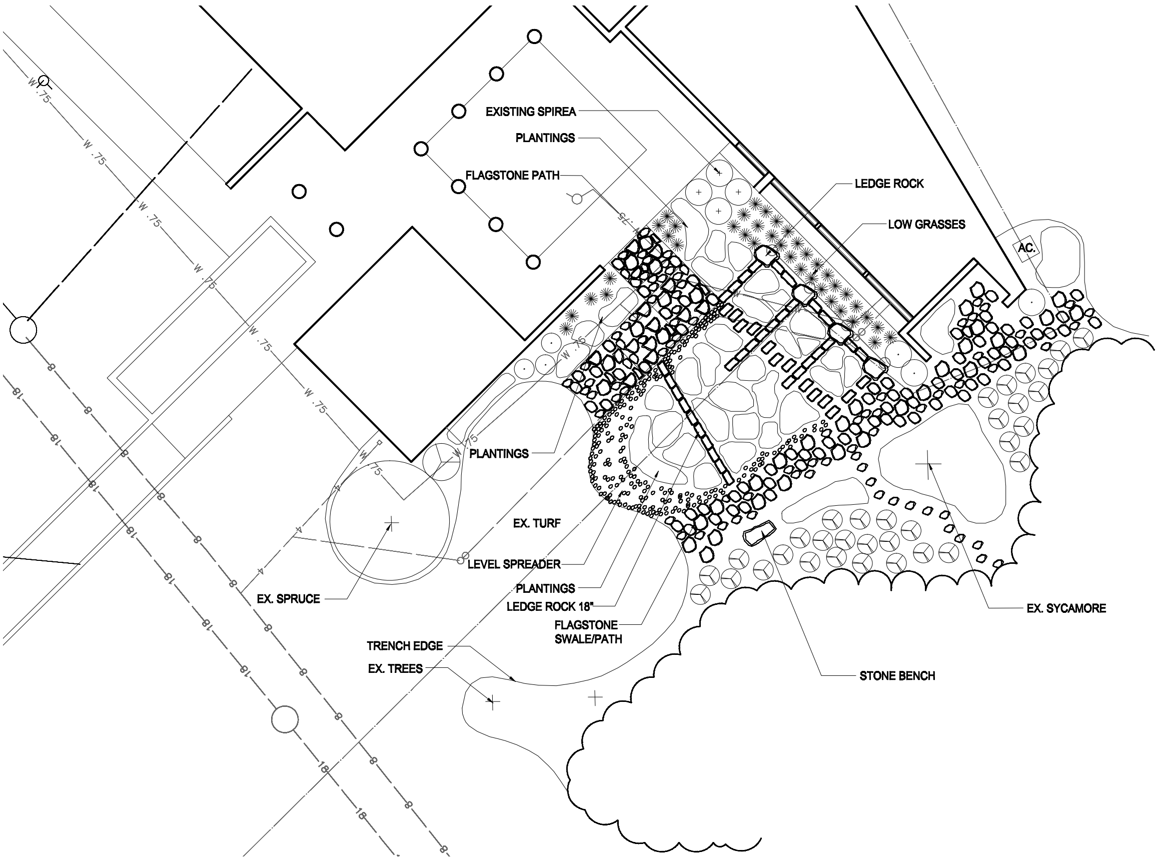
Persistence is required to create initial demonstration projects on a campus or in a community. Interest in energy and water savings opens the door for creative, multi-benefit projects that create more sustainable landscape structure and functions.

Deep-rooted prairie plants and small-scale rain-gardens can make an immediate impact on stormwater runoff. When carried out in an integrated and holistic manner—especially as usable garden spaces—even very small-scale projects can make a very important and positive impact.

Any garden requires dedicated maintenance. Weeding is essential. Fertilizing is not needed if native plants adapted to the region (and site) are used. Pruning is rarely needed, though clipping back perennials as needed throughout the year, including before spring, is important. Watering during the first growing season is vital, but can be discontinued in subsequent years if selected plants match climatic and soil conditions.

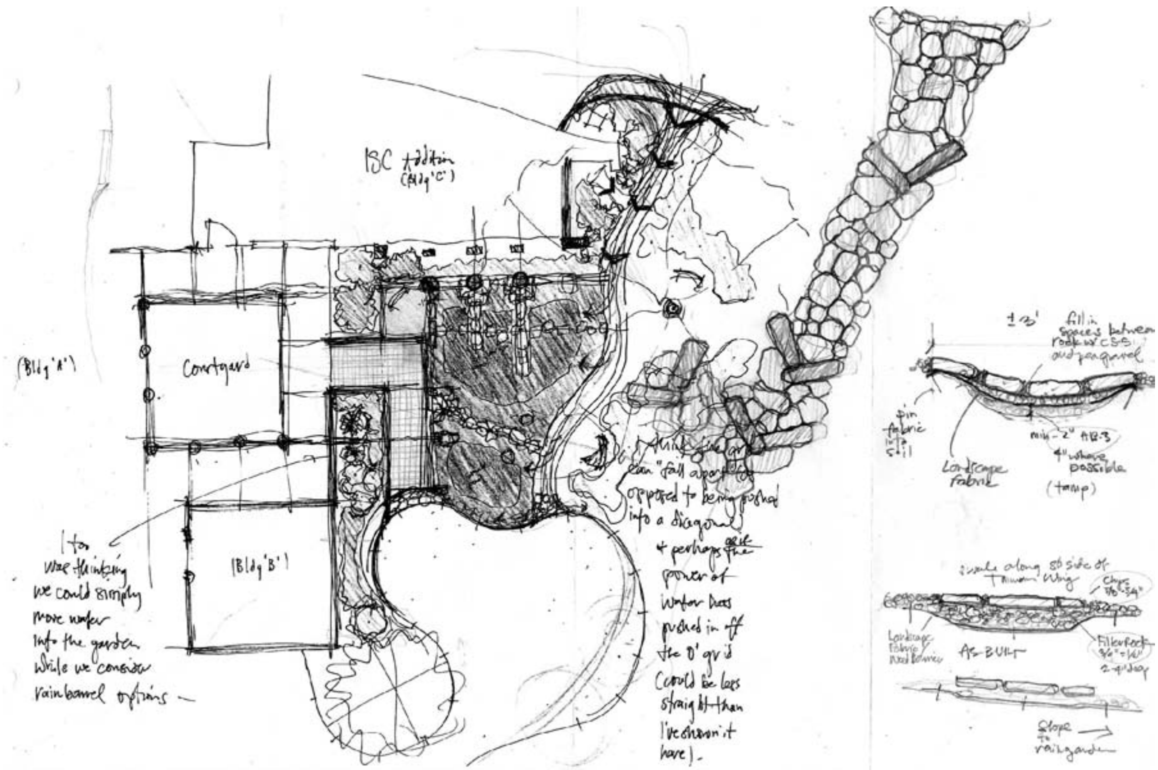
ISC Rain-Garden—view of ISC architecture and rain-garden site during and after construction (March and August 2007 lrs).

KSU-ISC Rain-Garden Site Plan (prepared by Cary Thomsen and Lee R. Skabelund, January to March 2007).



Rain-Bowls at the KSU-ISC Rain-Garden (following installation on May 10, 2008 and on August 9, 2009 lrs).

ISC Rain-Garden—design sketch by Lee R. Skabelund (March 2007).



Building institutional interest and capacity for ongoing monitoring and maintenance is essential. Universities, colleges, and other educational institutions can play an important role in assisting local communities monitor sites, helping them and others build increased understanding about the sustainability of specific planning, design, and construction practices.

Concluding Thoughts

As a result of the success of the rain-garden it is being used as a primary vehicle on campus to educate KSU students and other interested parties about the opportunity to create similar low-impact stormwater management projects, as well as the importance of regular, ongoing site maintenance and monitoring.

The project relied heavily on donated time, equipment, tools, and labor and took many hours to effectively coordinate. Learning from work at the ISC Rain-Garden, several rain-gardens were designed and constructed at Sunset Zoo in Manhattan, Kansas during the fall of 2008 and spring of 2009. As with the ISC Rain-Garden, the Sunset Zoo Rain Gardens were also constructed in large part using volunteer labor. Both designers and zoo staff concur that it is well worth the effort to move from eroded soil and grass to a series of pocket prairie-like rain-gardens and terraces. ISC-staff appreciate the perennial garden feel as well as the rain-garden's dynamic presence throughout the seasons.

Budget and Project Team

Not including volunteer time by KSU faculty and students, total donations from external partners and non-academic departments during Spring and Summer 2007 were estimated to be approximately $7,800. Hundreds of hours of donated time were also provided.

Financial support for a small portion of the time provided by the two co-designers came from

KSU-ISC Rain-Garden—view toward Campus Creek (volunteer maintenance on May 1, 2009 and on July 31, 2010).

a USEPA/KDHE grant, previously noted and described in full here. KDHE provided financial assistance to the KSU ISC Rain-Garden Project through EPA Section 319 Nonpoint Source Pollution Control Grant #C9007405-12. Three WaterLINK (Water Quality Restoration and Protection Service Learning Mini-Grants awarded to KSU by KDHE utilizing EPA funds) provided financial assistance for the Fall 2006 KSU Campus Creek Planning/Design Charrette, Spring and Summer 2007 ISC Rain-Garden construction for the KSU ISC Rain-Garden, and 2007–2008 ISC Rain-Bowl fabrication and installation.

Key participants from K-State and their project roles were:

Professor Lee R. Skabelund, landscape architecture, project coordinator and co-designer, awards submission advisor, rain-garden photographer and manager (monitoring & maintenance)—Dec 2006 to present

Cary Thomsen, co-designer and assistant project coordinator (MLA 2007)

Professor Dennis Day, landscape architecture, construction advisor, level-spreader designer

Mark Taussig, K-State Facilities, project approvals

Jackie Toburen, K-State Facilities and Grounds, project support

Donna Davis, K-State International Student Center, project support

Mark Ruzicka, landscape architecture student, volunteer and charrette coordinator (BLA 2007)

Tor Janson, landscape architecture student, volunteer and plant selection assistant

Aarthi Padmanabhan, landscape architecture student, volunteer and awards submission co-designer (MLA 2009)

Jeremy Merrill, landscape architecture student, awards submission co-designer (MLA 2009)

Professor Casey Westbrook, art/sculpture, rain-bowl construction and installation assistance, with: Sloan Smith, art/sculpture student, rain-bowl design and relief construction; and Austin Kirschenbaum, art/sculpture student, rain-bowl pattern construction, molding, casting, finishing, and installation

Note: Those who helped design and build K-State's International Student Center Rain-Garden were recipients of an award in the annual American Society of Landscape Architects (ASLA) National Student Design Competition. The project received an Honor Award in the Community Service category of the 2009 ASLA competition. As noted in the submission "the International Student Center Rain-Garden educates students, faculty, staff, administrators, and campus visitors about low-impact stormwater management solutions by revealing how designed landscapes can elegantly capture and use rooftop and surface water runoff. This rain-garden strategically addresses a significant hurdle to integrating natural stormwater management systems within the urban fabric—namely, the lack of public knowledge of and appreciation for the function and design of these systems—by integrating landscape architecture, art, architecture, ecology, hydrology, and people." Project collaborators included Landscape Architecture faculty and students, K-State Facilities personnel, K-State International Student Center faculty and staff, and students from the K-State Department of Art. Students and faculty from several other departments, including Biological and Agricultural Engineering, also contributed. Contributions of project materials and tools also came from many internal and external partners during rain-garden construction. The rain-garden is currently being monitored and maintained by Professor Skabelund with assistance from International Student Center faculty and staff, Facilities and Grounds personnel, and students.

More information and images about the project can be viewed at: http://www.asla.org/2009studentawards/264.html and http://faculty.capd.ksu.edu/lskab/.

KSU Seaton Hall Green Roof Planning/Design Research & Demonstration Project

An experimental green roof was installed in May 2009 on an approximately 305 square foot roof surface on Seaton Hall's West Wing. The rooftop sits above a third-floor breezeway and faces south. The rooftop is buffered from north winds by the fourth floor stairwell and KSU's Radio Club Room.

The project includes work implemented by KSU-Facilities and Danker Roofing (including the removal of the existing roof membrane and flashing, and installation of a new roof membrane and copper flashing). Derbigum, Inc. donated the waterproofing membrane. KSU donated the copper flashing. Elements implemented by KSU faculty and students include installation of green roof materials, donated by American Hydrotech, Inc. (namely, root barrier [Root Stop HD], drainage mat [Gardendrain GR30], filter fabric [Systemfilter], mineral aggregate, and semi-intensive "Lite-Top" grow media).

15 species of native Flint Hills prairie plants were installed in soil depths ranging from approximately four to seven inches, with three species of donated sedum placed along the edges of the grow media. Another species of drought-tolerant sedum was selected by the project designer and purchased at a local nursery. Monitoring equipment is being used to collect climatic data (including rooftop and soil temperatures and stormwater runoff). Plant growth and vigor are being closely monitored.

Project Materials, Construction, and Details

This collaborative green roof planning and design-build project engaged 30 students representing eight different disciplines, 14 faculty from six different disciplines, roughly a dozen staff members from KSU Facilities, at least five design professionals from the Kansas City area, several KSU administrators, and a number of suppliers and contractors. The green roof was originally conceived of in the fall of 2007, with proposals and detailed plans formalized during 2008 and 2009.

Planning, design, and implementation efforts included the following tasks:

- preparing conceptual green roof designs for eight different buildings on the KSU campus;
- preparing proposals for green roof implementation and monitoring on Seaton Hall's west wing;
- preparing detailed designs for a demonstration and research green roof at Seaton Hall;
- implementing waterproofing and installing green roof materials on this small Seaton Hall rooftop;
- installing monitoring equipment and a temporary drip irrigation system on this green roof; and,
- initiating monitoring procedures in relation to this same green roof.

The first task, preparing hypothetical green roof designs for eight buildings at KSU, created interest in designing a green roof demonstration on campus. In the following paragraphs, tasks from preparing proposals and designs to implementing and monitoring the Seaton Hall Green Roof are described in some detail.

Spring 2008 Natural Resources and Environmental Science Capstone Projects

In Spring 2008, Professor Skabelund worked with seven students enrolled in the Natural Resources & Environmental Science (NRES) Capstone Projects course, where students developed two different proposals for implementing green roofs atop three small rooftops on the west wing of Seaton Hall. These NRES proposals helped KSU faculty and KSU Facilities staff think through budgetary issues and the specific requirements for creating the first integrated green roof on campus.

The goal for these spring 2008 projects was to develop the framework necessary to implement this green roof in the rigorous Flint Hills Eco-Region climate. Three very small rooftops at Seaton Hall were proposed as locations for three different kinds of green roofs (the first in a very sunny and exposed location above a third-floor breezeway; a second on a west facing rooftop above two basement offices and surrounded by building mass on three sides, and a third on an east facing rooftop facing the Seaton Hall alleyway and also surrounded by building mass on three sides).

KSU students from six different departments worked together to develop proposals for implementing, monitoring, and maintaining three green roofs at Seaton Hall. Students estimated weights per square foot and total costs for each green roof. The proposed budget and process for implementing, monitoring, and maintaining each of the green roofs was documented in writing. Potential funding sources to cover the costs associated with green roof implementation and monitoring were considered. Potential hazards, liabilities, legal clearances, safety issues, tools, training needs, and required disciplines were noted.

Students recorded their findings related to this class project in a final report and public presentation. Students also presented green roof design ideas in small group meetings and a public forum that included local planning staff and KSU Facilities staff. As an inherent part of the planning/design process, participating students were required to reflect upon their own values and how those values related to the ideas proposed by other team members, other teams, and by those they are designing for (namely KSU students, KSU administrators, and visitors to KSU).

KSU faculty assessed student work by completing an evaluation of the final reports and team efforts throughout the semester. Peer evaluations by students were completed by participating team members. Based on the reports submitted by the seven Natural Resource & Environmental Sciences students, it was determined that more detailed plans for monitoring temperatures, stormwater capture and runoff, and seasonal vegetative changes and health would be needed for this applied research project. The students noted that detailed design and construction documents would be needed and should account for variations in seasonal temperatures and precipitation.

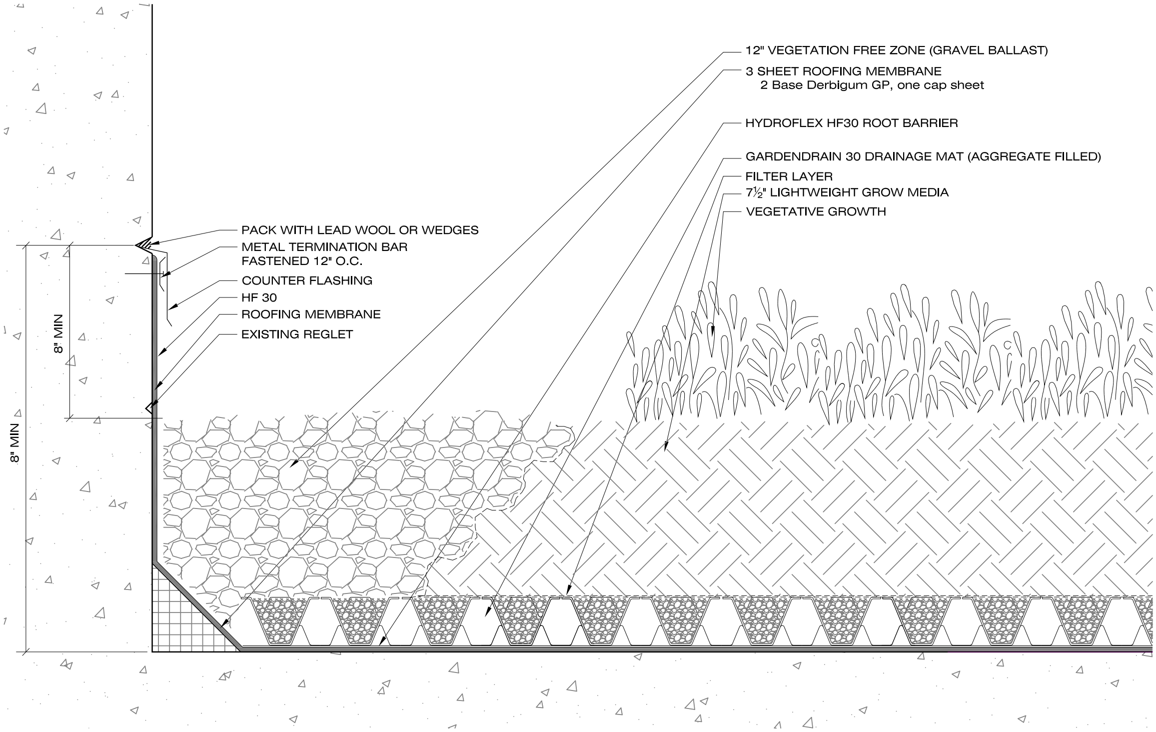
The photographs below show the existing conditions for two of the rooftops.

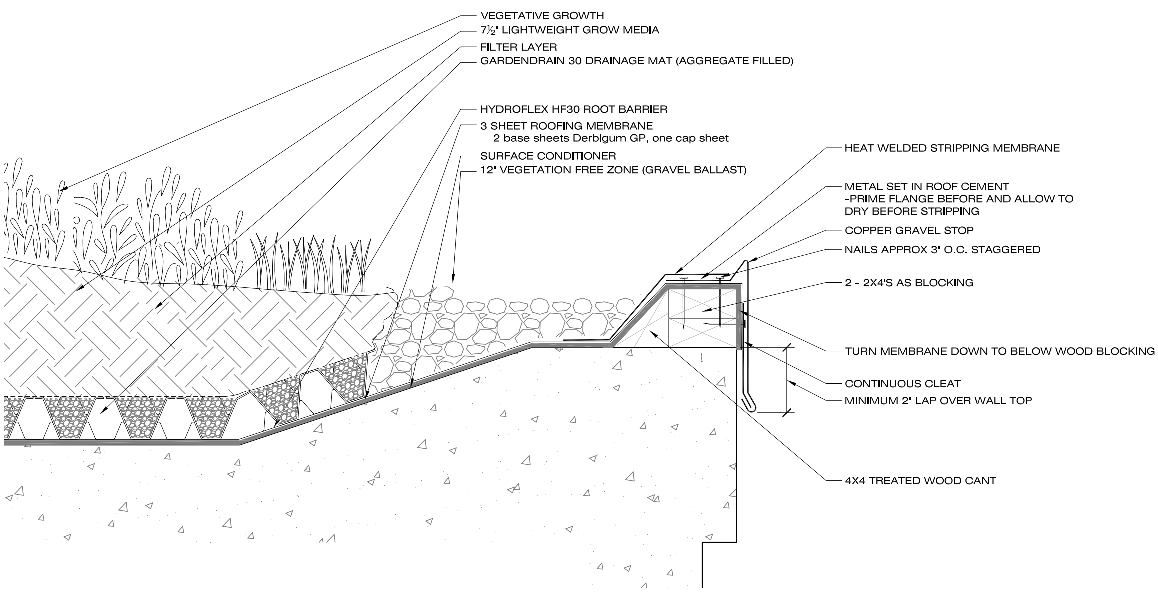
Seaton Hall: proposed locations for two green roof demonstration projects at KSU (September 2007 lrs).

Fall 2008 Independent Study and Pro-bono Service-learning Project Work

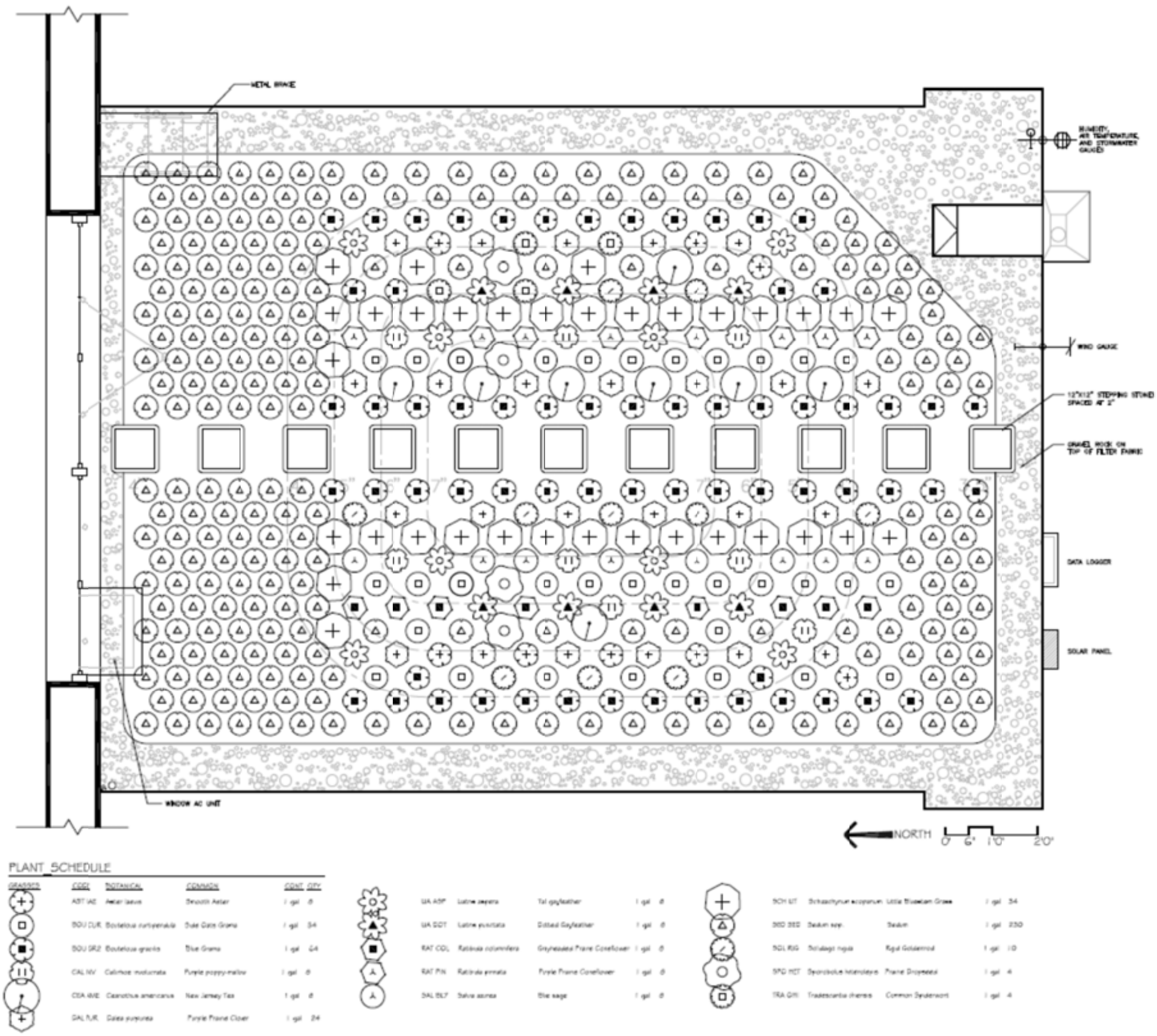
In Fall 2008, Professor Todd Gabbard (Architecture) collaborated with Professor Skabelund to develop a plan for implementing a demonstration green roof at Seaton Hall. Two architecture students, Michael Knapp and Mark Neibling, completed detailed green roof plans for a green roof atop the third-floor breezeway while a horticulture student researched possible plants for the roof. During the spring of 2008, a landscape architecture student prepared a digital planting plan for the green roof.

Seaton Hall Green Roof Details (prepared by Michael Knapp, Mark Neibling—with reviews by RTG and LRS, 2008–2009).





Seaton Hall Green Roof Planting Plan (prepared by Lee R. Skabelund; drawing by Michael Weber, May 2009).



Spring 2009 Green Roof Installation (Waterproofing, Green Roof, Monitoring Equipment…)

During the spring of 2009 the following tasks were completed: materials were secured, arrangements with donors and a roofing contractor made, waterproofing and flashing installed, final green roof certifications and approvals granted, green roof materials/plants shipped and installed, stormwater assessment and other green roof monitoring equipment installed, and monitoring of precipitation, air temperature, relative humidity, wind speed/direction, and stormwater runoff initiated.

After Danker Roofing donated a day's worth of time (by five people) to tear off the existing roof and then complete waterproofing work in March 2009, KSU faculty and students installed the green roof, set up the temporary irrigation system, and set up all green roof monitoring equipment (all in May 2009).

Personnel from the KSU Roof Shop and KSU Facilities provided assistance throughout the project, with Bob Williams playing a primary coordinating role for KSU Facilities and helping to ensure the success of this green roof design-build project (including oversight of waterproofing-related carpentry work and stone-smoothing work as preparation to secure the flashing against the face of the building).

Spring 2009 to Fall 2010 Green Roof Monitoring

During 2009 and 2010 faculty, students, and other partners collected and assessed a range of monitoring data, which is expected to offer invaluable information for future green roof design and decision-making in the Flint Hills Eco-region and other parts of the Great Plains of Central North America.

The following paragraphs summarize a portion of what has been gleaned to date from monitoring data.

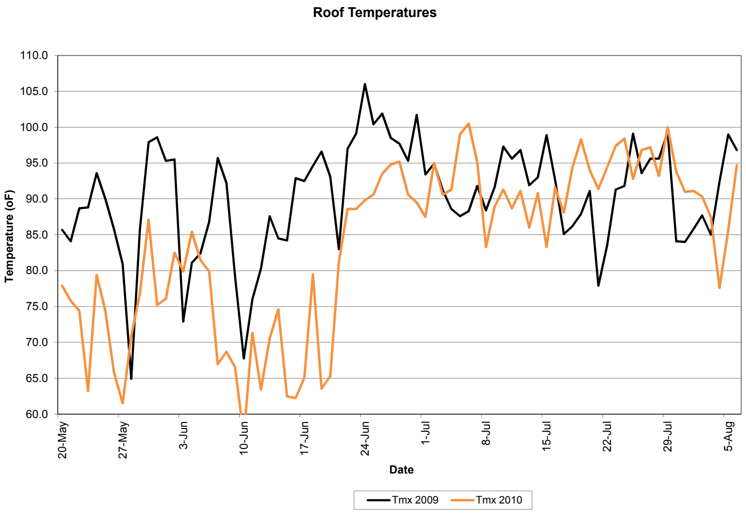
Based on 2009–2010 temperature data, the hottest green roof surface temperatures typically occur mid-day to early afternoon, while the hottest air temperatures occur between 2:00–4:00 p.m. Wind speed likely plays a role in moderating surface temperatures on the green roof, as seen by comparing June 24, 2009 and August 8, 2009 data. Air temperatures were nearly identical at 1:00 p.m. (97.7 to 97.9°F)—however, rooftop temperatures were 8 to 11.5°F higher on 6/24, when wind speeds were 5 to 10 miles per hour slower. Vegetation height (shading), soil moisture, sun angles, and heat build-up in green roof soils each likely influence both surface and sub-surface temperatures, but these variables need further evaluation.

As indicated by data from August 18–23, 2009, shade provided by taller prairie plants clearly makes a difference in reducing surface temperatures on the green roof. However, as revealed by summer 2010 temperature data, heat can also build up in shaded areas (as compared to areas where wind movements dissipate heat loads on the roof). Soil temperatures are warmer with greater depths (this may be due to water/soil moisture retaining heat). Rainfall does not rapidly cool green roof soils, even if air temperatures drop abruptly (10°F in five minutes). The dark brown/reddish-brown green roof soils absorb solar energy and are thus often hotter than the adjacent asphalt-and-gravel rooftop. At night, green roof soils also stay much warmer than exposed rooftops.

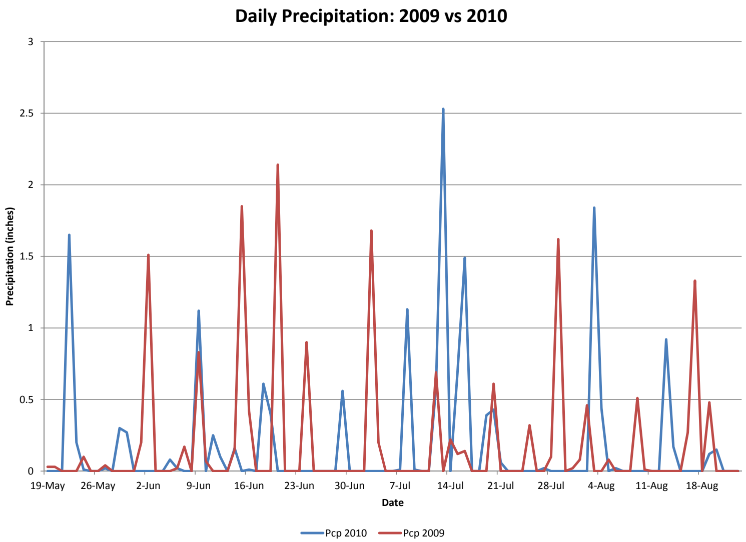
Seaton Hall Green Roof—summary of plant survival results for 2009 and 2010.

Plant survival documented 5/14/10 by Skabelund & Blocksome; 7/2/10 by LRS

Common Name	Scientific Name	Amt (5/19/09)	Amt (7/2/10)
Grasses		**133**	**131**
Side-oats grama	*Bouteloua curtipendula*	32	32 (16E;16W)
Blue grama	*Bouteloua gracilis*	64*	62 (30E;32W)
Little bluestem	*Schizachyrium scoparium*	32	32 (16E;16W)
Prairie dropseed	*Sporobolus heterolepis*	4	4** (2E;2W)
Indian grass	Sorghastrum nutans	1	1
Forbs		**100**	**98 + 1**
Purple poppy-mallow	*Callirhoe involucrata*	8	8 (4E;4W)
New Jersey tea	*Ceanothus americanus*	8	8 (2E;6W)
Purple prairieclover	*Dalea pupurea*	24	24 (12E;12W)
Tall gayfeather	*Liatris aspera*	8	7 (3E; 4W)
Dotted gayfeather	*Liatris punctata*	8	8 (3E; 5W)
Prairie coneflower	*Ratibida columnifera*	8	8W
Gray-headed prairie coneflower	*Ratibida pinnata*	8	7E
Wild Blue sage	*Salvia azurea*	8	8
Rigid goldenrod	*Solidago rigida*	8	9***
Smooth aster	*Symphyotrichum leave / Aster laevis*	8	8
Common spiderwort	*Tradescantia ohiensis*	4	4
Sedum (four varieties; precise quantity unknown/approx. 200, but some planted in bunches; lemon sedum died out over the winter of 2009 [some small remnants were present as of mid-May 2010 but had disappeared as of 7/2/10).			
Total native plants		**233**	**229 + 1**



Air temperatures at south end of the KSU Seaton Hall Green Roof (comparing summers of 2009 and 2010).



Rainfall recorded on the KSU Seaton Hall Green Roof (comparing summers of 2009 and 2010).

(Graphs courtesy of Mary Knapp KSU-Agronomy Department and Kansas State Climatologist.)

In regard to stormwater runoff, over a two-month period (April 15 to June 15, 2010) approximately 1,464 gallons were held on the green roof, while 943 gallons were recorded as runoff. This means that 60 to 65 percent of all rainfall was held on the roof on the green roof during this time period.

On July 2, 2010 an as-built planting plan was completed for the Seaton Hall Green Roof. Plant counts indicated that only two grasses and two forbs (out of a total of 133 native species originally planted in May 2009) had died out. Three native grasses were planted in rows of 16 for each species (two rows each of little bluestem and side-oats grama and four rows of blue grama). All 32 little bluestem (*Schizachyrium scoparium*) and all 32 side-oats grama (*Bouteloua curtipendula*) remained alive in July 2010, although one little bluestem, where plants were bunched quite closely in the northwest quadrant, looked to be in very poor condition in mid-October 2010. For blue grama (*Bouteloua gracilis*), 62 out of 64 plants survived the first two growing seasons (with one mortality due to roots drying out prior to planting, and one due to severe stress on the southeast corner early in the summer of 2009).

Native plants on shallow soils showed stress sooner and were typically smaller than plants of the same species on thicker soils during 2009. Stunted size for shallow-soil natives remains true as per 2010 data. Three of the four species of sedum survived the first full year (the lemon-colored sedum completely disappeared early in the second growing season following the rigorous winter of 2009–2010). Blue grama (*Bouteloua gracilis*) plants in deeper soils in the center of the roof were, on average at the end of the 2009 growing season, 3.75cm to 10cm taller than those on shallow soils (i.e., plants located at the end of the two center rows and along the two outside rows).

Woody plants (including shrub honeysuckle, red cedar, elm, zelkova, cottonwood, and other species) were removed when observed on the green roof; purslane was allowed to remain (a single plant being observed in 2009 between the northeast and northwest quadrants).

Dead biomass taller than three to four inches is being treated differently on two quadrants of the roof. The southeast and northwest quadrants were not clipped, while the southwest and northeast quadrants were clipped on April 1, 2010 (with the dead material removed from the roof). Clipping these two quadrants each spring will allow green roof researchers to see if biomass removal (which resembles haying prairie) makes any difference over time. Monthly photographs provide a visual record of growth rates on different parts of green roof, while physical measurements of selected plants (height, width, and number of seed-heads for three species of grasses) are being taken each October.

When visiting the roof to take photographs, check the range gauge, or for other monitoring and educational purposes, fauna are observed and noted. Birds observed on or very near the green roof include starlings (which were observed feeding on *Dalea purpurea* in 2009), sparrows, rock doves, swallows, and at least one other unidentified species. Insects observed during 2009–2010 include bees, wasps, beetles, grasshoppers, ladybugs, small blue dragonflies, and various other beetles and flies.

Assessment of Project Success to Date

The KSU Seaton Hall Green Roof Research and Demonstration Project provided many opportunities for service-learning. KSU staff, faculty, students, and professionals learned much from the process of project planning and design, and from the hands-on efforts to construct the Seaton Hall Green Roof. Discussions with BAE, Architecture, Landscape Architecture, and other students facilitated learning. Architecture and BAE students were asked to help make decisions about how the design ideas expressed on paper should be implemented at the project site. Adaptations and adjustments were required in a number of instances and required the two Architecture students to rethink the design and update green roof drawings several times. Architecture students also played vital roles in two key meetings with KSU Facilities personnel. BAE students designed and installed a temporary drip-irrigation system and have assumed responsibility to assist with watering green roof vegetation and monitoring rainfall and stormwater runoff. In early June 2009, the downspout on the south side of the green roof was connected to a cistern so that the quantity and quality of stormwater runoff can be monitored.

As green roof vegetation establishes more extensive root systems and above ground biomass the project will continue to provide students and faculty at KSU the opportunity to learn how well this green roof performs in regard to modifying surface temperatures on the roof and influencing stormwater runoff.

In addition, the comparison of sedum and native prairie species being tested on the Seaton Hall Green Roof will allow students, faculty, staff, and others to see which green roof species perform best over time, particularly once all supplemental irrigation is discontinued.

Concluding Thoughts

According to Dvorak and Volder, who completed a literature review of North American green roofs in April 2010, there are few choices more critical to green roof success than selecting appropriate soils and vegetation. Sutton (2007) and Oberndorfer et al. (2008) concur. Results of project reviews by Dvorak and Volder throughout the U.S. and Canada "indicate that investigation sites across ecoregions begin to reveal differences in plant survival [with] improved plant performance and ecological

Seaton Hall Green Roof: time-series photos (July 14, 2009; October 9, 2009; May 31, 2010 lrs).

services [for] diverse green roofs." They "conclude that as green roofs continue to become regulated and adopted in policy, further development of standards and guidelines is needed" with standards and guidelines based upon additional green roof investigations (Dvorak and Volder 2010, abstract). The Seaton Hall Green Roof project will contribute to the growing body of literature on both green roof design and performance, particularly for drought-prone areas where native grasses, forbs, and other well-adapted plants must be used in tandem with appropriate soil/grow media types and depths.

Project Budget and In-kind Donations

$5,000 in WaterLINK funding (a Water Quality Restoration and Protection Service Learning Mini-Grant awarded to KSU by the Kansas Dept. of Health and Environment utilizing USEPA funds). KSU provided financial assistance and in-kind support for this project. An additional $322 was donated by KSU's College of Architecture, Planning and Design.

Danker Roofing, Inc. donated in-kind time to help tear off the old roof and install waterproofing. Derbigum, Inc. donated waterproofing materials (facilitated by roofing supplier Kathy Hogarty). American Hydrotech, Inc. donated all green roof materials (including the root barrier, drainage layer, filter fabric, and soil or grow media, and three varieties of sedum shipped from the state of Washington). KSU-Facilities donated copper flashing and flexible drainage pipe (to move stormwater runoff into a cistern during the growing season), while Danker Roofing donated the recycled gravel (used along all four edges of the green roof).

Seaton Hall Green Roof monitoring (October 22–23, 2009 lrs).

KSU's Biological and Agricultural Engineering Department donated materials for the temporary irrigation system (installed in late May 2009 and removed in October of the same year). Several academic departments at KSU are loaning the automated tipping-bucket (used to measure rainfall), temperature sensors (used to measure rooftop and sub-soil temperatures), a data-logger and solar panel to power the data-logger, hoses (for hand-watering the roof during the establishment period), a cistern (to collect stormwater runoff from the green roof), and hose and flow-meter (to measure stormwater runoff collected in the cistern). Nearly all project monitoring efforts to date have been completed with loaned or donated resources and time.

Project Team:

Designers of Record

Lee R. Skabelund, KSU-Landscape Arch. (project lead; design and implementation)
R Todd Gabbard, KSU-Architecture (design and implementation oversight)
Michael Knapp and Mark Neibling, KSU-Architecture (design)

Additional Researchers and Team Members

Stacy Hutchinson and students, KSU-Bio-Ag. Engineering (green roof implementation)
Mary Knapp, Rhonda Janke and Carol Blocksome, KSU-Agronomy (climate and green roof monitoring)
Robert Williams (project coordinator for KSU-Facilities)

External Contributors

American Hydrotech, Inc. (green roof materials); Northwest Horticulture (sedum)
Derbigum, Inc. (waterproofing materials); Kathy Hogarty (roofing supplies)
Danker Roofing, Inc. (demolition and waterproofing); KSU-Facilities (miscellaneous work)
Kaw River Restoration Nursery (native prairie grasses and forbs)

Notes Regarding Number and Role of KSU Students and Faculty Involved

Twelve (12) Landscape Architecture students completed exploratory conceptual green roof designs for four different buildings on the KSU campus through the LAR Specialization Studio (Fall 2007). Professor Skabelund directed this studio work and arranged for students to present their ideas to key stakeholders, including KSU administrators Tom Rawson and Ed Rice and KSU Facilities staff. Two (2) Landscape Architecture students completed exploratory conceptual green roof designs for the new recreation building and three other buildings on the KSU campus through their LAR Capstone Design projects (Fall 2007 to Spring 2008). One of these students prepared a green roof master plan for the KSU campus. Several faculty provided critiques related to these project efforts, which were guided by Professor Stephanie Rolley and other LAR faculty members. Dr. Sutton Stephens oversaw structural analysis work.

Seven (7) students from five different disciplines (Architecture, Biological & Agricultural Engineering, Biology, Park Management, and Agriculture Communications) prepared green roof implementation and monitoring proposals for three small rooftops on Seaton Hall's west wing via the Spring 2008 NRES Capstone Projects course. Professor Skabelund directed these project efforts and arranged for students to learn from KSU and external roofing specialists (including a waterproofing specialist representing Derbigum, who later donated all waterproofing materials). The students presented their ideas in two different public venues. Professor Stacy Hutchinson played a primary role in helping students understand monitoring needs and design. Two (2) Architecture students completed detailed green roof design for the Third-Floor Breezeway at Seaton Hall via Independent Study coursework and pro-bono service learning efforts—with work guided by professors Gabbard and Skabelund (Fall 2008 to Spring 2009). Several meetings with KSU Facilities staff (including the Director of KSU Facilities, Abe Fattaey and KSU Landscape Architect, Mark Taussig). State Climatologist and KSU Agronomy Professor Mary Knapp played a central role in helping students understand how monitoring equipment would need to be integrated into the green roof design. One (1) Horticulture student researched green roof plant options as pro-bono service learning work. One (1) Landscape Architecture student created a digital version of the final planting plan as pro-bono service learning work.

Five (5) Biological & Agricultural Engineering students played a vital role in green roof installation and the creation of the temporary drip-irrigation system for the green roof. Working closely with Professor Skabelund, Professor Stacy Hutchinson played a primary role in helping students design and then install the green roof and irrigation systems. Four faculty members worked together to plant sedum and native prairie species atop the lightweight grow media. Professors Skabelund and Gabbard worked with all students, faculty, contractors, reviewers, and suppliers to ensure successful implementation of the green roof above the third-floor breezeway on Seaton Hall's west wing. At least eight (8) faculty/staff and four (4) students have played essential roles in green roof monitoring efforts.

Project Solar House: KSU's Entry to the 2007 Solar Decathlon

In Fall 2005, a group of faculty and students from the College of Architecture, Planning and Design (CAPD) and the College of Engineering proposed to compete in the Solar Decathlon, a limited entry competition organized by the U.S. Department of Energy. The competition challenges university-led teams to design and construct a small home that provides all the expected amenities required by a two-person household while deriving all its power from the sun. In Fall 2007, the homes from colleges across the country (as well as a few international entries) would be shipped to Washington D.C., where they would be judged in ten contests and open to the public. KSU was selected as one of the competitors in January 2006. Design work started immediately.

Project Organization

Though simply stated, the implicit complexities of the competition required an intently focused planning exercise that lasted for more than a year. Students were organized in disciplinary groups charged with specific aspects of the project that took advantage of their specific skills, talents, and interests. The groups were in constant communication, informing each other's designs far beyond their potential individually. This mode of integrated collaboration was modeled after professional projects that students will encounter in the field, with students taking on the aspects of consultants working toward a common end.

As the project moved into construction documentation, the design was ever more cooperative, and specific system designs were undertaken. Each architectural student took on the added responsibility of acting as a liaison to an external academic unit, updating both groups as to the latest design details and concerns. This activity was imperative to the success of the project.

The KSU Solar House Design

The house was 697 square feet—just enough space for a bedroom, bath, living area, and kitchen. The design team equated residential living to a process, and determined to streamline the building to optimize lifestyle. The chosen design arranged spaces of the house in a linear fashion. The goal was to design a house that would be comfortable, pleasing, restorative—in a word, livable.

In virtually every aspect of the design, the display of systems became a priority. The building shell, for instance, was composed of relatively thin, pure planes. The only interior partitions were around the bath and bedroom. The itinerary through the house was designed to expose visitors to all of the spaces of the house and many of the building's systems, including the solar array, solar hot water system, and building automation system.

System Integration

A major design strategy was to highlight the integration of active solar, passive solar, building envelope, and spatial systems. The solar array, for example, took on additional roles beyond its mandate to produce energy; it was used as a façade system. The requirements of the array (i.e., that it be tilted to maximize electrical production) deformed the shape and ultimately the interior of the house, affecting the composition and the experience of the house. The solar array also acted in conjunction with the shell design to provide a thermal barrier for the home, which helped to keep the home quite cool by absorbing the radiant energy from the sun.

Energy Efficiency

One important design determinant was to ensure the house would be as energy efficient as possible.

The first strategy for energy efficiency was the recognition that the solar house had very little volume compared to its surface area. Such a configuration would be prone to overheating. The student team determined that passive heating strategies would by-and-large be unnecessary, but passive cooling strategies would be important. In essence, the building would turn its back to the sun, and use its southern façade as the main solar collection system. The home was constructed of structural insulated panels (commonly called SIPs). Its roof and south face were clad in metal, which reflected and emitted a significant amount of incident solar radiation. Moreover, nearly the entire south wall was covered in solar panels mounted to the seams of the metal roof, providing almost complete shading to this surface. Building simulation software demonstrated that virtually all of the building's cooling needs were accounted for by these passive features.

Daylight

Daylighting was also stressed, not only as a way to decrease the need for energy but also as a design feature. Almost all apertures were shielded in some way from the sun, as direct solar gain was not desired. The majority of windows were along the building's north façade. Two different types were used. Large casement windows in the public areas of the home allowed a close connection to the site, while smaller fixed units floated within the SIPs to light the short hallway and bedroom. These windows were placed behind the polycarbonate that wrapped around the west, north, and east façades of the home, allowing for light without direct view. The sharp distinction between the two window types underscored the separation between public and private zones.

Skylights were another important part of the house's daylighting strategy. As the roof was relatively flat, skylights over the bedroom and kitchen area delivered a great deal of light to these areas. Heat gain and loss were considerations here. Both skylights were made of polycarbonate panels rather than clear glass. The panels were filled with translucent insulation. This assembly is five times more resistant to heat flow than standard glass skylights.

Perhaps the most innovative daylight aperture was located in the southern façade. While the majority of the south wall was designed as the building's solar array, there was a desire to balance the northern apertures, which brought in cool northern daylight, with warm direct sunlight. The students devised what was termed a light shelf—a horizontal window set roughly three feet above the floor. The window was tucked underneath the solar array, and functioned as a reverse skylight; the area above the skylight was inside the bath and bedroom, while underneath was outside. The idea was that southern sunlight would strike the ground and be bounced up into the spaces above. Sunlight tends to shed much of its heat on the first surface it encounters, so the building would be able to collect light without additional heat. At the competition, a water feature was placed below the light shelf. Dappled, reflected sunlight tracked across the bedroom's south wall throughout the day.

Other Energy Efficiency Measures

Mechanical Engineering students modified a standard air-to-air heat pump with a variable velocity fan, regulated by sophisticated sensors. These sensors were keyed to automatic dampers that could open and close as various rooms required conditioning or ventilation, which in turn ensured that the HVAC system would only deliver what heating or cooling was necessary. Built-in appliances by Bosch were chosen specifically for their energy efficiency.

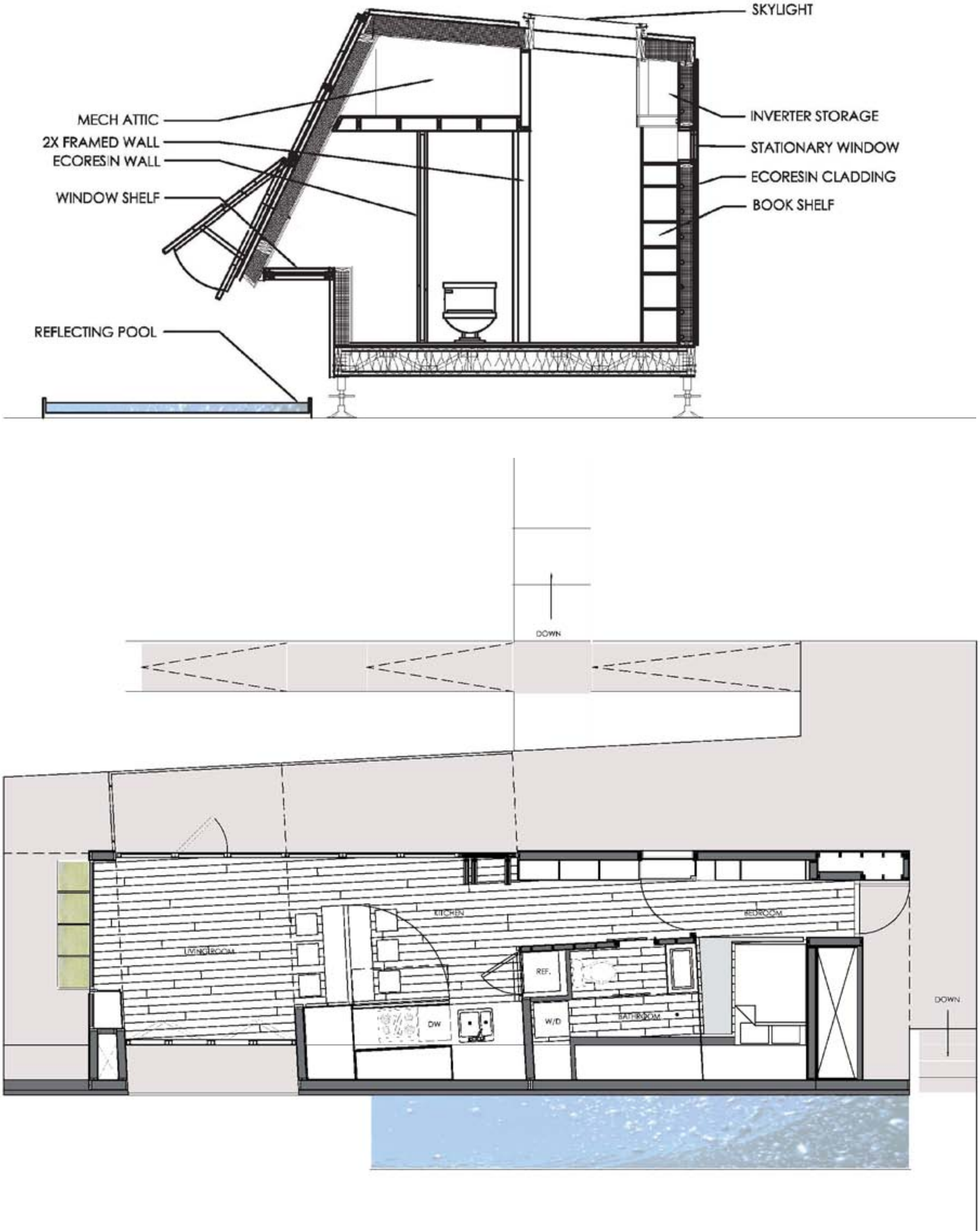
Energy Simulation as a Design Tool

The team used simulation software to model the energy loads of the house. The projected annual energy demand of the house was 7,013 kilowatt hours (kWh). The team compared this to a baseline case—a conventionally constructed house of similar dimension. The baseline would use 10,145 kWh. The energy efficient solar house, therefore, used 32 percent less electricity than conventional construction. This type of analysis introduced a layer of informed intent most students had little prior exposure to, namely that the performance of a building is well within the control of its designers. The photovoltaic team used these figures to design the size of the solar array.

Sustainable Materiality

Project Solar House's basic approach to sustainability was to reduce the building's overall resource

Project Solar House—as envisioned during the design process in section and plan (refer to section and floor plan notes).



Project Solar House—under construction in Manhattan, Kansas (structural insulation panels and battery bank).

footprint, or impact of the home on all available resources. This approach embraced the idea of energy efficiency, but went beyond this to include minimizing the energy embodied in the home itself. The house incorporated many materials manufactured from waste products of other processes. A major finish material, for example, was siding reclaimed from an old barn. All new finish wood surfaces were supplied from sustainably harvested forests. The bathroom tiles and countertop were made of red and clear EnviroGlas, a terrazzo-like product that uses recycled glass as an aggregate instead of marble or stone chips. The kitchen counter is of the same material, but with dark glass.

For additional information and images on the KSU Solar House see http://solarhouse.capd.ksu.edu/.

Project Solar House—as envisioned during the design process in hand-crafted model by KSU students.

Project Solar House—at the Solar Decathlon competition at the National Mall in Washington, D.C. in October 2007.

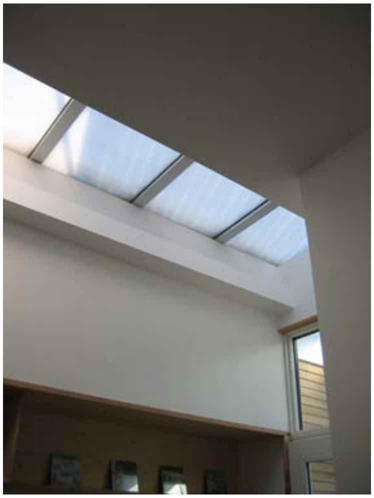
Images of Project Solar House—Exterior Conditions.

North façade of solar house. On the left is the private zone, containing the bedroom, bath, and a small hallway. Daylight apertures are just visible here, behind the layer of polycarbonate that is the finish surface of the home. To the right are the dining and living areas with multiple windows and doors for connection to the exterior.

South-west view (south façade). The solar wall extends past the west and east faces of the building, providing additional shading for these walls. The south wall is canted to provide maximum wintertime solar collection. The two bottom rows of panels can be seasonally adjusted. The 6.37 kW solar array provides more than enough power for normal household activities.

Students mount the solar panels before the competition begins. The panels are clipped directly to the seams of the metal roof, totally integrating the array as a building finish.

Images of Project Solar House—Interior Conditions.



Bedroom skylight. The skylight is filled with translucent insulation, allowing light through while minimizing heat transfer. The shadow on the aperture is cast by the solar hot water system, further diminishing heat gain.

Kitchen. The skylight here coupled with the north windows in the dining area obviated the need for artificial light during the day. All appliances were chosen based on their energy efficiency.

Hallway. The north façade of the hall and bedroom (beyond) were made a storage wall, built around the translucent north apertures. This heightens the separation between the exterior of the building and these private spaces. Most of the building's electronics are housed in the cabinets here.

Project Team

R. Todd Gabbard supervised KSU's Project Solar House along with Larry Bowne; both were assistant professors of architecture at the time. The team also received help from Ruth Miller, an associate professor of electrical and computer engineering. Steve Davidson and Rod Troyer (interior architecture faculty) also played a role, as did nine of their students. Twenty-two architecture students and two landscape architecture students played key roles in design and construction efforts.

Section and Floor Plan Notes

Cross section

Daylighting strategies are evident here. At left, the light shelf is visible below the solar array wall. A reflecting pool bounces south light up into the house. A polycarbonate skylight is filled with Aerogel, a type of translucent insulation. The north wall at right was conceived as a thick storage plenum. Several fixed windows allow north light in, though the windows are behind a layer of translucent polycarbonate to preserve privacy.

Floor plan

The house was a linear structure, designed to facilitate the morning and evening rituals of a working couple. They wake up, perform their morning ablutions, eat breakfast, and perhaps lounge for a bit before leaving for their daily activities. In the evening, the process reverses itself. The long, linear shape also facilitated transportation. The public spaces to the west (at left) are open, linked to the exterior decks and the site beyond. The private areas—the bedroom and bath—are protected from public scrutiny by layers of translucency and opacity.

Images of Project Solar House—Interior Conditions.

Dining area. Cabinets are made of ash veneer plywood made from formaldehyde-free glues. The crowds of visitors at the competition are visible outside. Operable windows allow for ventilation, one of the house's cooling strategies.

Living area. The doors at left lead to a south balcony, and are the only apertures directly exposed to the sun. All wood products are either salvaged barn wood or sustainably harvested hardwoods. All furniture was designed and constructed by interior architecture students, most of salvaged and recycled materials.

Bath. The colorful tiles are EnviroGlas, a product made of crushed recycled glass set in mortar. The ground and polished tiles resemble terrazzo. The bath is separated from the bedroom by a translucent wall, which preserves privacy while the light and shadows visible through the surface reduced the closed-in feeling of the tiny space.

Bedroom. The "light shelf" acts as a headboard for the bed. Dappled sunlight, reflected off a pool positioned below, brightens and animates the room.

Kitchen counter. The kitchen counter is made primarily of recycled glass.

REFERENCES

KBOR. 2007. "Inventory of Physical Facilities and Space Utilization, Fall 2006." Published by the Kansas Board of Regents, January 2007. Accessed online (23 August 2007): http://www.kansasregents.org/download/facilities/2006%20Complete%20Report.pdf.

KSU. 2006. "K-State Hazardous Substance Research Center Sponsoring Agricultural Sustainability Conference in California." July 25, 2006. KSU Media Relations New Release. http://www.k-state.edu/media/WEB/News/NewsReleases/sustain72506.html.

KSU. 2007a. "K-State to Be Host of Dialog on Sustainability." July 6, 2007. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/jul07/sustain70607.html.

KSU. 2007b. "An exercise in efficiency: K-State Pools Expertise with Center for Sustainable Energy." Oct. 23, 2007. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/oct07/energy102307.html.

KSU. 2008a. "K-State to Host Public Forums on Renewable Energy, Food and Sustainability." Jan. 3, 2008. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/jan08/forums10308.html.

KSU. 2008b. "Ben Champion to Direct K-State's Multiple Initiatives in Sustainability." May 12, 2008. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/may08/champion51208.html.

KSU. 2010a. "Conocophillips, K-State Center for Sustainable Energy Team Up to Reward Research by K-State Graduate Students." May 18, 2010. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/may10/sustainstudents51810.html.

KSU. 2010b. "K-State Becoming More Green as Sustainability Measures Take Hold." April 28, 2010. KSU Media Relations News Release. http://www.k-state.edu/media/k-statement/vol32/42810sustain.html.

KSU. 2010c. "Casey Lauer Joins K-State as First Director of Energy And Environment." May 18, 2010. KSU Media Relations New Release. http://www.k-state.edu/media/newsreleases/sept10/lauer90110.html.

The New York Times. 2010. "In Kansas, Climate Skeptics Embrace Cleaner Energy." October 19, 2010. http://www.nytimes.com/2010/10/19/science/earth/19fossil.html.

Green Roof References

Dvorak, B. and A. Volder. 2010. "Green roof vegetation for North American ecoregions: A literature review." *Landscape and Urban Planning* 96: 197-213.

Oberndorfer et al. 2007. "Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services." *BioScience* Nov. 2007 / 57(10):823-833.

Sutton, R.K. 2008. "Media modifications for native plant assemblages on green roofs." In: *Sixth Annual Greening Rooftops for Sustainable Communities Conference Proceedings*.

KSU Sustainability and "Sustainability Conference" websites

http://sustainability.k-state.edu/

http://sustainability.k-state.edu/conferences/2011/

http://sustainability.k-state.edu/conferences/2010/

http://sustainability.k-state.edu/conferences/2009/

http://www-proxy.engg.ksu.edu/chsr/sustainability/cesas/index.html

KSU Media Relations—Selected References

http://www.k-state.edu/media/webzine/green/index.html

K-State's International Student Center Rain-Garden

http://www.k-state.edu/media/newsreleases/april08/raingarden42508.html

Spring 2008 ISC Rain garden Podcast: "How a rain garden alleviates stormwater runoff."

For other Podcasts related to conservation and sustainability, refer to: http://www.k-state.edu/media/webzine/green/multimedia.html

K-State's Project Solar House

http://www.k-state.edu/media/webzine/green/solar.html

http://capd.ksu.edu/news-article/387/students-building-solar-house-for-national-contest

http://capd.ksu.edu/news-article/427/making-a-solar-house-a-home-k-staters-design-furnishings-for-dc-decathlon