Stormwater Green Infrastructure Installation at the Edible Campus Garden

Medium SCIF Grant Proposal

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PROJECT SUMMARY

The Sustainable Campus Initiative Fund at the University of Utah has the opportunity to make a student-initiated project economically feasible while solving an existing problem on campus. This project involves installing a bioswale to mitigate flooding issues at the Edible Gapus Garden. The primary focus is to improve the productivity and functionality of the Edible Campus Garden but the project will also provide notable environmental, ecological, and social benefits.

The primary function of a bioswale is to filter runoff through biofiltration of above ground vegetation and bioretention achieved by an application of engineered soil above the native soil. A high degree of effectiveness has been noted for retention and removal of oil and grease in runoff that is retained in bioswales.[1] Bioswales are also effective to a lesser extent for mitigating sediment, nutrient, metal, and bacteria pollution in runoff.[1] In addition to improving garden productivity and operations, this project will provide other valuable benefits. An improved water catchment design will replace a rudimentary trench the garden staff and volunteers dug out of necessity in the fall of 2022 that has raised safety concerns for pedestrians. This project also presents educational opportunities by way of signage along the walkway and/or near the public benches and picnic tables in the garden. Lastly, retaining rainwater in close proximity to the planting rows is very likely to reduce the irrigation demands from that portion of the garden. Managers of the campus garden have the potential to utilize the bioswale for plants that benefit from the moisture laden growing conditions of the green infrastructure design.

PROJECT CONCEPT

Statement of Need

The Edible Campus Garden is an important part of the University of Utah's campus. It was established in 1996 and facilitates access to healthy, fresh food options that are distributed to the community for free, to university dining services and other campus vendors, and donated to the Feed U Food Pantry. The flooding issue in the southeastern corner of the garden is reducing the square footage of plantable land, therefore reducing potential garden yields. In addition to food resources, the garden also provides opportunities for students and faculty to conduct research and educational opportunities regarding sustainable gardening practices. Furthermore, the garden's public area that is equipped with benches and tables provides people with a space to relax and connect with nature. For these reasons, it is important that the garden receives the attention and investment needed to restore it to its fully functional state.

Existing Conditions

The surface of the southeastern corner of the community garden is predominantly exposed soil. The layer of bark chip mulch that is intended to cover it has been washed down slope (west) as the stormwater initially pools against the paved sidewalk and then flows toward the interior of the garden. Based on information from previous garden team members, stormwater covers up to seven garden bed rows with significant water (Images 1 and 2) and persists for about a week after precipitation events. In addition to runoff from the surrounding sidewalks, the downspout near the doors on the west side of the Henry Eyring Building has been identified as a significant source of water flowing into the garden (Image 3, 4, and 5).

Image 1. Seven garden rows are consistently flooded with standing water for approximately a week after a storm. Photo taken March 2023.

Image 2. Seven garden rows are consistently flooded with standing water for approximately a week after a storm. Photo courtesy of Meghan Burrows, summer 2022.

Images 3, 4, and 5. Stormwater from the downspout located to the left of the entrance to the Henry Eyring Building drains across the sidewalk and ultimately into the garden. Image 6 was taken while standing on the edge of the garden. All photos taken April 2023.

The garden has always experienced moderate amounts of flooding from stormwater runoff in the southeastern corner. In recent years, the paved area immediately adjacent to the garden was expanded, causing flooding to intensify. According to garden staff, the flood waters take about a week to infiltrate and evaporate, rendering seven of the garden rows unusable and limiting access to the shed holding garden tools. The delay in infiltration is indicative of a greater percentage of fine soil or clay composition in the native soil. We are proposing the construction of a bioswale in the southeastern corner of the garden plot that will catch stormwater runoff and allow it to filter into the soil without compromising the growing space available to the garden.

PROJECT SPECIFICATIONS

Stormwater Green Infrastructure Solution

This grant will allow the garden to install a bioswale on the southeastern corner of the garden to mitigate the flooding that renders a large portion of the garden beds unusable for multiple days after a storm (see Image 6). A bioswale with a crushed rock layer below the soil medium is the most appropriate design for this space due to the challenges of containing a large volume of water in a relatively limited area. The design will be similar to those depicted in Images 7 and 8. Underground water retention maximizes the effectiveness of the swale while also providing a water source for plants with longer tap roots to access which reduces the need for artificial watering during drier periods. This proposal is informed by the successful use of a similar design in a bioswale at the southeast corner of the Hedco Building.

Image 6. The area currently subjected to problematic flooding is shown in blue. The proposed project will utilize the area shown in green.

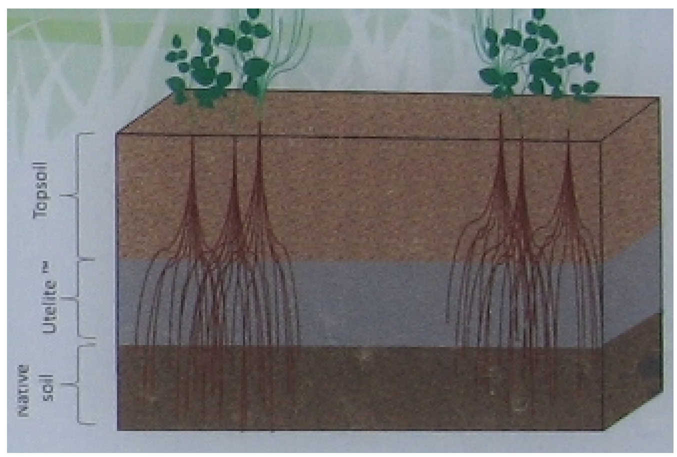

Image 7. The project design will informed by other successful bioswales on campus and use a layer of crushed rock to maximize below ground water storage area. https://www.escsi.org/e-newsletter/bio-retention-rain-gardens-at-the-university-of-utah/

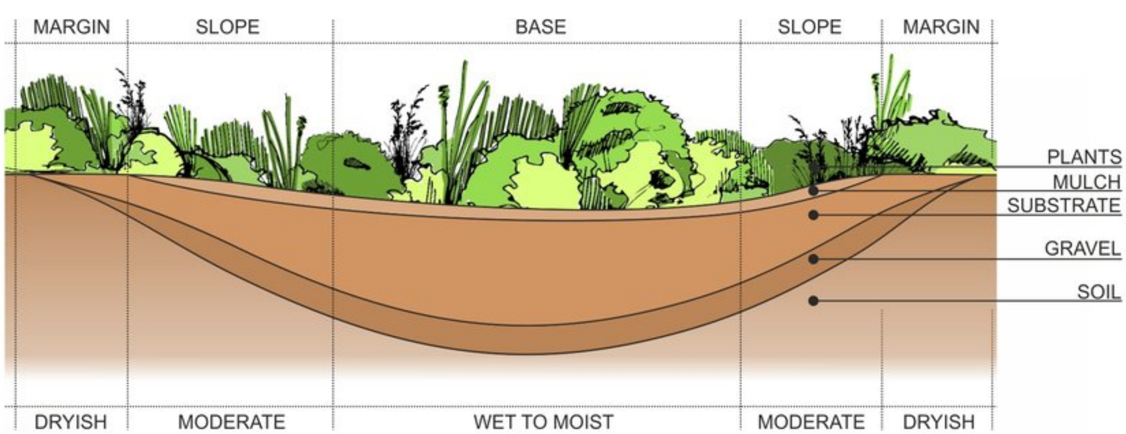

Image 8. The shape and materials of the proposed bioswale in the community garden will be similar to that seen here. Image from https://www.researchgate.net/figure/Layers-and-moisture-zones-of-a-rain-garden-Modified-from-Yuan-and-Dunnet-2018_fig5_354859712

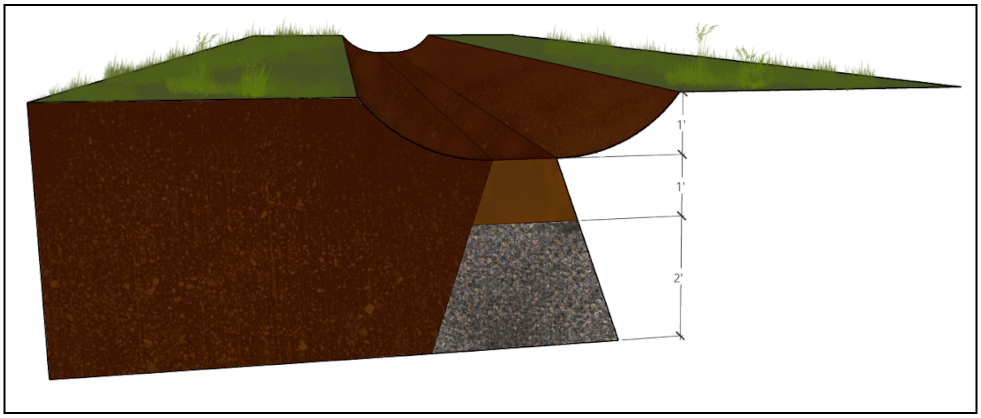

Image 9. 3-D Diagram of Proposed Bioswale on the southeast corner of Pioneer Garden. Image from: Taylor Maguire.

Design

Considerations taken into account for this design involve the project space, maintenance access, public safety concerns, and utility conflicts.[1] Other concerns relate to the quality of soil infiltration, proximity of the bioswale to existing structures, and the height of the groundwater table.[1] Prior to implementation of the design, a survey would be needed to ensure the depth of excavation would not impact any underground pipes or other utility lines. Additionally, the depth of the water table should be assessed to ensure undue flooding is avoided or unintentional pollution of groundwater.

All calculations below were adapted from guidelines and recommendations in a Department of Environmental Quality (DEQ) guide to low impact development within Utah.[1] The basic design approach involves understanding the water quality flow, the geometry of the bioswale's cross-section, flow depth, corresponding volume retention, and resulting flow velocities and residence time of water in the bioswale.[1] The area of nearby pavement and contributing rooftop drainage is calculated to understand impervious sheet flow into the garden. Google Earth area mapping feature was used to determine the total area of the project site and the surrounding drainage zone. Then the ratio of impervious to pervious area was determined.

$$A_{total} = A_{project\ site} + A_{impervious} + A_{pervious}$$
$$3,361\ m^2 = 51.5\ m^2 + 2,234\ m^2 + 1,345.5\ m^2$$
$$Contributing\ drainage\ area\ (A) = 0.885\ acre$$
$$Impervious\ ratio\ (I) = 0.552\ acre / 0.885\ acre = 0.62$$

The 80th percentile storm depth must also be accounted for when designing a bioswale system to find the goal volume to be retained over a 24-hour period during an 80th percentile storm event. For the University of Utah this is a corresponding storm depth less than or equal to 1.00 inches, with a depth of 0.55 inches generally in Salt Lake County.[1] These figures allow for determination of the volumetric runoff coefficient (R_v). The volumetric runoff coefficient when applied to a 2 year, 6 hour storm intensity (i)(0.169 in/hr) gives a value for overall water quality flow (WQF) in cfs that drains into the bioswale.[4]

$$R_v = 1.14(I) - 0.371 \; (Granato\ method\ when\ I \geq 0.55)$$
$$R_v = 1.14(0.62) - 0.371 = 0.34$$
$$WQF = (R_v)(i)(A)$$
$$WQF = (0.34)(0.169\ in/hr)(0.885\ acre) = 0.05\ cfs$$

Slope and depth of the intended bioswale will give a flow depth capacity for the bioswale. Area constraints at the edible campus garden mean that a narrow channel will be implemented with a horizontal bottom width of 2 ft along the longitudinal length of the bioswale. The upper portion of the bioswale may have to be 1 ft wide and can transition to 3 ft wide at the bottom portion of the bioswale. Adherence to recommended guidelines of a longitudinal slope of 2% will be used for this bioswale implementation.[1] Side slopes of 2 ft H:1 ft V is the maximum slope recommended, but is necessary because of space constraints.[1] Flow depth of water during a design storm event with flows of 0.05 cfs is determined through Manning's equation. A Manning's coefficient (n) value of 0.022 was determined for this design as it corresponds to clean, excavated Earth channels.[2] The trapezoid shaped channel would have a cross-sectional area of 4 ft^2, and a fully possible wetted perimeter of 6 ft, with a corresponding hydraulic radius of 0.67 ft. Given these parameters:[3]

$$Q = \frac{1.49}{n}(A)(R)^{2/3}\sqrt{S} \; (Manning's\ Equation\ Formula)$$
$$0.05\ cfs = \frac{1.49}{0.022}(4ft^2)(0.67ft)^{2/3}\sqrt{0.02} = 0.36\ inch\ uniform\ depth\ in\ channel\ (y_d)$$

The projected flow in cfs (0.05) divided by the cross sectional area of the bioswale with a uniform depth of water (0.36 in) must be less than a velocity (v) of 1 ft/s.[1] The velocity in the system can than be compared against a minimum hydraulic residence time requirement (5 minutes) to provide a minimum longitudinal length (L_{min}) for the intended bioswale.[1]

$$v = Q/A$$
$$v = (0.05\ cfs\ /\ 0.06\ ft^2) = 0.83\ ft/s$$
$$L_{min} = (0.83\ ft/s)(300\ s) = 249\ ft$$

This recommended length is not feasible for the project site at the edible campus garden, where restrictions in longitudinal length are approximately 52 ft from top to bottom. However, these approximated calculations make assumptions about the drainage area that stormwater originates from and may be overcalculating stormwater runoff flows or storm precipitation intensities. These equations also make assumptions for a uniform bottom channel width of 2 ft, whereas in reality the channel will broaden in width from top to bottom of the channel. All figures will need to be reviewed by an engineer prior to design implementation. The channel will be 1 ft deep and have the capability of holding a large volume of water with plans for an extensive drainage layer of crushed gravel below the surface of the channel to aid infiltration. General approximations based on these dimensions would allow for 125 cubic feet of storage with a uniform water depth of 6 inches in the bioswale. Issues may emerge if runoff flows are prolonged or if the drainage layer is not able to accommodate enough volume of water to prevent overflow. Residence times of water in the bioswale under 5 minutes may help to accommodate for the decreased proportions of the bioswale but that runs counter to guidelines as it reduces biofiltration goals or may be physically impossible depending on drainage parameters.

The excavated channel will have to account for an open air depth of 12 inches for potential water in the bioswale and freeboard. Additionally the channel will be designed to have 24 inches of crushed gravel as a drainage layer and another 12 inches of bioretention media (soil retained from excavation) as a top layer. This corresponds to a total excavated depth of 4 ft for the bioswale.

For vegetation purposes, the University of Utah is generally in the 6a-7b range for plant hardiness zones.[5] The DEQ guide suggests various trees, shrubs, grasses, perennials, or groundcovers that are adapted for various hardiness zones as well as the plant's ability to be utilized in various green infrastructure systems such as bioswales.[1] It is recommended that native and drought tolerant perennial species be prioritized for planting. Ultimately, the campus edible garden management will have final approval for any plants implemented in the proposed bioswale solution since they will maintain it in addition to the rest of the garden.

Installation Costs & Activities

Installation of the bioswale at the edible campus garden may be impacted and have to be delayed until or after Fall 2024 because of ongoing construction in buildings on lower campus. Staging for these construction efforts are located in a fenced off zone immediately adjacent to the campus garden.

Typical installation of this kind of project involves an excavator to create the initial bioswale trench. The subsurface is then backfilled with an underdrain system, engineered soil, etc. Grading is done to achieve desired slope for the longitudinal and horizontal profile. It is important to avoid any compaction of underlying native soil to prevent reduced infiltration of the bioswale.[1] A stormwater management plan for containment of sediment will likely be needed to prevent erosion and soil pollution in active runoff during the construction process. This can be achieved by maintaining a perimeter of silt fences around the construction area.

Costs will be related to labor expenses, although some of this may be mitigated by efforts of students involved as volunteers/collaborators in the completion of the SCIF grant/project. Labor activities involve excavation, grading, and landscaping.[1] Excavation represents one of the largest expenses due to the necessity of heavy machinery and disposal costs of any soil that cannot be reused as infill over the lower drainage layer. Material costs pertain to the crushed gravel used for drainage and soil in the top layer for planting. Some of the soil that is excavated may be reused as the top layer on top of the drainage gravel. Costs may be needed for other stone, mulch, geotextile fabric or liners. If needed, other costs relate to observation wells for determining the depth of the groundwater table, piping for underdrain systems, or above ground outlets/bypass structures.[1] However, this project is intended to be minimal in nature due to the small scale of the project area and rely primarily on a deep drainage layer below the surface of the bioswale to promote effective soil infiltration without other drains or outlets.

Promotion and Education

Opportunities exist for educational signage to be installed at the location of the garden bioswale. Signage can be designed to be cohesive with existing sustainability projects and messages found on campus (Image 10). The focus should be on the role of bioswales as an alternative from traditional stormwater management which seeks to convey high velocity flows off site via gutters and drains as directly as possible.[1] Instead of polluted runoff impacting aquatic life in natural creeks and rivers, the runoff is slowed, retained, and filtered of pollution. The reduction in high flows following storm events also helps to mitigate urban stream syndrome in natural waterways. Economic benefits in the form of less stormwater management and engineering construction are complimented by other practical and aesthetic benefits. These efforts contribute to an expanded focus of campus as a living lab where sustainability is seen as achievable and of critical importance. Signage can also expand on the design of bioswales and the type of plants that garden managers intended to maintain on site.

Image 10. Signage example from a similar stormwater management SCIF project installed near the southeast corner of the Hedco Building.

Planting & Maintenance

The garden staff will be responsible for the selection and planting of any vegetation as well as regular maintenance of the new plants. Edible perennial plants have been recommended as a way to maximize the space for the garden's primary purpose of growing food while still maintaining the integrity and functionality of the bioswale. Maintenance activities will include initial watering to ensure plant establishment, weeding, reseeding or replanting of vegetation in bare areas of the swale, infrequent regrading of side slopes, removing trash or other debris, and monitoring any standing water within the swale after storm events.[1]

Image 11. Potential site for a second bioswale to further flood mitigation. Photo taken April 2023.

Future Phases

The goal of this bioswale is to provide immediate relief to the most severe impacts of the flooding at the campus garden. Given the physical space constraints in which we can construct the bioswale, it is possible that future measures may need to be taken to mitigate all flooding from stormwater runoff and completely resolve the issue. Because all runoff is flowing across the impervious sidewalk, future alterations should be considered to decrease hard surface concrete adjacent to the location of the bioswale and utilize garden pavers or other pervious surfaces.[1] Alternatively, improvements could be made to the management of stormwater originating from the downspout on the west side of the Henry Eyring Building (Images 3, 4, and 5) by way of a secondary bioswale along the opposite side of the sidewalk (Image 11). These individual changes or a combination of them would contribute to less sheet flow and runoff into the garden and improve soil infiltration.

CONCLUSION

The existing need, relative ease of construction, and multifaceted benefits of a bioswale installation at this site make this project a strong candidate for SCIF grant funding. Without a permanent solution such as what is outlined in this proposal, the Edible Campus Garden will continue to be less productive, functional, and safe than it otherwise could be. A bioswale in the southeastern corner of the garden will enhance existing conditions in the garden and transform the way the site handles stormwater. It will also turn an area that is currently not viable for planting into an area where perennial food producing plants will thrive, supporting the mission of the garden. Lastly, the bioswale will serve as an important educational feature where students can learn about sustainable stormwater management through green stormwater infrastructure.

REFERENCES

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4. *PF Map: Contiguous US*. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ut.
5. *USDA Plant Hardiness Zone Map*. https://planthardiness.ars.usda.gov/.