A Case for Educational Communication on Sustainable Stormwater Management Sites Using Interpretive Methods: Applications for Utah State University

Lilian Taft
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/gradreports

Part of the Environmental Design Commons, Landscape Architecture Commons, and the Urban, Community and Regional Planning Commons

Recommended Citation
https://digitalcommons.usu.edu/gradreports/1735

This Creative Project is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Plan B and other Reports by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.
A Case for Educational Communication on Sustainable Stormwater Management Sites Using Interpretive Methods: Applications for Utah State University

by

Lilian Taft

A project submitted in partial fulfillment of the requirements for the degree of

MASTER OF LANDSCAPE ARCHITECTURE

Approved:

_______________________
Jake Powell
Major Professor

_______________________
David Anderson
Committee Member

_______________________
Erin Rivers, Ph.D.
Committee Member

_______________________
D. Richard Cutler, Ph.D.
Vice Provost of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah
2023
# Table of Contents

**Introduction** .................................................................................................................................................. 3  
**Chapter 1: Literature Review** ....................................................................................................................... 6  
- Urbanization and its effect on stormwater .............................................................................................................. 6  
- The role of landscape architects in stormwater management .................................................................................. 11  
- Stormwater in the Intermountain West ................................................................................................................ 13  
- Education in green stormwater infrastructure design ........................................................................................ 15  
- Green stormwater infrastructure as Artful Rainwater Design ............................................................................ 17  
**Chapter 2: Research Methods** .................................................................................................................... 23  
- Research Question and Objectives .................................................................................................................. 23  
- Applying existing research techniques to the Intermountain West ....................................................................... 23  
- Methods Overview ............................................................................................................................................... 25  
- Case study selection process .......................................................................................................................... 26  
- Case study methodology ...................................................................................................................................... 30  
- Signage design .................................................................................................................................................... 31  
- Education in Green Stormwater Infrastructure: digital guide creation ............................................................... 35  
**Chapter 3: Results** .......................................................................................................................................... 37  
- Case study locations ............................................................................................................................................ 37  
- Case study reports ............................................................................................................................................... 39  
- Interpretive signage .............................................................................................................................................. 50  
- Education in Green Stormwater Infrastructure: a digital guide ........................................................................ 53  
**Chapter 4: Recommendations and Limitations** ........................................................................................... 55  
- Limitations of the case studies ........................................................................................................................ 55  
- Recommendations for future research or design ............................................................................................... 57  
  - Dedicated stormwater management team ........................................................................................................ 57  
  - Increase the breadth of case studies .................................................................................................................. 57  
  - Observe the usage of the designed signage over time .................................................................................... 57  
  - Review and revision of digital guide ................................................................................................................ 58  
**Chapter 5: Conclusion** .................................................................................................................................. 59  
- Significance for site users ................................................................................................................................... 59  
- Significance for the field ...................................................................................................................................... 59  
- Summary ........................................................................................................................................................... 60  
*Educational Communication Guide* .................................................................................................................. 63  
*References*......................................................................................................................................................... 101
Introduction

As humans continue to develop natural landscapes into urban environments, there is a decreasing ratio of permeable to impermeable surfaces, reducing the opportunity for precipitation infiltration and increasing stormwater runoff. The runoff generated on urban surfaces must be managed in a sustainable manner to reduce impacts on urban water bodies, and landscape architects play a critical role in the design of sites that effectively and sustainably manage stormwater.

Though the process of stormwater management is understood by professionals such as engineers, city planners, and landscape architects, there remains a disconnect in the public understanding between the stormwater runoff that empties into storm drains and the natural environments into which it empties. To fill this gap, stormwater management site design techniques are evolving into more visible, sustainable methods that celebrate and highlight stormwater, rather than channel it underground, out of sight.

A design approach coined by Stuart Echols and Eliza Pennypacker (2008) as Artful Rainwater Design (ARD) highlights stormwater as a resource through the use of green infrastructure spaces that treat stormwater onsite and create stormwater management sites with community value. Among other goals, ARD aims to educate the public on the processes of stormwater management and the impacts of stormwater on urban water bodies and watersheds. A unique aspect of ARD when compared with other green stormwater infrastructure (GSI) site design approaches is its intention to provide educational amenity through intentional design of space and landscape.
This approach to education through deliberate design of spaces makes this technique suitable for use by landscape architects and similar professionals. Because of this, the techniques and work pioneered by Echols and Pennypacker are applied to this study of educational communication on GSI sites. Echols and Pennypacker (2008) identify three key objectives that a stormwater management site provides to successfully educate the users of the site on stormwater and the purpose of the project:

- Ideas to Learn: concepts that should or could be taught in the design
- Ways to Learn: how to educate about those concepts
- Context for Learning: creating an interesting, engaging and/or interactive learning environment.

These three objectives were found to be common traits among the original case study designs examining ARD projects that created an effective educational environment. However, these objectives are not widespread in green stormwater infrastructure design, and their integration into new and existing green stormwater infrastructure sites is not common practice.

The purpose of this study is to use the three objectives to design educational communication tactics (such as design decision, signage, displays, artwork, and/or demonstrations) for an existing green stormwater infrastructure site on Utah State University’s (USU) Logan campus. The design utilizes information gathered during the evaluation of existing university campuses’ GSI sites and their educational communication of stormwater management. In addition, there is an accompanying design manual to be used as a guide for landscape architects and campus facilities departments in the Intermountain West who would
like to integrate educational communication into the design of green stormwater infrastructure sites on university campuses but have no existing examples to follow or guides to reference.
Chapter 1: Literature Review

Urbanization and its effect on stormwater

The Intermountain West is experiencing rapid growth and this, compounded with prolonged periods of below-average rainfall, is putting extreme emphasis on the value of water. The US Census estimates that from 2010-2019, Utah’s population increased by 16% and is expected to double by 2050 (Harbeke, Garbett, Matsumori, & Kroes, 2014). Much of Utah’s growth has been concentrated in urban centers, with the highest growth rates occurring along the Wasatch Front and in Washington County (Harbeke et al., 2014; “U.S. Census Bureau QuickFacts,” n.d.). Landscape architects play a critical role in population growth. Whether it is in designing small-scale residential properties, working on master planned communities, planning large-scale business campuses, creating downtown revitalization plans, and assisting with other projects, the work of landscape architects is necessary in the design and development of the complex urban environments in which the growing population will reside.

The craft of landscape architects and designers involves altering and developing natural land, which often means replacing pervious surfaces with impervious surfaces. Pervious surfaces (woodlands, vegetated soils) infiltrate water through soil, while impervious surfaces (roads, parking lots, paved surfaces) act as a barrier that prevents the infiltration of precipitation (Arnold & Gibbons, 1996). In addition to concrete and paved surfaces, compacted soil and gravel disturbed by urban development activities have been shown to both behave similarly to impervious surfaces and either decrease or inhibit infiltration (Brabec, Schulte, & Richards, 2002).
Natural landscapes manage precipitation effectively. In a mature forest, vegetation catches some of the rainfall, keeping it on bark, leaves, and other foliage until it can evaporate back into the atmosphere. The water that makes its way to the ground slowly infiltrates through low-lying plants and filters through natural soil before it gets absorbed into the groundwater. A small amount of remaining water travels as surface runoff (Liptan, 2017).

In contrast, urban environments are full of plant-free, impervious surfaces, which disrupt the natural cycle and create a system where evapotranspiration and infiltration are inhibited. Arnold and Gibbons (1996) note that a 10-20% impervious surface cover increase from natural landcover doubles stormwater runoff, 35-50% impervious surface cover triples stormwater runoff, and 75-100% impervious surface cover more than quintuples stormwater runoff. This highlights the reality that as the area of impervious surface area increases and the area of permeable surface area decreases or is disturbed with development, fewer opportunities exist for water to soak into the ground. As a result, the majority of rainfall moves across surfaces as stormwater runoff and flows into surrounding water bodies, potentially overwhelming urban water bodies, causing flooding, and carrying contaminants that pollute urban water bodies. This is detrimental to both wildlife and humans (Marsalek, 2001).

Stormwater is defined as precipitation that falls either from rainfall or during and after a storm event within a watershed. Stormwater surface runoff consists of all stormwater, as well as irrigation, hose water, and other water sources that run off of impervious surfaces and do not absorb into the ground before entering the water system (Mississippi Department of Transportation, n.d.). As natural landscapes are developed into urban environments, permeable surfaces, such as natural grasses, loose dirt, forest stands, and other biological material, are
replaced with a growing number of impervious surfaces (Arnold & Gibbons, 1996), thereby increasing the amount of stormwater and surface runoff (Figure 1; U.S. EPA, 2003). Therefore, stormwater management is a critical factor to consider in rapidly developing landscapes. This presents a challenge as urban areas seek to design ways to manage runoff from impervious surfaces.

**Figure 1: Stormwater Runoff in Two Types of Groundcovers (U.S. EPA, 2003)**

![Diagram showing stormwater runoff in natural ground cover vs. impervious cover]

Within traditional stormwater management, design is primarily driven by a utilitarian goal: collecting the stormwater runoff and moving the water off the site as efficiently as possible to get it “out of sight, out of mind” (Wong & Eadie, 2015). This conventional method of using grey infrastructure (pipes, catch basins, gutters, treatment plants, etc.) to manage stormwater is widely used because it is an effective way to control urban flooding and maintain sanitation standards when systems are in kept in working order. Working order is achieved by doing such things as cleaning storm drain inlets and maintaining pipes and other stormwater infrastructure. However, these systems function best only when they receive the intended amount of stormwater runoff from surrounding impervious surfaces. When the amount of
stormwater runoff exceeds the capacity of the grey infrastructure, they can actually cause more flooding and erosion (US EPA, 2021).

Furthermore, conventional stormwater management techniques recognize stormwater management as having little to no amenity value beyond sanitation and flood control, thereby adding little to the community in the form of recreation, education, or aesthetic richness (Wong & Eadie, 2015). Additionally, this method does not facilitate opportunity for water to penetrate the earth and infiltrate the ground. Ground infiltration filters out pollutants in the stormwater before the water enters surrounding surface water bodies. Eliminating this step can degrade the water quality of a watershed as a whole (Ferguson, 1998; Marsalek, 2001). Piped stormwater conveyance also reduces the opportunity for evapotranspiration. This process is extremely critical in arid environments, such as Utah and the Intermountain West, as it has the potential to reduce urban heat islands and provide microclimate regulation (Voter & Loheide, 2021).

Green stormwater infrastructure (GSI) is an alternative to conventional stormwater management that has been found to effectively manage stormwater runoff in urban environments and provide a wealth of benefits, such as community amenity, improved water quality, flood control, reduced heat island effects, and more. Green infrastructure is broadly defined as networks of open space, parks, wildlife habitats, and other natural or semi-natural spaces contained within urban and rural environment (McMahon, 2000) that provide benefit for the community. GSI applies this broad definition of green infrastructure to landscapes, with the specific goal of containing and infiltrating rainfall and stormwater runoff within the networks of green spaces in urban areas (“What is GSI?,” 2021).
GSI sites infiltrate precipitation where it falls, rather than channeling water off the site and into surrounding water bodies. This keeps polluted hardscape runoff from going directly into urban water bodies, thereby improving water quality for natural inhabitants and human recreation. Implementing methods of GSI works to replicate the amount of infiltration that takes place in natural environments and increase the amount of evapotranspiration, mimicking the systems of natural environments. In addition, GSI has been shown to filter out pollutants and chemicals present in stormwater that would otherwise be channeled straight into surrounding rivers and streams, as well as to reduce water runoff quantity and runoff rates (MacElroy & Winterbottom, 2000). Such environmental benefits accompany the valuable community amenities that GSI provides. These benefits combine to create a highly effective, attractive alternative to traditional stormwater management for both the health of the environment and the human community in which it is located.

However, making the change to GSI is not simple. In addition to the vast amount of grey infrastructure already in place for conventional stormwater management techniques, GSI is still a new way to manage stormwater, and there are lingering questions regarding whether allowing water to penetrate the soil affects the quality of groundwater (US EPA, 2021). In addition, GSI is, for the most part, not in the design arsenal of a typical engineer who may be working on a project. This highlights the critical importance of landscape architects’ role in designing GSI sites and the significance of integrating education into GSI sites to increase public awareness. Though this may require bringing in an additional professional to the project and potentially increasing the overall project cost, the benefits to the community far outweigh the
upfront costs. Still, these elements create a complex transition from using grey infrastructure to manage stormwater to utilizing GSI and providing a community amenity.

The role of landscape architects in stormwater management

When landscape architects design new spaces and redesign existing stormwater management sites, they have an ideal opportunity to integrate mitigation measures using green infrastructure methods that provide natural stormwater drainage and treatment. The use of GSI for stormwater management is an integrative approach to stormwater management that has a multi-faceted utility focus, as it acts to improve water quality, manage stormwater and flooding, create a community resource, and perform microclimate regulations.

Further, GSI prioritizes spaces which emphasize human amenities in the site, thus creating a pleasant place to spend time, increasing sense of community, and incorporating an educational theme into the design (Smit Andersen, Lerer, Backhaus, Bergen Jensen, & Danielsen Sørup, 2017). This transforms traditional stormwater management from a necessary chore into a celebration of water, and the addition of human amenity increases public awareness of the process of stormwater management (Echols & Pennypacker, 2008).

This transition of stormwater management from classic retention basins and underground channels designed to send it “somewhere else,” to GSI aims to create designs that celebrate stormwater and highlight amenity and environmental gain while providing the utility of moving water off a site in the most efficient manner. Such a system has the potential to provide a host of environmental and community benefits (Echols & Pennypacker, 2015).
Landscape architects work with engineers and other professionals to integrate design principles into green stormwater management site designs. Engineers design GSI drainage systems through engineered soil media, and landscape architects create designs for integrating amenity into the facilities. Stuart Echols and Eliza Pennypacker (2008) have coined the term Artful Rainwater Design (ARD), which integrates the utility aspect of stormwater management while also highlighting amenity, thereby designing sites as places of education, art, and pleasure. ARD puts an emphasis on celebrating stormwater and showing stormwater’s power to create art and provide water for landscapes. A key aspect of ARD maintains that responsible stormwater management must be integrated into the landscape because it can be difficult to set aside large amounts of land to manage stormwater in retention basins, especially in urban environments (Echols & Pennypacker, 2008). ARD is a specific subset of GSI, into which landscape architects can implement aspects of ARD to provide the amenity aspect that might otherwise be lost in development.

It is important to note that stormwater management sites are often designed without including landscape architects, solely relying on the engineers who are already present in the planning process. Generally, an ARD approach cannot be implemented by an engineer, who is not trained in integrating theory of design into public spaces to add community amenity (and therefore ARD principles) to a stormwater management site.

Landscape architects represent the ideal professional to implement the techniques inherent in ARD. As a design approach, ARD reintegrates natural stormwater management processes into urbanized environments with an emphasis on creating a community amenity, valuable public spaces, and pleasurable places to pass time. These elements are within the
focus of a landscape architect’s work, underscoring their necessary role in the implementation of ARD throughout the design and planning of urban environments.

**Stormwater in the Intermountain West**

Much of the evolution toward GSI is occurring in locations that have more prolonged and frequent rainfall than Utah, such as the Pacific Northwest. This most likely stems from the fact that, in the 1990s, two major cities in the Pacific Northwest, Portland, Oregon and Seattle, Washington, were forced to make a change, due to new regulations intended to control sewage overflow problems and repair impaired salmon habitat in each respective location (Echols & Pennypacker, 2015). In addition to threatened habitat and sewage overflow issues, a large amount of annual rainfall creates the visible and immediate issue of flooding, further motivating action for more effective stormwater management. However, the principles applied in these locations can also be utilized elsewhere, even in locations with less rainfall.

Applications in the arid Intermountain West are not without challenge, given the infrequent rainfall and therefore lack of repeated, visible situations where stormwater management techniques are necessary. As stated by Utah’s Senate President, Stuart Adams, “Our limiting factor for growth in Utah is not our infrastructure. It’s not our public lands…it’s water. Our limiting factor for growth is water” (“‘It’s our water’: Utah Senate backs creation of new agency defending Utah’s Colorado River interests”). Nevertheless, an infrequency of rainfall does not diminish the necessity of sustainably managing stormwater for the health of urban water bodies and to manage periodic flooding that occurs even with scarce rainfall. Even
more importantly, the prolonged drought that exists in the West creates a scarcity of water that highlights the critical need for design principles which support caring for the health of the water bodies that do exist and the rain that does fall. Therefore, with adaptations to suit the climate, these tactics will be useful in developing general design criteria to be integrated into stormwater management projects in the Intermountain West.

Given the amount of growth occurring in Utah, the Utah Department of Water Quality committed to more environmentally conscious stormwater design with development (“Storm Water Management 2018 State of the Environment Report (WQ),” 2019). As of 2020, the Utah Department of Environmental Quality, Water Quality Division, requires that all new development disturbing more than one acre or increasing runoff includes Low Impact Development techniques, indicating a push toward more sustainable stormwater management practice (“Low Impact Development“). Though stormwater management in Utah is transitioning out of a strictly utilitarian stage and into a conscious effort to improve water quality, integration of GSI seems to be slow to develop. Targets of improved water quality can be reached using traditional retention basins or treating the water before entering water bodies, allowing the utilization of traditional grey infrastructure to achieve sustainability goals (Echols & Pennypacker, 2015). However, these methods of stormwater management are unattractive and provide no community amenity, decreasing their appeal and providing further reason for GSI. The rapid rate at which Utah’s population is growing, the reality of water scarcity, and general moves toward sustainability emphasize the necessity of sustainably managing stormwater to protect the health of watersheds and water supplies.
GSI plays a key role in this movement, and community acceptance of GSI practices is necessary to create an environment in which sustainable stormwater management techniques become the standard. The pursuit of community acceptance highlights a valuable community educational opportunity that can be integrated into existing and new GSI design.

Education in green stormwater infrastructure design

For sustainable stormwater management measures to be successful, the public must be aware and involved in practicing responsible stormwater control. Therefore, it is critical to integrate education into the design of green stormwater infrastructure sites (Marsalek, 2001). University campuses offer an existing scholarly environment that lends itself well to education in green stormwater infrastructure. The landscape of a university should embody that university’s values as an institution and help set an example for members of the university (Zhang, Zhou, Schmidt, & Garland, 2016). Communicating with users through educational techniques aids in the understanding of sustainably managing stormwater and promotes a university’s values as a sustainable asset in the community.

In addition, it is critical to paint broad strokes when considering who might be educated by the GSI. The primary users of university campuses are the students attending school. These university students represent a vibrant, diverse community consisting of future leaders. Because of this, they are a critical educational audience with which to share the process and purpose of green stormwater infrastructure. Furthermore, users of university campuses go beyond students to include professors, landscape crews, students’ families, local community
members, university staff, faculty, and more (Walton & Sweeney, 2013). At Utah State University, there is even a primary school located on campus, offering an ideal learning opportunity for age groups of all levels. This wide variety of users highlights the broad population which educational design of green stormwater infrastructure on university campuses would reach. It is also important to remember that many users of university campuses are pursuing higher education and may already have a good understanding of sustainable stormwater management techniques. This presents an opportunity to consider integrating education onto campuses beyond university campuses, such as secondary school and work campuses. Though the work of this thesis will focus on utilizing ARD principles on university campuses, the principles can be applied elsewhere as well.

There are many ways that education can be integrated into the design of green stormwater infrastructure sites, including integrating signage into the design (Table 1). Interpretive signage is an effective way to educate site visitors when there is a narrative to tell (explaining the negative impacts of stormwater runoff on the environment) and when an action is requested of the visitor (a call to utilize green stormwater infrastructure to positively mitigate those negative impacts) (Altmyer, 2020).

Signage is particularly important in the Intermountain West, where rainfall is sparse and GSI is not actively in use (collecting rainfall) much of the time. Creating a continuous display is critical and can be achieved through the use of interpretive signage, making the site’s narrative available and educational even when the site is dry (Altmyer, 2020).

In addition to interpretive signage, other methods of education in GSI, such as highlighting the processes of stormwater management, inviting users to gather in and utilize
the space, and creating a narrative of the hydrological cycle within the design, are highlighted by Echols and Pennypacker (2015) and can be integrated into the design of GSI sites on university campuses.

However, in order to integrate educational communication into GSI sites on university campuses, the designers, planners, and/or other campus staff must have guidelines for implementation. Though many design guides exist that are aimed at the design of green stormwater infrastructure (Eskin, Price, Cooper, & Schleizer, 2008; “Green Infrastructure Toolkit - Georgetown Climate Center,”; “San Antonio River Basin Low Impact Development Technical Design Guidance Manual, v2,” 2019; MacAdam, 2012), it is impossible to find a guide which describes specifically how to integrate educational elements into green stormwater infrastructure. This need is further emphasized by the utter lack of research being done on designing GSI sites with education in the Intermountain West. Filling this gap in knowledge is critical to assist landscape architects and planners in their integration of education into green stormwater infrastructure sites. The design guide resulting from this thesis contributes to the filling of that gap by providing information and examples of techniques for integrating education into the design of GSI sites on university campuses.

Green stormwater infrastructure as Artful Rainwater Design

Stuart Echols and Eliza Pennypacker (2008) have worked to market ARD as a stormwater management site technique which integrates community amenities into the design. These amenities are elements that highlight the experience of stormwater in a way that both enriches
the landscape in appearance or value and creates a design that celebrates stormwater (Echols & Pennypacker, 2008). ARD is a form of GSI, but it goes one step farther than sustainably managing stormwater, in that it includes a strong emphasis of these community amenities through the artwork, community gathering spaces, educational elements, and other elements of the design.

Echols and Pennypacker (2015) further explain that stormwater management systems should be integrated into the landscape because land is of high value, and vast amounts of it cannot be reserved for traditional retention basins in most urban areas (Echols & Pennypacker, 2015). The pair believe and act according to their mindset that stormwater management should be considered as more than just the chore of disposing and treating water runoff to manage flooding and control water quality. The two work to underscore the positive elements of stormwater management that exist in community amenity and a higher aesthetic quality, turning water runoff from a “waste product to be removed” from the site into an asset that can be highlighted in the design (Echols & Pennypacker, 2015).

In 2008, Echols and Pennypacker completed a case study project to examine how various stormwater management sites are utilizing amenities in their design. They focused on five overall amenity goals that go beyond managing flooding and water quality: education, recreation, safety, public relations, and aesthetic richness (Echols & Pennypacker, 2008). Though the inclusion of all five amenities is critical in ARD, this thesis utilizes the portion of their work focused on education. Their observations of the presence and characteristics of educational communication tools in each site play a key role in the work of this thesis. Through their case study projects, Echols and Pennypacker (2008) identified three educational objectives
that are to be present in an ARD site: ideas to learn, ways to learn, and context to learn (Table 1).

- **Ideas to learn** are concepts that can be taught with educational signage or displays on stormwater management sites. This could be the path of stormwater: going into storm drains and entering, often untreated, into surrounding bodies of water. It could be an explanation of the condition of a local watershed’s health. It could even be animal habitats that are affected by stormwater.

- **Ways to learn** are the ways in which the information is communicated to people visiting the site. This can include signage, demonstrations, or art exhibits that tell the stormwater story, the site’s historical water conditions, or more. Visual storytelling through the landscape is another strategy used as a way to learn and can create a narrative to which the user of the space can connect and then follow.

- **Context to learn** is made up of three pillars which create a highly successful educational design: visibility of the topic being highlighted, gathering spaces within or near the GSI, and interactivity with the GSI landscape. Context for learning translates into how effective the signage or other ways to learn are and highlights ways that the physical design can encourage passive education as users and viewers inhabit the space.
Table 1: Educational Goals in Stormwater Management (Echols & Pennypacker, 2008)

<table>
<thead>
<tr>
<th>EDUCATION GOAL</th>
<th>CREATE CONDITIONS TO LEARN ABOUT RAINWATER AND/OR STORMWATER RUNOFF–RELATED ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTIVES</td>
<td>DESIGN TECHNIQUES</td>
</tr>
<tr>
<td>To provide</td>
<td></td>
</tr>
<tr>
<td>IDEAS TO LEARN</td>
<td></td>
</tr>
<tr>
<td>Hydrologic cycle</td>
<td>Make stormwater trail visible and legible</td>
</tr>
<tr>
<td></td>
<td>Create a narrative of stormwater and/or the hydrologic cycle</td>
</tr>
<tr>
<td></td>
<td>Employ expressive hydrologic symbols</td>
</tr>
<tr>
<td>Historical water condition</td>
<td>Make stormwater trail visible and legible</td>
</tr>
<tr>
<td></td>
<td>Integrate stormwater-related site artifacts into the design</td>
</tr>
<tr>
<td></td>
<td>Create a narrative of the historical water condition</td>
</tr>
<tr>
<td></td>
<td>Employ expressive symbols of historical water condition</td>
</tr>
<tr>
<td>Water treatment types</td>
<td>Make stormwater treatment system visible and legible</td>
</tr>
<tr>
<td></td>
<td>Make stormwater treatment system playful, intriguing, or puzzling</td>
</tr>
<tr>
<td></td>
<td>Include variety of stormwater treatment systems in design</td>
</tr>
<tr>
<td>Treatment system impact</td>
<td>Create systems that visibly collect and store trash and/or pollution</td>
</tr>
<tr>
<td>Riparian plant types</td>
<td>Provide a variety of visible plant types and communities</td>
</tr>
<tr>
<td>Riparian wildlife</td>
<td>Provide a variety of interesting wildlife habitats:</td>
</tr>
<tr>
<td></td>
<td>Use plants that provide wildlife food</td>
</tr>
<tr>
<td></td>
<td>Provide different water depths</td>
</tr>
<tr>
<td></td>
<td>Create shelter for wildlife such as bird and bat houses</td>
</tr>
<tr>
<td>WAYS TO LEARN</td>
<td></td>
</tr>
<tr>
<td>Signage</td>
<td>Provide simple signage or exhibits that use:</td>
</tr>
<tr>
<td></td>
<td>Brief text</td>
</tr>
<tr>
<td></td>
<td>Clear graphics</td>
</tr>
<tr>
<td></td>
<td>Location, color, or motion that attracts people</td>
</tr>
<tr>
<td>Programming</td>
<td>Design treatment system to invite educational games or activities</td>
</tr>
<tr>
<td>CONTEXT FOR LEARNING</td>
<td></td>
</tr>
<tr>
<td>Visibility</td>
<td>Create treatment systems that are visible and legible</td>
</tr>
<tr>
<td></td>
<td>Create visual interest by varying the appearance of different parts of the stormwater treatment system</td>
</tr>
<tr>
<td>Gathering</td>
<td>Create a variety of spaces for groups to explore, gather, or sit near the stormwater treatment system</td>
</tr>
<tr>
<td>Interactivity</td>
<td>Create treatment systems that are touchable</td>
</tr>
<tr>
<td></td>
<td>Create designs that encourage people to explore and play near or in the treatment systems</td>
</tr>
</tbody>
</table>

Echols and Pennypacker (2015) provide techniques within each of these objectives that act as indicators of successful educational aspects for stormwater management sites. These techniques are methods for implementing the educational goals into GSI site design and can be evaluated to determine the presence of Echols and Pennypacker’s educational objectives in the design. Echols and Pennypacker (2015) describe their case study research methods, process,

The three ARD objectives are being utilized in many excellent site designs. A particularly commendable example of design is the Phipps Conservancy in Pittsburgh, Pennsylvania (Figures 2 & 3). The Phipps Center for Sustainable Landscapes, located at the Conservancy, includes “one of the greenest buildings on earth” (Center for Sustainable Landscapes | Phipps Conservatory and Botanical Gardens | Pittsburgh PA), surrounded by extensive green infrastructure that manages all of the building’s stormwater on-site. This site provides all three of Echols and Pennypacker’s objectives (Column 1, Table 1) and creates a visual narrative of the trail of stormwater treatment systems that integrates riparian plant types and wildlife habitat to provide the *ideas to learn* objective. *Ways to Learn* include signage and programming that tell the story of stormwater management, riparian plant types and wildlife, and more. Finally, The Center for Sustainable Landscapes provides *context for learning* in the form of visible, legible stormwater treatment systems and the creation of gathering spaces in and around the GSI site in order to familiarize users with the stormwater management systems up close (Center for Sustainable Landscapes | Phipps Conservatory and Botanical Gardens | Pittsburgh PA).
Figures 2 & 3: Phipps Conservancy integrates ideas to learn, ways to learn, and context for learning into the design of the GSI sites (Phipps Center for Sustainable Landscapes)
Chapter 2: Research Methods

Research Question and Objectives

The research question guiding my thesis is:

- How are educational tools applied on university campuses to communicate stormwater management processes and improve public understanding of sustainable stormwater management sites?

The objectives of my thesis are:

- To design educational signage and/or interactive displays in a stormwater management site on Utah State University’s campus using the case study method and three objectives defined by Echols and Pennypacker to guide the design process.
- To create a digital guide to be utilized by campus planners, landscape architects, and facilities staff to aid in the integration of educational communication tactics on university campus green stormwater infrastructure sites.

Applying existing research techniques to the Intermountain West

The case studies completed by Stuart Echols and Eliza Pennypacker to examine various amenities, including education, in ARD served as a precedent for the case study project performed in this research. However, though they prioritized a variation in geography, the majority of their case studies were located in the Pacific Northwest. Only one case study was located near the Intermountain West, in Tempe, Arizona. For the purposes of this thesis, their methodology and evaluation criteria were adapted to a series of case studies located on
university campuses in the Intermountain West (in Utah, Arizona, and Colorado) which focus on the educational amenity in green stormwater infrastructure. This examination of green stormwater infrastructure on college campuses served multiple purposes:

- To determine if Echols and Pennypacker’s objectives are present in the design, and, if so, to identify the techniques used to implement the objectives.
- To document existing examples of green stormwater infrastructure and educational signage, art, or demonstrations on university campuses.
- To evaluate the effectiveness of designs in educating the viewers about stormwater management and stormwater processes.

Information gathered from this research was used to inform the design of educational signage on stormwater management sites on Utah State University’s Logan campus. This design serves as a reference example for campus landscape architects, planners, designers, and campus facilities departments when integrating educational amenity into their stormwater management sites. In addition, a digital Educational Communication in Green Stormwater Infrastructure Guide was created, outlining methodology for integrating education into GSI sites on university campuses in the Intermountain West. At the time of its creation, there existed no guide of this type to aid campus landscape architects, planners, designers, and/or facilities departments that desire to integrate education into their GSI sites. Therefore, the Educational Communication in Green Stormwater Infrastructure Guide fills this critical gap in resources for education in GSI design. This guide will be invaluable to its audience, many of whom have not previously had precedent examples or resources to reference, as they seek to integrate education into GSI sites on university campuses in the Intermountain West.
Methods Overview

The stated research question and objectives were addressed through the following methodology:

First, the Utah State University Aggie Boulevard stormwater management site was surveyed to determine the educational communication techniques that would be employed and what knowledge would be needed to retrofit education into the design.

Second, green stormwater infrastructure sites on university campuses in Utah, Arizona, and Colorado that showed characteristics of green infrastructure, educational elements, and/or artful rainwater design were identified. The process for choosing the universities can be seen in Figure 4 and is outlined in the following section.

Third, a series of case studies were completed to study these stormwater management sites, specifically examining both the educational objectives and techniques each site used to achieve the objectives, as well as the designers’ processes in creating the sites. With each case study, informal interviews with campus faculty involved in the stormwater management site took place when possible. In addition, online research of precedent educational signage in stormwater management sites that were not within the geographical bounds of case studies was conducted to guide the design of the signage.

Fourth, the information gathered in the case studies, online research of precedent educational signage, and interviews were synthesized to produce a design for education signage for the stormwater management site on Utah State University’s campus and an Education in Green Stormwater Infrastructure digital guide. This design and corresponding
guide will serve as resources for landscape architects and designers when integrating educational goals into their stormwater management project designs.

Case study selection process

The case study process is being used increasingly in the field of landscape architecture and in the study of green stormwater infrastructure sites, as seen in *Artful Rainwater Design: Creative Ways to Manage Stormwater* (Echols & Pennypacker, 2015). As a form of research in the field of landscape architecture, completing case studies is a research method that takes information gathered from a project site(s) and records it in a methodical, systematic, and organized manner. This method has been widely used in a variety of fields but proves exceptionally useful within landscape architecture, as many of the best practices used in landscape architecture come from documentation of methods that work, anecdotal evidence of effectiveness, and past experiences. The case study method gives the researcher the opportunity to study effective projects and document evidence and recordings from their observations (Francis, 1999).

Because the purpose of this case study was to determine effective design principles for educational stormwater signage on Utah State University’s Logan campus, the chosen case study sites were comprised of sustainable stormwater management sites on university campuses. Due to budget constraints and travel distances, universities in Utah, Arizona, and Colorado were chosen as a representation of conditions in the Intermountain West. The steps for choosing the universities to visit and include as case studies were as follows:
First, all the universities in Utah, Arizona, Wyoming, Colorado, Nevada, and Idaho were identified (green in Figure 4). This list was then narrowed down via the following criteria: 1. Only public universities were chosen (brown in Figure 4) to better mirror Utah State University’s possible restrictions and limitations with regard to stormwater management site design and educational tool use. 2. Chosen universities had to have either a website or literature describing their green stormwater infrastructure. If this was not available, the researcher had to make direct contact with staff at the university to confirm the presence of green stormwater infrastructure and possible educational techniques used to confirm its value as a case study site. The information gathered during these steps was used to compile a final list of universities (orange in Figure 4), which included Northern Arizona University, Arizona State University Polytechnic campus, Colorado State University Fort Collins, The University of Utah, and Utah State University.
The chosen campuses have integrated green infrastructure into their stormwater management design and were visited and studied to assess their usage of educational communication through signage, demonstrations, art, and/or how the site design itself communicated its stormwater management purpose to educate the public using the space. During the site visits to each case study, every effort was made to facilitate a discussion with faculty at the university. In the sites where this was successful, informal interviews were conducted with campus staff involved in the green stormwater infrastructure sites. The interview process was reviewed and deemed non-human subject research, in accordance with...
USU IRB #12203. In addition, the following questions were considered during the visit:

a. Without any prior research, are there educational design techniques present in the design? This could be artwork, gathering spaces, signage, demonstrations, interactive design, sculptures, or other educational elements.

b. If the answer is yes to question A, which design techniques from Table 1 are employed on the site? If the answer is no, which techniques were missed that should have been utilized?

c. How will the information gathered in questions A and B be useful at the stormwater management site on Utah State University’s campus?

It is important to note that a differing element in the case study approach used in this research from that of Echols and Pennypacker’s (2008) research is that this study focuses solely on the amenity of education, rather than the other amenities Echols and Pennypacker examined in their case studies. This research examined the chosen case studies to discover if and how they integrated signage, interactive demonstrations, and other techniques identified in Table 1 (Echols & Pennypacker, 2008) to educate the public about stormwater management sites chosen showed a desire to promote awareness of the importance of water and stormwater in the arid Intermountain West. Because water is a limited resource in the Intermountain West, caring for rainwater and stormwater is becoming necessary in water conservation and reuse designs.

When choosing their case study sites, Echols and Pennypacker’s (2015) number one criteria for their choices of artful rainwater projects was that the sites must show a “celebration of
rain”. This criterion was important to the study of the stormwater management sites visited during this research’s case study selection. When the geographical areas in which the case studies were located are compared with parts of the country with large amounts of annual rainfall, there is relatively only small amount of rainwater to manage. Because of this, it is necessary to highlight rainwater’s importance when it does fall in these arid areas, and it is key to emphasize the need to appreciate it as a resource. Sites that show a “celebration of rain” are designed to showcase rainwater in a meaningful way.

After completing case studies, the results were synthesized into Table 2-6. The results discussed the key Echols and Pennypacker principles that the design utilized or missed, a case study library containing photos illustrating these principles, and general takeaways from each site. The case study results of Table 2-6 are recorded in Chapter 3: Results. This research helped inform both the design for educational signage at an existing stormwater management site on Utah State University’s Logan campus and an Education in Green Stormwater Infrastructure digital guide, which will serve as a resource for landscape architects in the integration of education into university stormwater management sites.

Case study methodology

In addition to detailed notes, the case study framework provided by Mark Francis (1999) was adapted and his criteria completed, resulting in a consistent document for each case study site. The methodology in the case studies of Echols and Pennypacker’s (2008, 2015) Artful Rainwater Design sites was also utilized and adapted to analyze the case study locations. Table
1 (Echols & Pennypacker, 2008) defines three education objectives, with subcategories in each. It also identifies various design techniques to achieve these educational objectives. These definitions were used to identify the educational objectives that the techniques employed to achieve the objective for each of the case study sites in the research of this thesis, thus mimicking the process Echols and Pennypacker followed during their case study research.

In their research, Echols and Pennypacker (2008) chose to include case studies that would inspire designers and architects to recognize any “stormwater problem” to be a rainwater opportunity. The reason for choosing to complete case studies in this research vein was to identify the sites providing this rainwater opportunity on college campuses in the Intermountain West. The documented case studies aided in showing what the implementation of educational objectives looked like in practice, thereby informing the design of educational signage for the stormwater management site on Utah State University’s campus and the design guide which will serve as a resource for local landscape architects and designers when they are faced with a rainwater opportunity.

Signage design

Utah State University’s Logan campus (shown as a dotted red outline in Figure 5) is located in a residential section of the city of Logan, creating a public space that the students, faculty, and university staff utilize, as well as local elementary students who attend school on-campus and neighboring residents who utilize the campus for passive and active recreation. The campus student/staff population and its location as a community resource creates a high-
traffic space, spurring the idea to create an educational hub to teach about and promote awareness of sustainable stormwater management throughout Utah State University’s campus. The educational hub’s planned location is beside a bioswale lining Aggie Bull-evard, one of the central pedestrian and vehicular arteries of campus (shown as an orange box in Figure 5). The bioswale’s central location on campus with high foot and bicycle traffic from students, faculty, staff, and public increased its appeal as a location for education, given the critical need to get enough visibility to make the signage worth the cost of installation (South Dakota State Historical Society).

Figure 5: Area Map of Educational Hub
After identifying the goals and audience for the educational communication, the site plan was reviewed and inventoried (Figure 6) to identify potential locations for the hub and supporting signage.

Figure 6: Initial Site Inventory

In addition to this review, conversations with the campus landscape architect and planning, design, and construction manager on the Logan campus, and the site designer took place. Goals of these conversations included learning about the potential limitations and restrictions that may be present while designing educational techniques for the green stormwater infrastructure site, revealing the intentions of the original site design, and understanding the complex layout of the stormwater management systems on site to better educate the public about these processes.
The LAEP Canyon house was identified as a second location for signage, due to the existing informational signage describing other sustainable practices on site. This existing signage was used as a precedent for the colors, type of signage, and layout of the new signage.

Echols and Pennypacker’s principles, precedent signage on Utah State University’s campus, knowledge gleaned during research on interpretive signage, and information gathered during the case study process on other university campuses were utilized to inform the design of the signage.

A first iteration of the signage was roughly sketched out at a concept stage. These first sketches explored signage layout and combined graphic skeletons with text copy to organize the signage in a way that was legible, clear, and eye-catching, all critical elements of interpretive signage. This work was then reviewed, critiqued, and revised to produce a second iteration of signage design that moved into details highlighting the water cycle, stormwater runoff in urban environments, and specific methods of green stormwater infrastructure. This process was repeated two times, each time including more site-specific examples and illustrations. After critiques by Utah State University’s Signage Committee, the final signage design was created (Figure 8-11). This design represents one interpretation of the information gathered during the research process for interpretive signage as it relates to stormwater management and GSI.
Education in Green Stormwater Infrastructure: digital guide creation

Resource guides, such as design guides, fact sheets, and toolkits are widely created and used within the field of landscape architecture, often pointed to as resources for design techniques and practices by institutions such as the United States Environmental Protection Agency (EPA) and American Society of Landscape Architects (ASLA). Though there are many such resources centered on sustainability in landscape architecture, designing green stormwater infrastructure, and implementing sustainable stormwater management practices, when one searches for a guide focused on integrating education into the design of those green stormwater infrastructure sites or stormwater management sites, the results are sparse.

Due to this lack of precedent examples on this specific topic, resources were reviewed that focused on similar topics, such as the design of green stormwater infrastructure sites, to serve as precedent work in the creation of the guide. In addition, the initial outline and ideas for the guide were brought to a professional in the field of the intended audience (identified as campus planners, landscape architects, and facilities staff) for suggestions and critique. This allowed for the creation of a guide that would be useful to its intended audience and serve as a practical source of guidance for integrating education into the design of green stormwater infrastructure sites on university campuses.

Case study research, experience gained while designing the signage at Utah State University, and the review of precedent examples highlighted the need for a guide which encompasses both the integration of education into new green stormwater infrastructure sites and explains the process of retrofitting existing green stormwater infrastructure sites with
educational elements. The guide synthesizes signage design with information from case study research and lessons learned while integrating education into the Aggie Bull-evard green stormwater infrastructure site, in order to create a resource which includes instructions for and real-world examples of education in green stormwater infrastructure site design, according to the techniques and principles developed by Echols and Pennypacker.
Chapter 3: Results

Case study locations

For the case study process, four universities were visited, while one university was utilized without an in-person visit. In Figure 7, the chosen universities are marked with a number corresponding to the list which follows the figure.

Figure 7: Map of Case Study Site Locations
1. *Arizona State University, Polytechnic Campus in Mesa, Arizona.* On this campus, there is a multi-stage, artful rainwater design stormwater management site that replicates natural, desert process and historical water usage to educate viewers about the landscape.

2. *Colorado State University in Fort Collins, Colorado.* This university has a plethora of green infrastructure and sustainable stormwater management sites, as well as various elements of education in some of them.

3. *Northern Arizona University in Flagstaff, Arizona.* The campus has one green roof with a small indoor sign associated with it. The limited amount of green stormwater infrastructure did not financially justify the trip to visit the campus in-person, so photos sufficient for understanding the signage were obtained through email correspondence with university staff.

4. *University of Utah in Salt Lake City, Utah.* This university has many green infrastructure and sustainable stormwater management sites on its campus. There is no educational signage associated with it, though the campus staff expressed interest in retrofitting sites with educational elements. The reason for visiting this site was to observe the stormwater management sites and speak with university staff about how they wish and plan to implement educational criteria into future designs.

5. *Utah State University in Logan, Utah.* There are many examples of green stormwater infrastructure on campus, some with educational elements that will be of use for this project.
Case study reports

The following Tables 2-6 synthesize the information gleaned in the case study process, including elements from both the methods of Francis and the methods of Echols and Pennypacker. The tables highlight a summary of the visit, general background and goals of each case study’s GSI, key principles from Echols and Pennypacker’s objectives as described in Table 1, that the design utilized or missed with photos illustrating these principles, and general takeaways from each site.
### Arizona State University Polytechnic Campus

<table>
<thead>
<tr>
<th>Summary of Visit</th>
<th>Project Background and Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff at Arizona State University Polytechnic campus were not available for interview regarding the green stormwater infrastructure site. Thorough notes and documentation were taken on a self-guided tour of the green stormwater infrastructure site, and research was completed on the project while utilizing the campus landscape architecture firm’s ASLA award article (“ASLA 2012 Professional Awards</td>
<td>This project is a retrofit of a frequently flooded roadway on the ASU Polytechnic campus. In addition, the renovation was intended to transform a vastly paved area into one that implemented more natural vegetation and softscapes. In addition to flood mitigation, the project seeks to facilitate a daily connection to nature and emphasize the natural processes of stormwater management within the desert arroyo in which the campus is located.</td>
</tr>
<tr>
<td>Site visit highlighted that this GSI site lacks ways to learn. This photo is an illustrative example of a sign that could exist in the space, integrating Echols and Pennypacker’s criteria for effective signage and explaining the context for learning, by inviting people to gather in the spaces. This example shows a seat wall integrated into part of the GSI system, with benches and walkways</td>
<td></td>
</tr>
</tbody>
</table>

### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Ways to Learn</th>
<th>Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of the many ideas to learn that the design of the site highlights is showing the Historical Water Condition. The design of the stormwater management system narrates historical agricultural irrigation techniques. They are</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The site visit highlighted that this GSI site lacks ways to learn. This photo is an illustrative example of a sign that could exist in the space, integrating Echols and Pennypacker’s criteria for effective signage and explaining the context for learning, by inviting people to gather in the spaces. This example shows a seat wall integrated into part of the GSI system, with benches and walkways</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessons Learned</td>
<td>The site is attractively designed and highlights numerous intricate demonstrations of natural stormwater management processes, such as historical water condition, natural hydrological processes, and natural stormwater management systems. However, to an average passerby who is not educated in the historical water conditions, arroyo stormwater processes, or green stormwater infrastructure generally, these intricate demonstrations and displays could be overlooked as simply landscape design or minimalist landscaping.</td>
<td></td>
</tr>
<tr>
<td>Key Takeaways</td>
<td>Signage, art, or explanation in the form of <strong>ways to learn</strong> would be greatly beneficial to aid in the understanding of the stormwater management processes at work in the green stormwater infrastructure site on ASU’s polytechnic campus.</td>
<td></td>
</tr>
</tbody>
</table>
### Colorado State University Fort Collins (CSU FC)

#### Summary of Visit
Staff at CSU FC were available for an interview and tour of the green stormwater infrastructure on campus during the site visit. During the campus tour with university staff, staff and I discussed green stormwater management, including its history on campus, the role of education during design, maintenance, precedents, and more. The generosity of the campus staff to share their time and knowledge is immensely appreciated and created an ideal scenario for this case study.

#### Project Background and Goals
This project is a continually ongoing project on the CSU FC campus, beginning in 2008 with Leadership in Energy and Environmental Design (LEED) certificates paving the way for sustainable development. In addition, the university staff, including landscape architects, engineers, planners, and facilities, demonstrate a care for and understanding of the importance of sustainable development practices. Most, if not all, of the green stormwater infrastructure projects on campus are a result of new development, and very few take the form of retrofitting an existing gray stormwater management system.

Green stormwater infrastructure is present throughout the university campus and is integrated into the everyday life of users in various ways, which are discussed throughout this report. The university primarily utilizes the ideas to learn and context for learning objectives outlined by Echols and Pennypacker, as elements from ways to learn were not heavily present in the campus’s green stormwater infrastructure.

### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Ways to Learn</th>
<th>Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSU FC uses permeable pavers in highly trafficked areas and on most of the bike rack ground surfaces (and are in the process of</td>
<td>The campus had one example using signage as a way to learn. The signage highlights a water treatment system for wastewater from a</td>
<td>This retention basin turned amphitheater is just one of the examples of context for learning on CSU’s campus, along with dry riverbed with study</td>
</tr>
</tbody>
</table>

#### Summary
- **Ideas to Learn**: CSU FC uses permeable pavers in highly trafficked areas and on most of the bike rack ground surfaces (and are in the process of)
- **Ways to Learn**: The campus had one example using signage as a way to learn. The signage highlights a water treatment system for wastewater from a
- **Context for Learning**: This retention basin turned amphitheater is just one of the examples of context for learning on CSU’s campus, along with dry riverbed with study
<table>
<thead>
<tr>
<th>Lessons Learned</th>
<th>The main lesson learned, which also serves as a design challenge, that was iterated by the faculty is the gap between campus landscape architects who design a site, engineers working on the projects, and contractors installing the elements. Lack of knowledge about specific soil types, filtration needs, and plant selection during the installation process often prevents original designs from being successful. In addition, there is little emphasis on communication during the design process between the three entities, resulting in miscommunication, incorrect installations, changes to design, and more. The university faces a unique challenge to stormwater management because it lies on a flood plain. Because of this, stormwater management must be taken into consideration in every aspect of campus renovations. This, combined with staff who sincerely care about creating a sustainable and resilient campus, creates an opportunity for focus and dedication to sustainable stormwater management techniques on the CSU FC campus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Takeaways</td>
<td>The examples of education in green stormwater infrastructure at CSU FC were completed as new projects rather than retrofits, and the Utah State University Aggie Bull-evard stormwater management site is an example of retrofitting a green stormwater infrastructure project with the goal of integrating educational elements into the site. Therefore, CSU FC’s influence on the Aggie Bull-evard project is someone limited with regard to the design of the educational signage, but greatly present in the Technical Design Guide resulting from the study. The examples of designs, including various riparian plant types and consistent integration of visibility, gathering, and interactivity into the designs, provide strong precedents to supplement the design suggestions in the guide.</td>
</tr>
<tr>
<td>Northern Arizona University (NAU)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Summary of Visit</strong></td>
<td>According to staff communication, there is a single example of education in green stormwater infrastructure on the NAU campus: one green roof accompanied by an indoor sign describing its purpose. This single example did not financially justify a trip to visit the campus in-person because photos sufficient for understanding the signage were obtained through email correspondence and phone interviews with university staff.</td>
</tr>
</tbody>
</table>
| **Project Background and Goals** | This site demonstrates the *ways to learn* objective highlighted by Echols and Pennypacker, shown in the two small signs describing the purpose of the green roof.  
Motivation to build to LEED standards stemmed from a state mandate. This building became a way for NAU to show leadership in green building design. The green roof was a demonstration situation when it was created, dedicated to highlighting its ability to reduce the heat island effect created by urban environments. |
| **Evidence of Objectives** | **Ideas to Learn** | **Ways to Learn** | **Context for Learning** |
| | The green roof is in an area that is visible from the windows of another building, showing an example of *ideas to learn* by highlighting a *water treatment type*: a green roof. | The *signage* associated with the green roof is the *way to learn* associated with the site and explains the purpose of the roof and its original intent upon installation. However, the green roof’s original purpose was related to energy consumption and reducing the heat island effect. | The design, as is, does not have *context for learning*. This graphic is an illustrative example of a possible way to integrate *context for learning* into the design by inviting users into the stormwater management site. If provided, seating and shade could be used for studying, eating, or socializing. |
| Lessons Learned | Staff emphasized that there is a limit to how much they are able to do with the design of green stormwater infrastructure on campus. For example, there had been an attempt to create a parking lot from permeable pavement with signage explaining the infiltration. However, the extreme weather conditions of the area forced them to remove the pavement and signage shortly after installation. The roof garden was made initially to be a demonstration of sorts, while allowing for LEED platinum certification of the building. Unfortunately, the green roof has not been effectively utilized or maintained. The signage displays the roof’s goals for reducing Heat Island Effect, as the roof was not designed with the intent of managing stormwater. |
| Key Takeaways | ASU’s signs are simple and have a visually appealing color palette. They do not contain graphics, nor do they offer much interpretation or interactivity. These two elements will be more of a focus in the signage created for USU’s site. |
Table 5: University of Utah

<table>
<thead>
<tr>
<th>University of Utah (U of U)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary of Visit</strong></td>
</tr>
<tr>
<td>The staff at the University of Utah provided a generous amount of time in the form of an informal interview in a conference room combined with a full campus tour of both green stormwater infrastructure sites and a stormwater management demonstration site, the Living Lab. During the conversations and tour, staff and I discussed the role of green stormwater infrastructure on campus, its design and evolution, and what elements the university uses to educate about its purpose and function.</td>
</tr>
<tr>
<td><strong>Project Background and Goals</strong></td>
</tr>
<tr>
<td>About 15 years ago, the University of Utah made a shift toward green stormwater infrastructure. This stemmed from the state’s implementation of sustainability regulations and was emphasized by campus staff at the time, to whom green stormwater infrastructure was important. There are many traditional retention basins on the University of Utah’s campus to manage stormwater. However, in addition to these, there is green stormwater infrastructure sprinkled throughout in visible locations. One site is a functioning demonstration piece designed as a scientific experiment, and there are others in visible locations on campus. In general, the main goal of the University of Utah’s various green stormwater infrastructure sites is to manage flooding on campus. However, the demonstration piece, called the Living Lab, was designed with the goal of measuring the performance of native vegetation versus non-native plants in bioretention systems, in addition to other ecological, social, maintenance, and performance-oriented measurements (“Landscape Lab: Collaborative Re-Design of the Williams Building Landscape,” 2016).</td>
</tr>
<tr>
<td><strong>Evidence of Objectives</strong></td>
</tr>
<tr>
<td><strong>Ideas to Learn</strong></td>
</tr>
<tr>
<td>This pollinator garden shows <em>ideas to learn</em> in its design as it is an example of a <em>water treatment system</em> that also</td>
</tr>
<tr>
<td><strong>Ways to Learn</strong></td>
</tr>
<tr>
<td>This garden has a <em>way to learn</em> with an informational <em>sign</em> describing its purposes for managing stormwater and</td>
</tr>
<tr>
<td><strong>Context for Learning</strong></td>
</tr>
<tr>
<td>This garden’s interesting plantings and design highlight its multi-faceted purpose and provide <em>visual interest</em>. It could</td>
</tr>
</tbody>
</table>
integrates numerous *plant types*, offering habitat for *wildlife* in the form of insects and pollinators. providing pollinator habitat. The sign utilizes design techniques highlighted by Echols and Pennypacker, such as brevity, graphics, and a location which attracts people: right along a main path.

benefit from more context for learning to educate about the stormwater processes, flooding prevention, and pollinator benefits of the vegetation in the garden in the means of *gathering* and *interactivity*.

A walking path through it runs parallel to the main path. There is some motivation (a signage about pollinators) to utilize this path instead of the main sidewalk it, but seating or artwork could create more incentive.

**Lessons Learned**

Because designers change with every project, university staff could identify no lessons learned regarding the general green stormwater infrastructure throughout campus. The staff noted that a lesson learned from the Living Lab project was that given the transient nature of students at the university, year-to-year measurements often fall to staff to complete, which is at times not viable, given their professional duties and priorities.

Though the campus staff does seem to care about creating green stormwater infrastructure, their primary goals are centered on flood mitigation, with little emphasis on educational communication in any of the green stormwater infrastructure sites other than the Living Lab demonstration area.

**Key Takeaways**

It is clear that there is a fair amount of green stormwater infrastructure on the U of U campus, though there is not a large amount of education surrounding it. The only sign with the purpose of education is well-designed, but it is not located in a heavily trafficked area, and some members of staff were not aware of its existence.

Stormwater management seems to be catered more toward flood mitigation than sustainability and green stormwater infrastructure. Therefore, the main takeaways will be with regard to the sign and some elements of the demonstration Living Lab area. In addition, because much of the work is contracted out to consultants, creating an element in the guide that could aid in reviewing and modifying proposed designs or ensuring the integration of education in green stormwater infrastructure would be a useful addition to the guide.
Table 6: Utah State University

<table>
<thead>
<tr>
<th>Utah State University (USU)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary of Visit</strong></td>
</tr>
<tr>
<td>There are many green stormwater infrastructure sites on USU’s campus in addition to the Aggie Bull-evard site that this thesis examines. This case study looks at the various other green stormwater infrastructure sites and their associated educational communication techniques through a self-guided walking tour of campus. In addition, an office interview with campus staff took place to discuss both the green stormwater infrastructure on campus and the staff and university’s educational and sustainability goals.</td>
</tr>
<tr>
<td><strong>Project Background and Goals</strong></td>
</tr>
<tr>
<td>USU has been moving toward sustainable methods of managing stormwater for approximately 25 years. The catalyst for this effort was a general paradigm shift toward sustainability that began about 25 years ago in. In addition, staff at the university push for sustainability in their designs, working to design new elements with resilience in mind. This is shown in various types of green stormwater infrastructure throughout campus, including demonstration areas which serve to educate and are not actively utilized for stormwater management. Goals of implementing green stormwater infrastructure throughout the campus are to create educational sites that sustainably manage stormwater. The team works to implement this in their design of new and existing projects on campus whenever physically and fiscally possible.</td>
</tr>
<tr>
<td><strong>Evidence of Objectives</strong></td>
</tr>
<tr>
<td><strong>Ideas to Learn</strong></td>
</tr>
<tr>
<td>A long bioswale that collects water from the main road on campus creates a visible water treatment system that highlights the hydrological cycle. The treatment system</td>
</tr>
</tbody>
</table>
**Lessons Learned**

Site planners emphasized that there are climatic concerns regarding freezing of water that is discharged to the surface level and certain elements of drainage, such as curb cuts to reduce pavement runoff. Such designs could use improvement to be more effective.

The study of USU showed that there is a large amount of green stormwater infrastructure on campus. In addition to clearly visible sites, much of the water that goes into storm drains on campus empties to dry wells underground, which filter the water and return it to the groundwater. These processes go unnoticed on campus, due to their invisibility and lack of explanation for passersby. Furthermore, there is a good amount of green stormwater infrastructure that is visible, giving a context for learning, but it does not necessarily attract users to the space, nor does it include ways to learn, such as signage. This appears to be a missed opportunity for education on USU’s campus in areas that could more effectively communicate the green stormwater infrastructure’s purpose.

**Key Takeaways**

There are examples of informational signage on campus that can be utilized as examples of design and serve as precedents for the design of the Aggie Bull-evard signage. In addition to visible green stormwater infrastructure, there is some that is not visible to users. It could be useful to integrate elements into the guide that demonstrate examples of communication that do not require a physical green stormwater infrastructure site into which to integrate them.

Though the full extent of these case studies is not included in the final digital design manual, an abbreviated version of the tables and excerpts from some of the case studies with applicable information are present in the design manual to illustrate real-life applications and opportunities for education in GSI.
Interpretive signage

One of the outputs of this thesis was the design and development of interpretive signage to be installed on Utah State University’s Logan Campus. Developing this signage provided an opportunity to utilize research on interpretive signage, information gathered during case study research at other universities, and application of the principles learned from Echols and Pennypacker’s work on ARD. Still, the interpretive signage design represents only one interpretation of the information gathered from the case studies and precedent work. The signage is located on two separate GSI sites on Utah State University’s campus: a bioswale that lies adjacent to Aggie Bull-evard and a permeable driveway at the LAEP Canyon House. In total, four signs were created: three for the Aggie Bull-evard site and one for the LAEP Canyon House site. The signage design is now completed, and the signs will be installed utilizing Utah Department of Water Quality Non-Point Source funds.

The final design outputs include a larger (22”x23”) main sign (Figure 8) which will serve as the face of the plaza hub on the east end of the bioswale along Aggie Bull-evard. In addition, there are two smaller (11”x23”) supporting signs on the Aggie Bull-evard site (Figures 9 & 10). At the LAEP Canyon House is an 11”x23” sign describing the permeable pavers installed in the driveway (Figure 11).
Figure 8: Main Sign on Aggie Bull-evard
The final sign designs have been approved by the Utah State University Signage Committee and are in the process of being manufactured and installed. Illustrations of installation have been digitally created to envision the final output (Figures 12-15).
Figures 12-15: Mock-ups of Installed Signage on Utah State University Campus

Education in Green Stormwater Infrastructure: a digital guide

In addition to the design of interpretive signage that serves as a precedent for landscape architects and campus facilities departments in the Intermountain West, an outcome of this
thesis is a digital design manual that can used by campus staff who would like to integrate educational communication into the design of green stormwater infrastructure sites on university campuses. The full Educational Communication in Green Stormwater Infrastructure Guide is found on page 63 of this document.

The Educational Communication in Green Stormwater Infrastructure Guide explains how to integrate educational communication tactics into new GSI site design, as well as how to retrofit existing GSI sites to include educational elements.

The guide builds and expounds upon the extensive work of Stuart Echols and Eliza Pennypacker on Artful Rainwater Design as a design approach to green infrastructure sites with community amenity. This, in conjunction with a series of case studies on green stormwater infrastructure sites located on public university campuses in the Intermountain West, created a unique guide that is tailored to integrating educational communication tactics at university campuses in the Intermountain West, an area that has been historically overlooked in GSI design techniques for various reasons, perhaps due to its arid environment and/or cultural practices.

Though the guide was created with the intention of integrating educational communication tactics on university campuses, it is worth noting that the information presented could be easily adapted and applied elsewhere, such as community spaces, secondary schools, work campuses, business landscapes, public parks, or other public spaces.
Chapter 4: Recommendations and Limitations

Limitations of the case studies

Due to the monetary constraints of this self-funded master’s thesis, case studies were limited to universities in Utah and the states that border it, for proximity’s sake. As a result, they only represent a small portion of university campuses which employ green stormwater infrastructure. However, this representation highlights a unique geographic area that has been widely neglected in the study of GSI. The results of studying the arid and semi-arid locations chosen for the case studies provide very context-specific results that are critical for understanding stormwater in the Intermountain West.

In addition, the findings from the case studies were to be applied to Utah State University, a public institution. Because of this, universities studied were limited to public institutions, in order to create similar monetary and bidding constraints during the landscape design process. Including private institutions could potentially yield a wider variety of both green stormwater infrastructure and approaches to educational communication tactics on those sites.

Furthermore, universities who did not meet all criteria during the university choosing process were not visited, as confirmation of green infrastructure could not be attained, and an interview with university staff could not be obtained. ASU Polytechnic Campus is an exception to this, due to the fact that it was a site highlighted in the case studies of Stuart Echols and Eliza Pennypacker, whose process was being utilized and modified. Therefore, this university was
visited, and its green stormwater infrastructure observed, though an interview with staff did not occur.

It is worth noting that universities at which confirmation of GSI could not be obtained may indeed have GSI on their campus. In some cases, I was directed from staff member to staff member, with no one aware of whether or not this type of stormwater management existed on campus. This highlights the issue that this thesis attempts to address. When GSI is present and no one knows about it, there exists a critical need for educational communication tactics to be employed. The integration of educational techniques is the responsibility of campus planners, landscape architects, facilities departments, and other campus staff. This thesis seeks to provide both precedent and explicit guidance for including education in the design of new and existing GSI sites on university campuses.

In addition, there is potential for further limitations on the case studies that were completed. As noted by Francis (2001), project designers or managers may have been unwilling to provide candid information on the sites and/or may have provided inaccurate information due to lack of knowledge or experience with the site. It is not possible to verify the information provided in the interviews, which provides potential for inaccuracies. Further, as the researcher, I have not received formal training in the processes of a scientific case study. Though the case studies were completed systematically and in accordance with Francis’s (1999) and Echols and Pennypacker’s methods, my lack of training can potentially limit the scientific accuracy of the study.
Recommendations for future research or design

Dedicated stormwater management team

Universities with dedicated stormwater teams were much better equipped to handle the maintenance of GSI sites, as shown in the abundance and quality of those on the Colorado State University Fort Collins campus. This is critical, because the cost and feasibility of maintenance is an important factor that is considered when designing new landscapes on university campuses. In addition, the dedicated stormwater team encouraged greater communication between campus planners, landscape architects, and the hired consultants who were completing the design projects. This communication was found to be critical to successful green stormwater infrastructure sites.

Increase the breadth of case studies

Increasing the number of case studies would allow for gathering increased precedent ideas. This could be in the form of increasing geographical area, including private institutions, and visiting all universities thought to have green stormwater infrastructure, even those with whom contact is not made.

Observe the usage of the designed signage over time

The installation of the interpretive signage resulting from this thesis could benefit from being studied further to allow for improvements and changes. An observational study of users
or interviews with viewers could be useful in determining the effectiveness of the signage and identifying any modifications that may be necessary to improve its success.

Review and revision of digital guide

Though the digital guide describing integration of educational communication in stormwater management sites resulting from this thesis was reviewed by the intended audience and multiple landscape architects, there is opportunity for further revisions and iterations to be generated. This could be in response to feedback from real-life users or further professional review. There is not currently a methodology for improving this design guide, but therein lies an opportunity for further work on the subject.
Chapter 5: Conclusion

Significance for site users

This research document, the resulting signage, and the digital guide all serve as a unique resource in the Intermountain West to bridge the gap between professional understanding and public knowledge of the workings of green stormwater infrastructure. The designs for which these materials serve as precedent will increase public awareness of sustainable stormwater management and its implications for the health of urban and natural environments.

Significance for the field

For the public to want to responsibly manage stormwater and understand their water-related impacts on the environment, they must first be aware of and understand the processes of stormwater management and its effect on the natural environment (Marsalek, 2001). University campuses offer an existing scholarly environment well-suited for an educational stormwater management site. In addition, facilities staff at numerous universities I contacted want to integrate education into their stormwater management sites, but do not know how to go about it. There is a limited amount of existing research on this topic in the geographical location of the Intermountain West. This is critically important, because the Intermountain West is home to an unusual situation regarding water ownership, rainfall, politics in water management, and plant types. It is in this unique environment where there exist no examples or guides demonstrating how to integrate education into the design of GSI sites. This research seeks to fill that gap.
The results of the research will serve to help campus planners, landscape architects, and facilities staff who wish to integrate education into the design of green stormwater infrastructure projects on campus, but who do not know what this looks like in practice. During the initial steps of selecting case study sites, universities indicated that they were very interested in and had considered integrating educational communication into their green stormwater infrastructure. Many expressed an interest in obtaining a copy of the guide resulting from this project. The guide will serve as a handbook for those in every stage of the design of green stormwater infrastructure sites on university campuses and will explain how to integrate educational communication into the site.

In addition, the signage design on Utah State University's campus will be an example for landscape architects, designers, and campus facilities departments to reference during their planning and implementation process of educational design on stormwater management sites. Especially in the Intermountain West, there are a limited number of stormwater management sites that integrate education into the design, so it is not practical for the average landscape architect or designer to have many local precedent designs from which to base their design.

Summary

As growth and the associated urbanization in the Intermountain West continue, so does the need to manage stormwater runoff sustainably to mitigate negative impacts on the health of urban-adjacent water bodies. Landscape architects hold a critical position in the development of our urban centers and are utilizing this prime opportunity to design sustainable
stormwater management sites through the design of GSI sites. Public awareness of these stormwater processes, however, is lacking. Therein lies an opportunity to integrate educational amenity into GSI design, one of the pillars of Artful Rainwater and the work completed by Stuart Echols and Eliza Pennypacker, both inspirations for this project.

This thesis utilized their pioneering design techniques for integrating educational communication into GSI sites. To address the unique geographic location in which this study takes place, the work of Echols and Pennypacker was used in conjunction with case studies on public university campuses in the Intermountain West. The research aided in the design of interpretive signage for a stormwater management site on Utah State University’s campus. In addition, during the case studies, it became apparent that campus staff yearned to integrate education into their GSI sites but lacked precedent designs and would benefit from a guide aiding in adding educational communication to their GSI designs. The second output of this thesis is a technical design manual tailored toward those campus planners, landscape architects, and/or facilities staff to use as a reference when integrating education into the design while retrofitting existing GSI sites or creating new GSI sites. This manual is the first of its kind.

As would be expected, there remains opportunity for further study on this subject. The techniques identified could be further researched to increase their applicability to GSI sites that are not only university campuses, but also secondary school campuses, business campuses, or public open space and streetscapes. With the addition of a website and more signage throughout the university campus, the signage designed for USU’s GSI site can be built upon to create a hub for stormwater education on campus. This project, its outputs, and subsequent
research on the integration of education into GSI design will seek to close the gap between professional understanding and limited public knowledge of sustainable stormwater management processes and the critical role of GSI sites.
Educational Communication for Green Stormwater Infrastructure Sites:
A Guide for University Campuses in the Intermountain West

Lilian Taft, Utah State University Department of Landscape Architecture & Environmental Planning
Advised by:
Jake Powell, Utah State University Department of Landscape Architecture & Environmental Planning
David Anderson, Utah State University Department of Landscape Architecture & Environmental Planning
Erin Rivers, Ph.D., Utah State University Department of Watershed Sciences

May 2023
Utah State University, Department of Landscape Architecture & Environmental Planning
# Table of Contents

**Section 1: Overview** ................................................................. 1  
  What is green stormwater infrastructure (GSI)?  ........................................... 2  
  Why is educating about GSI important? ....................................................... 3  
  Where and Who to educate about it? .......................................................... 3  
  How to do it? .................................................................................. 4  
  Ideas to learn. .................................................................................. 4  
  Ways to learn .................................................................................. 4  
  Context for learning ........................................................................ 4  
**Section 2: New Site Design** ............................................................ 5  
  What is it? ...................................................................................... 6  
  Where can it be done? ....................................................................... 6  
  How to do it? .................................................................................. 6  
  Key Principles. ................................................................................ 6  
  Critical Design Elements ................................................................... 7  
  Design Examples ............................................................................. 9  
**Section 3: Existing Site Retrofit** ..................................................... 11  
  What is it? ...................................................................................... 12  
  Where can it be done? ....................................................................... 12  
  How to do it? .................................................................................. 12  
  Key Principles. ................................................................................ 12  
  Critical Design Elements ................................................................... 13  
  Design Examples ............................................................................. 15  
**Section 4: Case Study Reports** ....................................................... 19  
  Arizona State University Polytechnic Campus ........................................... 20  
  Colorado State University Fort Collins ..................................................... 21  
  Northern Arizona University ................................................................. 22  
  University of Utah ............................................................................. 23  
  Utah State University .......................................................................... 24  
**Section 5: Quick Tips** ..................................................................... 25  
  Examples in Real Life. ....................................................................... 27  
**Section 6: Conclusion** ................................................................. 29  
  Where to go from here? ...................................................................... 31  
  Useful resources ............................................................................. 31
Thank you!
for choosing this guide to help you integrate educational communication into the design of your green stormwater infrastructure site

Intentions of This Guide

This guide on integrating educational communication tactics in green stormwater infrastructure site design was created as a product of many hours of research on a Master’s Thesis in the Department of Landscape Architecture at Utah State University.

Further, the extensive work of Stuart Echols and Eliza Pennypacker on Artful Rainwater Design as a design approach to green infrastructure sites with community amenity was built on and expounded upon to form the ideas presented in this guide in conjunction with a series of case studies on green stormwater infrastructure sites located on public university campuses in the Intermountain West.

Though the guide was created with the intention of integrating educational communication tactics on university campuses, it is worth noting that the information presented could be applied elsewhere in various community spaces, such as secondary schools, work campuses, business landscapes, public parks, or other public spaces.
Section 1: Overview

1 Overview
Section 1: Overview

What is green stormwater infrastructure (GSI)?

It is evident that the west is experiencing a prolonged drought that severely affects the availability of water throughout the intermountain west. It is this shortage, combined with rapid population growth, that highlights the importance of sustainably managing stormwater with the goals of keeping polluted water out of local water bodies, recharging depleting groundwater systems, and decreasing stormwater runoff in urban environments.

Green stormwater infrastructure (GSI) is an alternative method to managing stormwater to that of conventional stormwater management practices. In this conventional stormwater management, the design is primarily driven by a utilitarian goal, moving water off of the site as efficiently as possible to get it “out of sight, out of mind” (Wong & Eadie, 2015). This is often done by draining water off hardscapes into underground networks of pipes built to convey stormwater to treatment systems or surrounding water bodies. This method leaves little opportunity for infiltration and filtration, which degrades the water quality of the watershed as a whole (Ferguson, 1998; Marsalek, 2001). In addition, conventional stormwater management techniques recognize stormwater as having little to no amenity value, adding nothing to the community in the form of recreation, education, or aesthetic richness (Wong & Eadie, 2015).

In contrast, GSI is a more integrative approach to stormwater management and has a multi-faceted, utility focus. GSI acts to manage stormwater and flooding while simultaneously improving water quality, recharging groundwater systems, and creating a community resource (Eskin et al., 2008). Further, green stormwater infrastructure

Impervious surfaces (traditional roofs, roads, pavement, parking lots, etc.) increase the volume and speed of stormwater runoff.

Pervious surfaces (green roofs, bioswales, rain gardens, vegetated areas, etc.) decrease the volume and speed of stormwater runoff.

Graphic modified from Green Infrastructure Toolkit - Georgetown Climate Center, n.d.
prioritizes spaces which emphasize human amenities in the site, thus creating a pleasant place to spend time and incorporating an educational theme into the design (Smit Andersen et al., 2017).

Common elements included in GSI are rain gardens, bioswales, green roofs, permeable pavers and pavements, water collection and storage systems, and open green space. GSI turns traditional stormwater management from a necessary chore to a celebration of water and the addition of human amenity increases public awareness of the process of stormwater management (Echols & Pennypacker, 2008).

**Why is educating about GSI important?**

The use of GSI for stormwater management is an integrative approach to stormwater management that has a multifaceted, utility focus, as it acts to improve water quality, manage stormwater and flooding, create a community resource, and perform microclimate regulations.

Further, GSI prioritizes spaces which emphasize human amenities in the site, thus creating a pleasant place to spend time, increasing sense of community, and incorporating an educational theme into the design (Smit Andersen, Lerer, Backhaus, Bergen Jensen, & Danielsen Sørup, 2017).

Design professionals and government organizations are realizing the environmental and social benefits of sustainably managing stormwater in urban environments. However there remains a gap in knowledge in the public sphere as to what stormwater management is and what the benefits of GSI are. For the public to want to responsibly manage stormwater and understand their water-related impacts on the environment, they must be aware of and understand the processes of stormwater management and its effect on the natural environment (Marsalek, 2001).

**Where and Who to educate about it?**

University campuses offer an existing, scholarly environment that lends itself well to education in GSI. The landscape of each university should embody the university’s values as an institution (Zhang et al., 2016). Communicating that message to the users through educational techniques both aids in the understanding of sustainably managing stormwater and promotes a university’s values to be a sustainable asset in the community.

In addition, it is critical to be broad as to who may be educated by the green stormwater infrastructure. The primary users of university campuses are of course, the students. University students represent a vibrant, diverse community consisting of future leaders. Because of this, they are a critical educational audience with which to share the process and purpose of green stormwater infrastructure. Users of university campuses go beyond students and include professors, landscape crews, students’ families, local community members, university staff, faculty, and more (Walton & Sweeney, 2013). The communication tactics described in this guide can be applied to all users of the space and are meant to be inclusive of the diverse audience present on a university campus.
**How to do it?**

Educating on the purpose of and processes of GSI can be done in numerous ways, which will be discussed in-depth throughout this guide. For the most part, the guide will follow the three learning objectives outlined by Artful Rainwater Design’s Stuart Echols and Eliza Pennypacker in their publications and book, Artful Rainwater Design: Creative Ways to Manage Stormwater (Echols & Pennypacker, 2015). Both scenarios (existing site and new site) in this guide will work with three objectives in the integration of education into GSI sites, which are **Ideas to Learn**, **Ways to Learn**, and **Context for Learning**.

**Ideas to learn**

**Ideas to Learn** are concepts within the GSI landscape that can be taught with educational communication tactics. These include elements such as demonstrations that highlight the **hydrologic cycle**, **riparian flora and fauna**, **water treatment systems**, and more. The ideas to be taught could be illustrated by creating a **visible stormwater path** or **water treatment systems** with accompanying narratives, providing rich **riparian habitats** in the landscape, among various other design techniques, which will be touched upon throughout this guide.

**Ways to learn**

**Ways to Learn** are more or less what they sound like: the ways in which ideas and concepts are communicated to the audience. This can include **signage**, **interactive games**, or **activities** that promote education, **art exhibits**, and more. These elements are usually present in addition to the ideas to learn. The **Ways to learn** can describe the water’s path, the site’s historical water conditions, past water usage and habits, riparian species that live or have lived in the area, among other elements. This visual storytelling can be used throughout the landscape as a way to learn and can create a narrative that the user of the space follows and connects to.

**Context for learning**

**Context for Learning** is made up of three pillars which create a highly successful educational design: **visibility** of the topic being highlighted, **gathering** spaces within or near the GSI, and **interactivity** with the GSI landscape. Context for learning translates how effective the signage or other ways to learn are and highlight ways that the physical design can encourage passive education as the users and viewers inhabit the space.
Section 2: New Site Design

What is it?

This section describes techniques for integrating educational communication elements in the design of a new green stormwater infrastructure site.

Where can it be done?

The ideas discussed here can be employed in any new design of a green stormwater infrastructure project on your campus.

How to do it?

New green stormwater infrastructure projects on university campuses offer an ideal opportunity for highlighting sustainable stormwater management processes. Provided are techniques to add to your toolbox and use to include educational communication elements in the design of a new green stormwater infrastructure site.

Key Principles

Start Early

The sites that were most successful in integrating educational elements into the final design were the sites that worked the educational elements into the design process from the very start. Starting with initial concept designs, make educational elements a key part of the GSI site design.

Most universities must go through a bidding process to acquire a team to build a site. Make it clear early on that education will be a critical element in the GSI site by taking the initiative to integrate education into initial design solidifies its role and makes clear that the GSI and its educational elements are critical aspects of the site design.

Follow Through!

In the design of a new green stormwater infrastructure site, it is helpful to consider three key learning objectives, Ideas to Learn, Ways to Learn, and Context for Learning. Elements from each should be integrated to the design throughout the site to create an ideal learning environment for users of the space.

Make eduction priority in the finished GSI site design!

This involves ensuring there is money left at the end of the design for implementation of educational elements. In addition, continual monitoring of the engineers/construction leads throughout the construction process is critical to be sure that the GSI and its educational components are accomplished accurately (or at all).
Critical Design Elements

Install Signage

One of the most effective but often unused elements to integrate education into GSI sites is to include signage in the design! Many campus staff noted that signage is often one of the first elements of the design to lose funding at the end of the project. Be sure to have a dedicated pot of money set aside to ensure that signage gets built after the site construction is complete.

Most universities have signage committees specifically in place to ensure the visual identity on campus. When designing signage, it is useful to reference precedent signage on campus: look at signs that were already approved by the university’s signage committee. This style of sign is more likely to get accepted again.

Signage design is nuanced—it is a great opportunity to seek out a graphic designer, a student who needs a project, or another person who has experience in this area.

Add Visual Interest

Sites can be designed with visual interest in numerous ways, some of which include integrating variations in plantings, site elevations, and design materials. In addition, stormwater or water-related artifacts and designs can be integrated into the site via the hardscape, site furnishings, or stand alone features in the design.

Many Universities have standards when it comes to integrating architectural elements or artwork into the landscape. Often, there is a committee at the university assigned to approving the projects who will maintain the installation over time.

It is useful to note that temporary artifacts that add interest to the design can be easier to get approved and installed.

Encourage Exploration

GSI sites that allow for exploration increase the user experience of the space and facilitate greater learning opportunities. Exploration supports tactical learning skills and creates physical opportunity to learn about the stormwater processes in a site.

Examples of this include interactive demonstrations, integrating seating into the stormwater management element of the site, and adding pathways and demonstrations throughout the site, as well as other design elements which encourage exploration.

Create Gathering Spaces

Successful GSI sites encourage sitting, exploring, and otherwise spending time within them. Spending time in the space increases opportunity for learning, as well as creating a space that may be revisited and more often used.

The primary users of University campuses (students) are at school to learn and are always looking for places to study. This is a fantastic opportunity to integrate studying nooks, both private and public, into GSI sites. In addition, larger sites can serve multiple uses, such as a retention basin that could also be an outdoor classroom.
Design Examples

The following design examples result from case study research on university campuses. These examples are meant to serve as a reference, but are by no means exhaustive in the ways education can be integrated into GSI sites on university campuses. **Reference** them, **use** them, **imitate** them, but **know** that there are **more ways** to integrate education in the design. Additional examples can be found by referencing Stuart Echols’ and Eliza Pennypacker’s work with Penn State University on Artful Rainwater Design, in addition to numerous other resources found on the internet.
Design Examples

Create Gathering Spaces

Designers of this stormwater management site created a retention basin that functions as an amphitheater for daily use when it is not serving its stormwater management purpose. This transforms a necessary utility into multi-use community amenity while increasing awareness of stormwater management processes.

Encourage Exploration

Integrating flat-topped boulders, which act as benches, into this dry river bed encourages users to gather in the GSI site, socializing, exploring, or studying.
These signs use eye-catching graphics and short text. One highlights the purposes of the garden as a stormwater management site as well as pollinator habitat, and the other explains how water runoff from a greenhouse is treated using settling basins. Both are located adjacent to high-traffic paths, providing ideal learning opportunities for users.

This site contains large visual interest in its variation of plantings, changes in elevation, and integration of various textures.
3
Existing Site Retrofit
Section 3: Existing Site Retrofit

What is it?

The following section describes techniques for integrating educational communication elements in the design of an existing green stormwater infrastructure site. These elements are meant to be added after a site is designed and do not need to be included in the concept phase.

Where can it be done?

Any green stormwater infrastructure project that already exists on your university campus can be retrofitted to include education.

How to do it?

Existing green stormwater infrastructure projects on university campuses provide an excellent opportunity for integrating educational communication tactics. The project sites are already doing the work to sustainably manage stormwater, and now all that is left is to tell the users about the process! The following section will highlight ways to employ retrofit design techniques that promote educational communication on an existing GSI site.

This section highlights only some of the objectives that Echols and Pennypacker include in their framework. The objectives included are those that are most suitable for retrofitting an existing stormwater management site to include education.

The following examples illustrate additional elements that you could integrate into the design, such as signage, seating, or artwork. However, in addition to the techniques presented here, there may be existing ideas to learn, such as a visible stormwater management process or hydrologic cycle, that you might choose to highlight within the GSI site.

Key Principles

Maintenance is Key

Keeping the GSI in working order and maintained is critical for its effectiveness in managing stormwater and remaining a public amenity. Many educational design techniques highlight the GSI site and university campuses often pride themselves on high aesthetic quality in their landscapes. Maintenance, therefore, is critical. You will not want to emphasize a site whose landscape is neglected!

Retrofit Whenever!

Educational elements can be added to a GSI site whenever works for the particular location. This could be dependent on funding, design, season, availability of labor, etc. At any point in the lifetime of the site, retrofitting with education is worth the effort because it benefits all users of the space. Integrating education in the GSI site later is better than never!
Critical Design Elements

**Get People into the Space**

Even once a design is complete, there are ways to retroactively integrate elements into the site to get people into the GSI. Adding seating is one simple way to encourage people into a space. When the weather is nice, students and professors are always looking for a spot to sit between classes to eat, study, or socialize, making this a highly appropriate technique.

The addition of visual interest within the GSI site could also encourage exploration into the space to get a closer look.

**Install Signage**

Perhaps the easiest and one of the most effective ways to retrofit a GSI site with educational elements: signage! It is often the case that amazing GSI is happening in the landscape, but there is nothing to explain it and it is completely lost on people who are not familiar with the workings of GSI.

Most universities have signage committees specifically in place to ensure the visual identity on campus. When designing signage, it is useful to reference precedent signage on campus: look at signs that already got approved by the university's signage committee. This style of sign is more likely to get accepted again.

Signage should be in a visible location that receives a large amount of pedestrian use. It should contain concise, brief text with catchy graphics and/or photos. Designing signage is nuanced—it is a great opportunity to seek out a graphic designer, a student who needs a project, or another person who has experience in this area.

**Add Visual Interest**

Add visual interest into the design: this could be artwork, water-related artifacts, sculptures, or other sources of interest.

These can show expressive hydrological symbols—they could be static or have movement or transformation when it rains, when they are wet, or when the soil is moist. This exhibit should be attractive and visible, with variance and a design that invites interactivity.

Many Universities have standards when it comes to integrating architectural elements or artwork into the landscape. Often, there is a committee at the university assigned to approving the projects who will maintain the installation over time.

If all else fails, you could also install temporary artwork that adds interest to the design, which can be easier to get approved and installed.

**Diversify the Plantings**

Plants and plantings can be changed or added to a design fairly easily. A turf grass or rock-lined retention basin without plantings can be transformed with the addition of native or riparian vegetation.

With vegetation comes wildlife habitat. These areas can be enhanced with other habitat shelter, such as bird boxes, bat houses, mason bee nesting tubes, and more.
The following design examples are illustrative demonstrations of educational elements that can be retrofitted into GSI sites. These examples are meant to serve as a reference, but are by no means exhaustive in the ways education can be retrofitted into GSI sites on university campuses. Reference them, use them, imitate them, but know that there are more ways to retrofit the design with educational elements. Additional examples can be found by referencing Stuart Echols’ and Eliza Pennypacker’s work with Penn State University on Artful Rainwater Design, in addition to numerous other resources found on the internet.
Design Examples

Get People into the Space

Adding a small bench along this path encourages users to divert off of the main sidewalk and seek refuge in this buzzing pollinator garden, where they otherwise may choose to walk by without stopping. When the tree grows larger, it will provide an overhead canopy with shade, further increasing the appeal of the bench.
Integrating artful sculptures containing moisture-activated LED lights is an interesting, artful way to add interest to the landscape and educate passersby on the purpose of the bioswale. When the soil is moist, the light glows blue. The sculptures remain in the bioswale as art pieces when the soil is dry.
This bioswale is located down the center of one of the main walking/biking paths spanning the university campus. Adding a sign explaining the purpose of the bioswale would encourage path users to either stop and look or simply read as they walk by, integrating education with minimal effort on the part of the user and designer.

This sign is designed to complement a bioswale on a university campus, explaining both the path of stormwater in urban environments and the workings of the bioswale. The sign utilizes brief text and catchy graphics to tell the story of stormwater.
4 Case Study Reports
### Arizona State University Polytechnic Campus

#### Summary of Visit

Staff at Arizona State University Polytechnic campus were not available for interview regarding the green stormwater infrastructure site. Thorough notes and documentation were taken on a self-guided tour of the green stormwater infrastructure site and research was done on the project utilizing the landscape architecture firm’s ASLA award article (‘ASLA 2012 Professional Awards | Arizona State University Polytechnic Campus — New Academic Complex’, 2012) describing the green stormwater infrastructure site and the Artful Rainwater Design’s case study report on the campus from Artful Rainwater Design: Creative Ways to Manage Stormwater (Echols & Pennypacker, 2015).

#### Project Background & Goals

This project is a retrofit of a frequently flooded roadway on the ASU Polytechnic campus. In addition, the renovation was intended to transform a vastly paved area into one that implemented more natural vegetation and softscapes. In addition to flood mitigation, the project seeks to facilitate a daily connection to nature and emphasize the natural processes of stormwater management of a desert arroyo in which the campus is located.

#### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Example: Ways to Learn</th>
<th>Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible water treatment system</td>
<td>- As is, does not exist</td>
<td>- Gathering: benches are part of the stormwater management systems</td>
</tr>
<tr>
<td>Visible historical water condition: agricultural irrigation techniques</td>
<td>- <em>Example of Signage</em>: integrates Echols and Pennypacker’s criteria for effective signage and explains stormwater management processes</td>
<td>- There exists much more context for learning all throughout the site: walkways, pavilions, benches, artwork, etc.</td>
</tr>
<tr>
<td>Visible hydrological cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riparian plant types and wildlife</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Lessons Learned

The site is attractively designed and highlights numerous, intricate demonstrations of natural stormwater management processes, such as historical water condition, natural hydrological processes, and natural stormwater management systems. However, to an average passerby who is not educated in the historical water conditions or arroyo stormwater processes or green stormwater infrastructure generally, these intricate demonstrations and displays could be overlooked as simply landscape design or minimalist landscaping.
### Colorado State University Fort Collins (CSU FC)

<table>
<thead>
<tr>
<th>Summary of Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff at CSU FC were available for an interview and tour of the green stormwater infrastructure on campus during the site visit. During the campus tour, university staff and I discussed the extent of green stormwater management, its history, integrating education into design, maintenance, precedents, and more. The generosity of campus staff to share time and knowledge is immensely appreciated and created an ideal scenario for this case study.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Background &amp; Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>This continually ongoing project on the CSU FC campus began in 2008 with Leadership in Energy and Environmental Design (LEED) certificates paving the way for sustainable development. In addition, university staff demonstrate an understanding of the importance of sustainable development practices. Most the green stormwater infrastructure projects on the campus have come with new development and are not a retrofit of gray stormwater management. The green stormwater infrastructure present through the university campus is integrated into the everyday life of users.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence of Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ideas to Learn</strong></td>
</tr>
<tr>
<td>- Visible water treatment system</td>
</tr>
<tr>
<td>- Various water treatment types throughout site</td>
</tr>
<tr>
<td><strong>Ways to Learn</strong></td>
</tr>
<tr>
<td>- Signage: describes water treatment system, but it is not stormwater runoff; sign is effective, uses brief text and catchy graphics</td>
</tr>
<tr>
<td><strong>Context for Learning</strong></td>
</tr>
<tr>
<td>- Gathering spaces: detention basin and amphitheater; dry riverbed with study nooks; vegetated bioswale adjacent to a non-vehicular multi-use path all encourage groups to gather, sit in, and explore in and around water treatment areas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lessons Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td>A design challenge identified is the gaps between campus landscape architects who design a site, the engineers working on the projects, and the contractors installing the elements. Lack of knowledge during the installation on specific soil types, filtration needs, and plant selection often prevent the original designs from being executed successfully. In addition, there is little emphasis on communication during the design process between the three entities, resulting in miscommunications, incorrect installations, changes to design, and more. The university faces a unique challenge to stormwater management because it lies on a flood plain. Stormwater management must be taken into consideration in every aspect of campus renovations. This, combined with staff who sincerely care about creating a sustainable and resilient campus, creates an opportunity for focus and dedication to sustainable stormwater management techniques on the CSU FC campus.</td>
</tr>
</tbody>
</table>
### Northern Arizona University (NAU)

#### Summary of Visit

According to staff during communication, there is a single example of education in green stormwater infrastructure on this campus: one green roof accompanied by an indoor sign describing its purpose. This single example did not financially justify the trip to visit the campus in-person because photos sufficient for understanding the signage were obtained through email correspondence and phone interviews with university staff.

#### Project Background & Goals

This site demonstrates the ways to learn objective highlighted by Echols and Pennypacker, shown in the two small signs describing the purpose of the green roof.

- Motivation stemmed from a state mandate to build to LEED standards and that building was going for LEED platinum. This was a way for NAU to show leadership in green building design.
- The green roof was a demonstration situation when it was created, dedicated to highlighting its ability to reduce the heat island effect created by urban environments.

#### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Ways to Learn</th>
<th>Example: Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Visible water treatment system</td>
<td>- Signage: does not utilize Echols and Pennypacker’s guidelines; does not explain stormwater management</td>
<td>- As is, does not exist</td>
</tr>
<tr>
<td>- Visible hydrological cycle</td>
<td>Visible hydrological cycle</td>
<td>- Example of Gathering: seating and shade that could be used for studying, eating, or socializing</td>
</tr>
</tbody>
</table>

#### Lessons Learned

Staff emphasized that there is a limit to how much they were able to do with the design of green stormwater infrastructure on campus. For example, there had been an attempt to create a parking lot from permeable pavement with signage explaining the infiltration.

- However, the extreme weather conditions of the area forced them to remove the pavement and signage shortly after installation.
- The roof garden was made initially to be a demonstration of sort and allow for LEED platinum certification of the building. It is not really utilized or maintained. The signage displays the roof’s goals for reducing Heat Island Effect, and the roof was not designed with the intent of managing stormwater.
### University of Utah (U of U)

#### Summary of Visit
The staff at University of Utah provided a generous amount of time in the form of an informal interview and a campus tour of green stormwater infrastructure sites and a stormwater management demonstration site. During the conversations and tour, staff and I discussed the role of green stormwater infrastructure on campus, its design and evolution, and what elements the university uses to educate on its purpose and function.

#### Project Background & Goals
About 15 years ago, the University of Utah made a shift toward green stormwater infrastructure, stemming from the Utah’s implementation of sustainability regulations. The movement was emphasized by campus staff at the time, to whom green stormwater infrastructure was important. Though there are many traditional detention basins on the University of Utah’s campus to manage stormwater, there is also green stormwater infrastructure throughout in visible locations. One site is a functioning demonstration piece, designed to be a scientific experiment and others are in visible locations throughout campus. In general, U of U’s main goals with green stormwater infrastructure is to manage flooding on campus. However, the demonstration piece, called the Living Lab, was designed as an experiment with the goal of measuring the performance of native vegetation versus non-native plants in bioretention systems, in addition to other ecological, social, maintenance, and performance-oriented measurements.

#### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Ways to Learn</th>
<th>Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Visible water treatment system</td>
<td>- Signage: informational describing processes of stormwater management and pollinator habitat; sign is brief, graphic-heavy, and located to attract viewers</td>
<td>- Visible water treatment system</td>
</tr>
<tr>
<td>- Visible hydrological cycle</td>
<td></td>
<td>- Exploration: foot-path runs through garden</td>
</tr>
<tr>
<td>- Riparian habitat: variety of plant types offering habitat for insects and pollinators</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Lessons Learned
Because the designers change with every project, there were no lessons learned identified by university staff regarding the general green stormwater infrastructure throughout campus. The staff noted that a lesson learned from the Living Lab project was that given the transient nature of students at the university, year-to-year measurements often fall to staff to complete, which is at times not viable, given their professional duties and priorities. Though the campus staff does seem to care about creating green stormwater infrastructure, the main goals for this are clearly oriented toward flood mitigation and there is little emphasis on educational communication in any of the green stormwater infrastructure sites, apart from the Living Lab demonstration area.
### Summary of Visit

There are many green stormwater infrastructure sites on USU’s campus apart from the Aggie Bull-evard site that this thesis works on. This case study looks at the various other green stormwater infrastructure sites and the educational communication techniques associated with them through a self-guided walking tour of campus. In addition, an office interview with the campus staff took place to discuss the green stormwater infrastructure on campus and the staff and university’s educational and sustainability goals.

### Project Background & Goals

USU has been moving toward sustainable stormwater management for approximately 25 years. The catalyst for this was a general paradigm shift ago toward sustainability in various ways and staff at the university pushed for sustainability and resilience in their designs. This is shown in various types of green stormwater infrastructure throughout campus, including demonstration areas which serve to educate. Goals of implementing green stormwater infrastructure throughout the campus are to create educational sites that sustainably manage stormwater. The team works to implement this in their design whenever physically and fiscally possible in new and existing projects on campus.

### Evidence of Objectives

<table>
<thead>
<tr>
<th>Ideas to Learn</th>
<th>Ways to Learn</th>
<th>Context for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Visible water treatment system</td>
<td>- Visible water treatment system</td>
<td>- High-visibility location</td>
</tr>
<tr>
<td>- Visible hydrological cycle</td>
<td>- Signage with clear, colorful graphics</td>
<td>- Gathering space near stormwater treatment system</td>
</tr>
<tr>
<td>- Treatment system impact: two basins collecting debris</td>
<td>- Riparian habitat: green roof plantings buzz with insects</td>
<td></td>
</tr>
<tr>
<td>- Riparian habitat: variety of plant types and communities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lessons Learned

Site planners emphasized that there are climatic concerns regarding freezing of water that is discharged to the surface level. The study showed a large amount of green stormwater infrastructure on campus. In addition to clearly visible sites, much of the water that goes into storm drains on campus empties to dry wells underground, which filter the water and return it to the groundwater. These processes go unnoticed on campus, due to their invisibility and lack of explanation for passersby. Furthermore, a significant amount of green stormwater infrastructure that is visible gives a context for learning, but does not necessarily attract users to be in the space nor do they have ways to learn associated with them, such as signage. This appears to be a missed opportunity for education on USU’s campus that could more effectively communicate the green stormwater infrastructure’s purpose.
5 Quick Tips
**Examples in real life**

### Get People Into the Space
- Add benches in the stormwater treatment system
- Add study nooks to stormwater treatment landscape
- Create opportunities for games & play

### Create Gathering Spaces
- Integrate benches into the surrounding landscape
- Create picnic areas near stormwater treatment systems
- Add study nooks
- Create communal seating

### Add Visual Interest
- Put art pieces in the stormwater treatment system
- Add stormwater related artifacts
- Paint the pavement around storm drains
- Create art in permeable pavers

### Install Signage
- Add a large, main sign showing the process of stormwater management system
- Integrate smaller signs throughout the entire site
- Ensure signs use brief text and catchy graphics

### Encourage Exploration
- Paths through stormwater management system
- Add bird houses, bat boxes, or other wildlife habitat
- Add educational structures that change when wet
- Add small signs within the stormwater treatment system

### Diversify the Plantings
- Replace a lining of turf or rock in detention basins with vegetation that can handle both dry & wet conditions
- Plant pollinator-friendly species
- Use only native or near-native plantings in the stormwater treatment landscape
6 Conclusion
Section 4: Conclusion

Where to go from here?

The guidelines presented in this document were tailored to and resulting from research on university campuses in particular. Because university campuses are an existing learning environment, they are particularly appealing for integrating education into GSI design.

It follows, then, that these techniques could also be integrated into other learning environments, such as secondary schools or work campuses. It is with that in mind that I would hope the techniques and methods described could be utilized in these and other scenarios to offer educational opportunities in a variety of environments. The methods are widely applicable and the examples are broad, utilizing parts of designed landscape not exclusive to university campuses. Though research has not been done on the topic, it can be assumed that the educational techniques described in this guide would be effective educationally in more environments than just on university campuses. This is shown by the diverse usage that university campuses already experience, being places that community utilizes as public open space, professors and university staff spend time, and landscape crews maintain GSI sites and the landscape.

The communication tactics described in this guide apply to all users of the space, are inclusive of the diverse audience present on a university campus, and can therefore be applicable beyond the university campus.

Useful resources

Publications:
Artful Rainwater Design: Creative Ways to Manage Stormwater | Stuart Echols & Eliza Pennypacker, 2015

Websites:
Center for Sustainable Landscapes | Phipps Conservatory and Botanical Gardens
EPA | Green Infrastructure Design and Implementation
Pennsylvania State University Extension | Artful Rainwater Design
References


Mississippi Department of Transportation. (n.d.). Stormwater management terms & definitions, 3.


