



Green Infrastructure & Stormwater Management CASE STUDY

Performing Arts District Garage

Location: Kansas City, MO

Client: City of Kansas City, Missouri

Design Firm(s): Jeffrey L. Bruce & Company,
Reed Hilderbrand, Moody Noland Inc., Carl
Walker Inc., George Butler Associates

Landscape architect/Project contact:
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Company

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ASLA Chapter: Prairie Gateway



Project Specifications

Project Description: The Arts District Garage is a \$32 million, 1,000 car underground parking structure attached to the new Kauffman Performing Arts Center in downtown Kansas City, Mo. The green roof atop the structure is designed as a 2.63 acre open space park. The green roof component of the garage serves as the primary stormwater collection and detention system with the capability of collecting and detaining 50% of a 100-year storm event for the first 24 hours and the system will continue to detain 25% of the storm water for up to the next 66 hours before release into water harvesting cisterns.

Project Type:

Government complex
Part of a new development

Design features: Green roof and cistern.

This project was designed to meet the following specific requirements or mandates:

Local ordinance; local ordinances mandated a storm water detention facility for the garage, but did not mandate a green roof. This component of the design was envisioned by the landscape architect who provided the research data to determine the retention and flow characteristics of the growing media and demonstrated meeting the storm water ordinance requirements with alternative means.

Impervious area managed: 1 acre to 5 acres

Amount of existing green space/open space conserved or preserved for managing stormwater on site: 1 acre to 5 acres. The green roof is the creation of 2.63 acres of new valuable public open space within the core of downtown Kansas City, Missouri. The entire "on-structure" green roof is the first such green roof permitted by the City of Kansas City as a stormwater detention facility.

The regulatory environment and regulator was apprehensive about the project.

Did the client request that other factors be considered, such as energy savings, usable green space, or property value enhancements? The green roof was defined during the initial design development phase of the Kauffman Performing Arts Center. The parking garage is not classified as an occupied space and is not heated, therefore energy savings associated with the benefits provided by a green roof do not apply and was not a factor in the design. However, the 100,000 gallon cistern when used for irrigation represents 140 tons of evaporative cooling mitigating the impact of urban heat island in the city core. Considering the area of the green roof and the evapo-transpiration potential of the site, the green roof represents the 3,865 tons of evaporative cooling potential on an annual basis.

Cost & Jobs Analysis

Estimated Cost of Stormwater Project: >\$5,000,000 (Public funding: Local. As a Kansas City, Missouri owned and operated facility all construction costs were publicly funded by bonds which are to be paid back through parking revenue.)

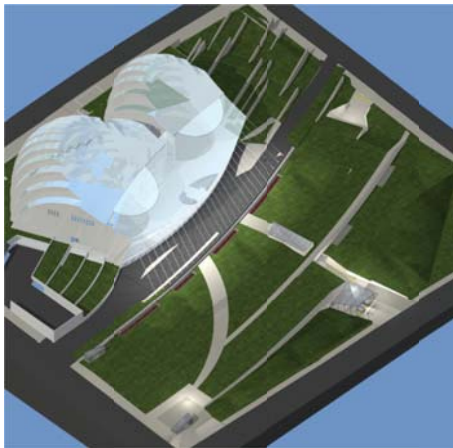
Related Information:

- i. The green roof component of the Arts District Garage was \$2.3 million of a total \$32 million parking garage project.
- ii. Structural foam ranging in depth from 12" to 8' was placed over waterproofing membrane; estimated cost \$910,000
- iii. A subsurface roof drain collection system combined with limited surface collection systems were routed to 2 - 50,000 gal underground cisterns at a cost of \$290,000.
- iv. A fiber reinforced 6" deep sand base was used as the growing medium for the turf grass surface as well as 4' to 5' deep tree planting pits on roof.
- v. A fully automatic irrigation system was installed with booster pumps to distribute the collected harvested stormwater from the cisterns.
- vi. The vegetated green roof consists of high performance turf surface and vegetated slopes of native grasses.
- vii. The hardscape included concrete pavers on reinforced sand, concrete seat walls and concrete paver ramps providing handicapped access into and across the site.

Was a green vs. grey cost analysis performed? No; however the green roof eliminated the need for a traditional stormwater detention facility which was estimated at \$348,000. This project savings allowed for the funds to be redirected toward the purchase of a \$290,000 water harvesting system. The remaining savings helped defer the cost of the green roof.

Cost impact of conserving green/open space to the overall costs of the site

design/development project: This was a unique project in that the existing site had been a mix of heavily paved urban fabric within the city's core and was part of a much larger Performing Arts Center (PAC) redevelopment. Looking at the predevelopment conditions, there was no quality open space available to preserve on site. The current development efforts of the PAC actually created 2.63 acres of highly visual and functional urban open space for public use and enjoyment where none existed previously. The overall design concept for both projects was created during the design development phase for the Performing Arts Center which established the requirement for open space as a green roof on structure and became part of the original project budget. Conservation or preservation of the existing space was not considered as an option for this project.



Cost impact of conserving green/open space for stormwater management over traditional site design/site development approaches (grey infrastructure)?

Significantly reduced costs (10% or greater savings). A complete analysis of the pre and post construction storm water runoff quantity was submitted by the project civil engineer who stated the pre-construction runoff quantity was 68 cubic feet per second (cfs) for the entire project site. A traditional subsurface collection and detention structure that would collect the 100 year storm event reducing the post construction runoff quantity to the city requirement of 35 cfs was estimated to be \$348,000. Use of the green roof reduced the actual post construction stormwater quantity to less than 15 cfs, greatly exceeding the city requirements. The cost of the land required to meet the city's requirements with traditional methods and the increased reduction of stormwater impact in the combined sewer overflow area were never calculated, but is considered to be substantial.

Based on the landscape architects' estimate, using the green roof as the project storm water detention facility and harvesting excess capacity in a cistern for irrigation usage will save the City an estimated \$52,000 per year in potable water costs. Another public benefit to consider is the cost to acquire 2.63 acres of land in the downtown core to provide comparable open space is \$2.8 million dollars which is cost which was avoided by implementing the green roof.

Number of jobs created: The end product is an open space which will need to be maintained by either a maintenance company contracted by the city or the Performing Arts Commission. It is difficult at this time to determine actual job creation for this feature of such a large facility.

Job hours devoted to project:

Planning and Design: 1,200 (landscape architect)

Construction: 600 (landscape architect)

Annual Maintenance: Annual maintenance contract is currently being bid.

Performance Measures

Stormwater reduction performance analysis:

As this project is just completing construction with this submittal, the performance analysis is based on data gathered under laboratory conditions. Using the sand based media mix designed for the green roof a mock-up of the green roof profile was created to mimic as built conditions. Moisture sensors were placed within the soil profile to measure moisture density and flow characteristics within the soil media. Using the Kansas City storm water design parameters which mandate retention of the first 25% of a 100-year storm event, the lab simulated a 3" storm event within a 25-minute time period, thus exceeding the City requirements. The water flow was tracked through the sand based profile via the moisture sensors and the subsurface runoff was collected and measured at 15-minute intervals to calculate the actual quantity of water released. This experiment was conducted under two scenarios; one with the sand based soil in a saturated condition and the second with the soil in an unsaturated condition. The measurements were documented over a 120-hour period with the following results:

- 50% of the storm event was retained within the soil profile for the first 24 hours.
- 25% of the storm event was retained within the soil profile for 66 hours before the soil moisture content returned to an unsaturated condition.

Based on this data storm events such as the 2, 10, and 25-year storm events would be retained in the soil making the water available to the plant material or slowly draining to the collection system when the soil profile is in an unsaturated condition thus eliminating runoff. With the addition of the 2 cisterns the storm water would be collected and returned to the green roof for reuse as irrigation water.

The storm water calculations prepared by the civil engineer for submittal to the city also documented the overall storm water reduction of the 100-year storm event to less than 5 cfs versus the original pre-construction projection of 65 cfs and the city requirement to reduce storm water to 35 cfs.

Community & economic benefits that have resulted from the project: The benefits to the community will be the addition of a new open space park within Kansas City's downtown area. It will provide a new venue for patrons of the arts by providing landscaped lawn areas for arts and crafts events and well as outdoor on the lawn concerts. Additionally, the reduction in storm water runoff to an aging city storm water system helps to improve the capacity of the existing combine sewer system.

Additional Information

Links to images: http://www.jlbruce.com/b_projects/l-arch/KCPA.pdf

The Arts District Garage green roof is the first green roof project in the State of Missouri which has been permitted as a stormwater detention facility. It provides life cycle cost savings by increasing the life of the waterproofing membrane, reducing water cost for the irrigation system and provides a pristine open space within the urban landscape. The creation of this green roof open space also provides a storm water detention facility which greatly exceeds the local storm water requirements and serves as part of the structure's infrastructure.

The most impressive aspect of the solution is the potential to greatly reduce if not totally eliminate stormwater runoff from a 2.63 acre site within the urban core of Kansas City. This project will capture the majority of the excess water from the green roof and use it for irrigation in which will be transpired or evaporated from the landscape.

In the traditional sense engineers have discussed storm water BMP benefits in terms of reduced volume, which really meant a reduction in peak flow, with the majority of the water eventually finding its way back into the system for treatment. This green infrastructure solution represents true volume reduction though evaporative cooling with an evapo-transpiration (ET) potential of 37.44 inches per year. Considering the area of the green roof the potential storm water volume reduction or elimination due to ET is in excess of 2.8 million gallons of water or 8.2 acre-feet of water on an annual basis. This solution achieves significant volume "elimination" from the combined sewer system. We are currently seeking funding sources for monitoring so that these calculations can be verified and calibrated.