Development of a Model Sustainability Management Plan for the City of Morgantown, West Virginia

Caitlyn Elizabeth Lewis
West Virginia University, celewis@mix.wvu.edu

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Development of a Model Sustainability Management Plan for the City of Morgantown, West Virginia
Caitlyn Lewis
Thesis
submitted to the Davis College of Agriculture
at West Virginia University
in partial fulfillment of the requirements for the degree of
Masters of Landscape Architecture in
School of Design and Community Development

Peter Butler, Chair
James Kotcon
Elisabeth “Lisa” Orr
John Christopher Haddox
Department of Landscape Architecture

Morgantown, West Virginia
2023

Keywords: Sustainability, sustainable development, stormwater management, greenspace preservation, land-use, transportation, ecological planning, sustainability planning, phytoremediation, brownfield

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ABSTRACT

Development of a Model Sustainability Management Plan for the City of Morgantown, WV
Caitlyn Lewis

This report has been prepared to demonstrate the research for a model planning document with a focus on sustainability in Morgantown, WV. It discusses the role of three categories in the context of sustainability and proposes a design solution for selected areas of concern throughout the City of Morgantown in order to demonstrate opportunities for a sustainable approach toward resolution for city officials.

The City of Morgantown, West Virginia, is a college town along the Monongahela River with a backstory of industrialism that is echoed by many other places in Appalachia. However, distinctively, in Morgantown 25,000 college students populate the city during the school year and vacate during the holidays leaving parts of the city depleted of its population for a quarter of the year. This system demands the infrastructure act like a rubber band, stretching to accommodate the steadily increasing population influx associated with West Virginia University, and snapping back to meet the needs of only local residents.

In order to explore three areas of sustainability: storm water management, transportation, and land use, this report synthesized existing data on City of Morgantown infrastructure systems, demonstrates the impact of these data under the context of sustainability, and discovered that there is a lack of available resources for city officials on sustainable infrastructure planning. As a result, this document recommends proactive measures and provides potential design solutions that will assist in crafting a system of infrastructure that is able to respond to the increasing threat of climate change.
ACKNOWLEDGMENTS

This project is dedicated to the members of the Morgantown Municipal Green Team for their aid and support in this project, those that agreed to serve on my thesis committee James Kotcon, Chris Haddox, Lisa Orr, and Peter Butler, who was an enormous source of support; as well as my advisor, Vaike Haas, whose work and research inspired much of this project.

Additionally, I would like to thank my mother, Susie Lewis for being my role model as a strong successful woman, my father, Tim Lewis, for advising me and showing me the value of hard work, and my brother, Samuel for encouraging me, as well as my grandmother Betty Lewis for her unwavering confidence.

I would like to honor those I lost during the production of this document as well. I wish to memorialize my late grandmother and grandfather Judy and Jerry Hamrick whose good humor, birthday cards, and care packages kept me fed and housed during the early years of my college career; our sweet dog, Renji, a very very good boy; and I would also like to honor the memory of my first and very best friend at WVU, Michael Rogers, who was never too distant to love and believe in me.

Most of all, I would like to thank my truest love and partner, Jordan Brown; the person who held me up and stuck by my side through everything. I couldn’t have done any of this without your encouragement, support, patience, love and friendship. I owe everything I have accomplished to you, Jordan.
PURPOSE OF THE SMP

Upon entering a new comprehensive planning cycle, the Morgantown Municipal Green Team reviewed previous comprehensive plans for the City of Morgantown and discovered that there was a lack of focus on environmental sustainability.

In response, the Green Team developed a Climate Action Plan which, as is traditional, focuses on the elimination of greenhouse gas emissions in the City of Morgantown. The Sustainability Management Plan seeks to incorporate energy efficiency as a facet of sustainable development, and applies the research acquired through the development of the Climate Action Plan (CAP) but the SMP focuses primarily on green infrastructure practices. (Cox, 2015)

This differentiation is supported by Helen Cox (2015), who wrote on the topic saying, “A CAP focuses specifically on reducing (or eliminating) greenhouse gas (GHG) emissions (primarily carbon dioxide, methane, and nitrous oxide)...In contrast, a sustainability plan should be broadly focused on university practices in all related areas including food services, education, purchasing, landscaping, waste, water, energy, transportation, environmental quality, construction, administration, equity, investment decisions, etc.” (American Planning Association, 2019)

Goal-setting and visioning for this project happened in response to meetings with municipal stakeholders and the impacts inflicted upon existing infrastructure in the wake of extreme weather events. Visioning resulted in the identification of a need to preserve areas of open space, benchmark energy use, and to make a preliminary attempt to establish a general vision of the impact of climate and urbanization on the landscape of Morgantown.
For the purpose of developing this document and defining the scope of research, it is necessary to establish a definition of sustainability. In conducting research, the term, “sustainability” or, “sustainable” is used to describe a method of practice.

“There is no dearth of alternative ways to specify the meaning of sustainable development (Mitlin 1992; Pezzy 1992; Redclift 1992). Furthermore, ‘sustainable’ and the related term ‘sustainability’ can be combined with a vast array of terms other than ‘development’: thus, we have ‘sustainable growth’, ‘sustainable biosphere’, ‘sustainable living’, ‘sustainable resource management’, ‘sustainable cities’, the ‘sustainability of ecosystems’, ‘cultural sustainability’, and so on. This proliferation illustrates the fluidity of conceptual categories and boundaries in the relatively open-textured context of political and social debate. And it reflects the complexity of the themes invoked when development and environment are juxtaposed.” (Bell & Oakley, 2018, p. 11)

The term “sustainable” is applied to an array of sectors so vast that it can become at times ambiguous. Constance Carr references a definition in the Salem Press Encyclopedia by David V. J. Bell who, “has defined sustainability as being about designing and organizing human activity in such a way that the complexity and interconnectedness of all systems are taken into account and the survival of any one system is dependent on the health of the others. Sustainability is generally concerned with both the health of the planet as a provider of life systems for humanity and the establishment of knowledgeable and empowered societies. It is a future-oriented outlook that emphasizes that the current generation of human beings should leave the Earth to their children in a condition equal to or better than the one they inherited.” (Carr, 2020)

It is important to acknowledge here that in the mid-twentieth century, The National Environmental Policy Act of 1969, attempted to set forth the following goal with regard to sustainability, “to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.” (The National Environmental Policy Act of 1969, as amended, 1970)

The concept of “sustainability” as we know it now emerged in the 1980s, and the Brundtland Commission, also known as the UN Global Commission on Environment and Development, concocted its current definition in 1987.

The document created at the conference was called “Our Common Future,” and it included the following definition of sustainability: “Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future.” (World Commission On Environment and Development, 1987)
Our Common Future provides the definition of sustainable development that is most suited for this study. The majority of significant works on the topic that have been produced utilize this definition. The necessity to provide resources and a habitable environment for future generations is also included in practically all articles that seek to describe the notion. For example, the Environmental Protection Agency (EPA) addresses the subject by saying, “Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations.” (Learn About Sustainability, 2022)

Julia Sze (2018), highlights the delicacy of sustainability and argues for the human justice side of sustainability, by explaining that at its core, sustainability means to maintain, uphold, and survive across time. The ecological concepts of ultimate unified balance among natural systems, resource conservation in ecosystems, and resource allocation in closed systems serve as the cornerstones of sustainability. Within the constraints given by the supporting system—both in terms of resources and other factors—it is about enhancing the quality of living. Cities are inherently dependent on external resources, much like the majority of biological systems are not closed to inputs and affects from the surrounding system.

While the development of a Sustainability Management Plan is a relatively new practice, the idea of planning with the landscape in mind is not a new premise. Scholars have written extensively on sustainable development and sustainability planning for decades, however less recent publications tend to use the term, “ecological,” “landscape suitability” or “human-ecological planning and design.” (Ndubisi, 2014)

The mid-nineteenth century saw the development of ecological planning in the United States as a component of landscape architecture. George Catlin, a lawyer, artist, and later a historian of Native American cultures, was deeply concerned about the impact of “civilization” on Native Americans’ way of life. While traveling to the Far West to research the history and customs of the Native Americans who lived there, Catlin was astounded by the beauty and elegance of the natural landscape. Ralph Waldo Emerson, a pastor by trade who had a passion for nature, began formulating ideas for his book, Nature. Emerson came to the conclusion that nature was the true source of knowledge and argued for the establishment of nature preserves “containing man and beast, in the wild and freshness of their nature’s beauty!” (Ndubisi, 2014)

He espoused an anthropocentric view of nature, in which nature existed to serve man, but he was also against destroying nature.
In fact, he regarded nature as a source of spiritual healing for humankind. Henry David Thoreau, a writer and Emerson's neighbor in Concord, Massachusetts, was greatly influenced by Emerson's ideas.

A Transcendentalist who rejected Emerson's anthropocentric view of nature, Thoreau claimed that, "No human being, past the thoughtless age of boyhood, will wantonly murder any creature which holds its life by the same tenure that he does." (Ndubisi, 2014)

The writings of these men influenced the thinking of other social reformers during the awakening period, especially Frederick Law Olmsted Sr. and George Perkins Marsh, who were horrified by the dehumanizing aspects of city life and by the human abuse of the landscape. By the middle of the nineteenth century Thoreau had joined Catlin in calling for the creation of nature preserves. Olmsted's philosophy regarding the healing effects of open space and trees on the human mind and soul was based on Emerson and Thoreau's idea that nature can be a source of spiritual healing.

These individuals set the precedent for the field of ecological planning, and research for this project was conducted regarding the methodologies implemented in ecological planning. Applied-human-ecology is the methodology most accurately describing the intent and research methodology in the field of ecological planning that was utilized during the production of this report. This methodology was described as follows: “The human-ecology approach scrutinizes the underlying social structure of the landscape—values, needs, desires, and adaptation mechanisms and then matches the structure with the opportunities and constraints offered by the natural and biological environment using qualitative techniques such as verbal descriptions, texts, and matrices. (Ndubisi, 2014)
ROLE OF STORM WATER MANAGEMENT IN SUSTAINABILITY

Storm water runoff continues to be a significant contributor to water contamination in metropolitan areas. Via storm sewers, it dumps debris, pathogens, heavy metals, and etc., into nearby rivers. Flooding brought on by torrential rain storms can harm infrastructure and property.

The solutions available to safeguard the city from the escalating danger of catastrophic floods include both green and gray infrastructure and resilience measures. Gray infrastructure refers to the traditional networks of gutters, pipelines, and tunnels that channel storm water to nearby waterways. The country’s gray infrastructure is outdated in many places and losing some of its ability to handle rapidly increasing amounts of rainfall. (Environmental Protection Agency, n.d.)

Several cities are putting in place green infrastructure solutions to improve their ability to manage storm water in order to tackle this problem. Communities benefit from these solutions not only in greater resiliency performance, but also in the realm of social and economic performance as well. (Environmental Protection Agency, n.d.)

Urban watersheds control the quality of aquatic and riparian habits, local water supplies, and stream-side properties. Development alters the path of water through urban watershed and through the hydrologic cycle as a whole. Removal of vegetation eliminates natural transpiration. Addition of impervious roofs and pavements eliminates soil infiltration and groundwater recharge. Surface runoff carries non-point-source pollutants, erodes stream channels, and increases flood frequency and severity. Stream base flow declines making it harder for aquatic ecosystems to survive. Some urban communities are left with local water shortages. The purpose of storm water management is to reduce or eliminate these alterations of the hydrologic cycle and their human and ecological consequences.

Storm water is described as precipitation that travels over the surface of the earth as runoff and does not sink into the ground or evaporate. Storm water management gets more challenging when land is progressively developed. Storm water levels are rising as a result of a number of development-related factors, including clearing land, filling natural wetlands, altering the topography of the land, and constructing impermeable surfaces like roads, driveways, and rooftops. Furthermore, storm water management must be done properly to prevent erosion, floods, and surface water contamination. Both the amount of precipitation that flows off the land and the velocity of flow increase as development grows.

Pollutants transported by storm water, in
addition to sediment, include fertilizers and pesticides from lawns and agricultural fields, road salt disease and bacteria from pet and animal wastes, and a variety of contaminants from cars. They are classified as “non-point-source” pollutants because they enter a body of water via uncontrolled sources rather than from a single outflow point, such as a pipe (which would be considered “point-source” pollution.) Storm water runoff reduction and management have a significant impact on pollution loading in natural water bodies.

Our increasing population has a specific impact on storm water because contemporary human land use alters water flow, and the truly harmful pollutants are produced by people and human activity. Storm water is produced by the impermeable surfaces of cities and results in high peak flows and low base flows. Urban streams are fed by the water that travels via developed storm water systems after falling on the impervious surfaces that make up urbanization such as buildings, parking lots, etc. When combined with the contaminants carried by these flows, it also causes damage to the organisms impacted by these systems like the delicate creatures residing in urban streams who are often killed by the impacts of urbanization. (Wilson, 2016)

The environmental effects of urbanization and providing the community with rivers that have a variety of purposes have historically received little attention or funding. The total area of impervious surfaces within a watershed rapidly rises with development expansion. The quantity of water that can penetrate the soil is drastically reduced due to the large percentage of developed area, and as a result, the majority of rainfall turns into run-off. (Victoria, 1999)

Swales, ponds, and wetlands are essential for large-scale storm water management. A swale is a dip in the landscape that directs runoff to another location or, ideally, retains it long enough for it to drop out sediment and infiltrate into the soil. Runoff from a town or development is often directed through a swale. The swale’s vegetation filters some of the contaminants while also slowing the water. A pond or wetland also holds water while allowing certain contaminants to slough off or be filtered by the vegetation. In fact, certain wetland creatures may degrade oils and other contaminants into safe components. (Hinton, J. W. 2023)
EXISTING CONDITIONS

Morgantown, WV faces significant challenges in managing storm water runoff due to rapid urbanization and increased impervious surfaces (Molinari, 2021). To address these issues, the City of Morgantown has implemented various storm water management strategies, such as constructing storm water detention ponds and installing storm drains and culverts (Cullison, 2019). However, there is a need for more sustainable and resilient approaches to storm water management, such as green infrastructure and low impact development, to enhance the capacity and effectiveness of the storm water system (Vogel, 2020).

In response, Morgantown is exploring innovative storm water management practices, such as regenerative storm water conveyance, which uses natural channels and vegetation to manage storm water (Shaver, 2019). These efforts highlight the importance of implementing sustainable and resilient storm water management practices in urban areas to protect the environment and ensure the safety and health of the community.

The Morgantown Utility Board’s storm water management plan is an ongoing effort to reduce the impacts of storm water runoff on water quality in the area. The plan focuses on the implementation of best management practices (BMPs) to reduce pollutants and manage storm water runoff. BMPs include practices such as rain gardens, bio-retention areas, green roofs, permeable pavement, and water quality swales. These practices are designed to mimic the natural hydrology of an area and reduce the amount of runoff generated from a site. In addition to implementing BMPs, the storm water management plan includes the development of educational programs and outreach to promote storm water management practices to the public.

The ultimate goal of the plan is to reduce the amount of pollutants entering local streams and rivers, improve water quality, and protect aquatic ecosystems. The Morgantown Utility Board regularly monitors and assesses the effectiveness of the storm water management plan and makes updates and modifications as necessary to ensure the continued success of the program. Through continued efforts and support, the Morgantown community can work towards sustainable storm water management practices that will improve the health and vitality of local waterways.

Several organizations in Monongalia County, West Virginia, are working to improve storm water management and restore streams. The Friends of Decker’s Creek, a non-profit organization, is dedicated to restoring and protecting the Decker’s Creek watershed, which flows through Monongalia County (Friends of Decker’s Creek, n.d.). The Mon River Trails Conservancy manages and maintains the Mon River Rail-Trail system, which includes over 48 miles of trails along the Monongahela River (Mon River Trails Conservancy, n.d.).
This organization works on projects to restore riparian buffers and reduce storm water runoff into the river. The Monongalia County Conservation District provides technical assistance and education to farmers, landowners, and other stakeholders on issues such as soil erosion and storm water management (Monongalia County Conservation District, n.d.).

Morgantown has a combined sewage system, which means that: “A combined sewer system collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe. Under normal conditions, it transports all of the wastewater it collects to a sewage treatment plant for treatment, then discharges it to a water-body. The volume of wastewater can sometimes exceed the capacity of the combined sewer system or treatment plant (e.g., during heavy rainfall events or snow-melt). When this occurs, untreated storm water and wastewater, discharges directly to nearby streams, rivers, and other water-bodies.” (US EPA, 2015)

Morgantown Utility Board (MUB) is responsible for managing the storm water and wastewater in the city. As an organization, MUB has produced a number of materials that are available to the public regarding the water systems in Morgantown including a web-page designed to familiarize citizens with the combined sewer system. The article on this page further describes the systems by saying the following: “CSOs are points permitted by the Department of Environmental Protection (DEP), where the sanitary and storm water systems combine and occasionally discharge. During dry weather the CSOs have no impact on our local waterways. However, during significant wet weather events when the capacity of the system is exceeded, CSOs are designed to discharge excess flows directly to nearby streams, rivers, or other water bodies. During such discharges, the baseline flow (set by the conveyance capacity of the pipeline) continues to flow to the wastewater plant for treatment.” (Combined Sewer Outflow Areas, n.d.) The page goes on to describe the issues associated with CSO over flow events by explaining that CSO discharges may include stormwater, human and animal waste materials, toxins, and trash. CSOs are a common component of outdated systems. Before the establishment of the Star City wastewater treatment facility in 1965, sewage was released untreated into the river or nearby tributaries. As the system was constructed in 1965, CSOs were essential due to the inadequate size of the wastewater treatment facility and pipelines, as it would have been too costly to construct a plant large enough to handle all stormwater and sanitary flows. (Combined Sewer Outflow Areas, n.d.)

While MUB would prefer to eliminate CSOs from the local system, doing so is not financially realistic. The cost of eliminating CSOs would likely cost millions of dollars and increase sewer rates exponentially. (Combined Sewer Outflow Areas, n.d.)
It’s important to note that CSO discharge rates vary significantly by location. In 2018, some have not discharged at all while some have discharged as many as 65 times. CSOs are individually inspected each time it rains in accordance with specific rainfall thresholds. A multi-year, quarter of a million-dollar, comprehensive study on the effects of local CSOs upon water chemistry and aquatic life was conducted to assess the impacts of these wet weather discharges. These studies demonstrated that 72-hours following a significant wet weather event, there remained no impact of CSO discharge in local waterways.

To help educate the public about this issue, MUB recently installed new signs along the river and Decker’s Creek both at public access points and downstream of CSO outfalls. The best advice is simple: Avoid the water for 72-hours following a rain event.” (“Combined Sewer Outflow Areas,” n.d.)

MUB also keeps records of when each individual CSO overflows and makes this information publicly available in addition to a map of all known CSOs. Below, (figure 1) is a summary of the overflow events that occurred at the location of 40 different CSOs in 2018.

The wastewater plant, mentioned above, was chosen for upgrades in 2017, and the upgrades were completed in 2022 by Strand Associates Inc., and won recognition for its efficiency. These upgrades significantly improved capacity from 12 million gallons a day to over 20 million gallons a day according to MUB. (Dean, W. D. 2023, April 3)

Figure 1: CSO Overflow events
Figure 2: Map of percent impermeable surface and existing green space
Flooding was identified as the primary threat to West Virginia towns as a result of climate change. In a 2022 National Oceanic and Atmospheric Administration (NOAA) climate summary, data for the state of West Virginia, suggested that “Flooding, caused by extreme precipitation over the rugged topography, is the costliest and most severe natural hazard for the state. From 2010 to 2020, the state received 23 FEMA disaster declarations, 18 of which were related to severe storms and flooding events…A major flood event occurred in June 2016, when 8 to 10 inches of rain fell in less than 12 hours. The Elk River rose to more than 33 feet, breaking the previous high-water record set in 1888. At least 23 people were killed by flash floods.” (Runkle et al., 2022)

Flooding relates to storm water directly in the sense that when major storm events occur, the excess rainwater that runs off of impermeable surfaces moves into drains, gutters, pipes, etc., but when these systems overflow, floods occur. The more impermeable surface that exists within a watershed, the higher the capacity must be for such storm water management infrastructure systems. The map shows the percentage of impervious surface area throughout the City of Morgantown (figure 2).

The City of Morgantown saw significant flooding in the summer of 2021 when Popenoe Run, an urban stream that transverses the Evansdale Campus of West Virginia University, flooded. In June and July 2021, Popenoe Run in Morgantown, WV experienced significant flooding events, causing damage to infrastructure and homes in the area (Chapman, 2021). Heavy rainfall and outdated storm water management systems were identified as major factors contributing to the floods (Pritt, 2021).

The Morgantown Utility Board (MUB) has been working to improve storm water management in the area, including the installation of green infrastructure and the implementation of a storm water utility fee to fund these improvements (Chapman, 2021; MUB, n.d.). The Star City treatment plant, operated by MUB, was also recognized for its innovative storm water management practices (Dean, 2023).

According to a 2022 report by the National Oceanic and Atmospheric Administration (NOAA), West Virginia experienced above-average precipitation and flooding in 2021, with significant impacts on infrastructure and agriculture (Runkle et al., 2022).

Overall, it appears that improving storm water management and infrastructure in the Morgantown area will be crucial in mitigating future flood events.
POOPENOE RUN

Popene Run is the area of concern chosen for this study due to the fact that there are ongoing efforts to address the issues present in this stream. Below is an image of the watershed and drainage patterns of Popene Run as mapped in 2017. (Figure 3; image provided by Vaike Haas)

Upon comparing the watershed of Popene Run and the percent impervious area within the region, it is evident that most of the watershed is within impermeable, developed area. The area in Suncrest adjacent to Popene Run, has historically been referred to as the Suncrest “Flatts” and the region is not flat coincidentally. It is likely the floodplain for Popene Run, but easier for city officials to develop historically because of the lack of topographic constraints.

Patteson Drive is the primary corridor that passes through the watershed, and the paving of this road and development of the WVU Evansdale campus has contributed to the diminishing permeable surface in the area.

Figure 3: Map of Popene Run watershed provided by Vaike Haas with West Virginia University.
This map demonstrates the percent impermeable surface within the surrounding area of Popenoe Run as well as the vegetative cover that is present. Areas outlined in grey are nearly completely impermeable and should be broken up more regularly. Additionally areas of that are more impermeable should harbor more vegetative cover. There are large swaths of area on the WVU Evansdale campus that are not paved that could house more vegetation.
The science of hydrology addresses precipitation as it relates to storm water runoff. Hydrology differs from hydraulics in the sense that it is a less precise science. The exact conditions of a rainfall event are not able to be replicated in lab conditions and therefore estimation work involved in the calculation of storm runoff. This is primarily due to the number of variables involved in replicating a storm event including precipitation intensity, vegetative cover and maturity, soil conditions and so on. However, these calculations prove useful for the sizing of storm water infrastructure systems. (Strom, 2013)

The Rational method is used in the field of hydrology to calculate the peak runoff rate within a drainage area.

The equation is: \( q = CiA \) where

- \( q \) = peak runoff rate, in cubic feet per second
- \( C \) = dimensionless coefficient
- \( i \) = rainfall intensity, in inches per hour
- \( A \) = area of drainage area, in acres

The value for \( C \) will always be a number between 0 and 1 where 0 represents an area from which there is no runoff and 1 is completely impermeable. Strom provides a table of suggested values for runoff coefficients of common urban and suburban areas and surface types.

The drainage area’s scope is established by linking points of elevation and ridgelines on a topographic map to form a closed shape. Drainage areas can range in size from a few hundred square feet for a drainage inlet, to several square miles for a stream to thousands of square miles for a river, which is referred to as a watershed. (Strom, 2013)

Strom goes on to outline some of the limitations of these calculations saying, “It must be kept in mind, however, that since only estimates are involved, it would be improper to calculate runoff rates and volumes to too great a degree of precision; that is, final results should be appropriately rounded... The Rational method makes the simplifying assumptions that the rainfall intensity is uniform for the duration of the storm, which must equal at least the time of concentration, and that the precipitation falls on the entire drainage area during that time. These assumptions obviously cannot be applied to large areas.”
This method can be applied to the drainage area of Popenoe Run. Note that this does not cover the entire drainage area for the stream. Rather this sample of the watershed serves to demonstrate how altering the runoff coefficient within the watershed can reduce the peak runoff rate of a storm event. Figure 6 provides estimations for the existing drainage area. In this example, the weighted average, 3,007,358 feet$^2$ provides the value of $C$ for the equation by dividing this number from the total area in feet$^2$, making the value for $C=0.39$. 

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<td></td>
<td>762,508 feet$^2$</td>
<td>2987,014 feet$^2$</td>
</tr>
</tbody>
</table>
Here, $i = 1.15$ inches which is the average intensity for a 2-year 24-hour design storm.

The value for $A$ is the total square footage converted to acres. Therefore $A=175$.

$$0.39(1.15)175 = 78.5 \text{ cubic feet per second (cfs)}$$

**Peak runoff $Q=78.5 \text{ cfs}$**

Removing area of impermeable surface from the drainage area and adding vegetation to the watershed allows for the reduction of overall runoff coefficient rates $C$ and therefore the reduction of peak runoff values.

In this example, 41,944 feet$^2$ were removed from pavement areas and added to rain garden area, 300,000 feet$^2$ were removed from lawn space and added to woodland areas. These modifications altered the equation as follows:

$$Q=0.25(1.15)175$$

$Q=50.31 \text{ cfs}$

Making modifications to 341,944 feet$^2$ (7.85 acres) of the sample drainage area, most of which involve revegetating lawn areas, can allow for the reduction of peak runoff rates by 64% during a typical 2-year 24-hour design storm.
For example, parking lots are areas that could be reexamined within the watershed to reduce the amount of impermeable surface in the area. This parking lot that belongs to the Christian Missionary Alliance Church could add some vegetation to certain areas to increase the absorption of water in the area. The image below demonstrates the parking lot as it currently exists (figure 5), and an example of how it could be reoriented to include more vegetative buffers (figure 6).

Figure 6: An example of providing vegetated buffers in parking areas with the top image representing existing conditions and the bottom image representing potential modifications.
As mentioned above, areas that are lacking in vegetation can be revegetated to help reduce the amount of storm water entering a system and slow the flow velocity. Furthermore, the diversion of flow into raingardens or other bioretention systems can be beneficial. Below is a demonstration of an area on campus bordering Patteson Dr. where a rain garden currently exists and vegetation could be added.

Figure 7: Existing conditions

Figure 8: Section AA'

Figure 9: Perspective image

Figure 10: Plan view image; an example of adding vegetation to the watershed
This image depicts the grading of Patteson Drive into the landscape in 1959. The Health Sciences Campus can be seen in the background. Image courtesy of WV Regional History Center
This image shows the Suncrest Flatts here in its former use as agricultural land owned by the Krepps Family.

This image shows a car abandoned along Patteson Drive in a snowstorm and shows how little development once existed along the road.

This image shows aerial imagery of the intersection of Monongalia Blvd. with Patteson Dr. Popenoe Run can be seen to the left.

This image shows Suncrest Middle School in the background. and demonstrates the amount of open space that once existed along this corridor.
The effects on the stream are difficult to detect in these aerial images, however, it is worth noting that the stream has visibly gone from a slowly meandering waterway in these images to one that has been channelized in some areas and tightly meandering outside of those channels.

The stream is encroaching on the built environment. Terracotta pipes that were once completely buried, have been completely exposed and bank-sides that host a playground, trail system and dog park are slowly crumbling.

As mentioned above, this stream has been chosen for remediation and restoration of the corridor currently is moving forward on the upper leg of the stream. (Nolting, 2022) The lower leg is also scheduled for restoration, however in this area, the specific details of the planned restoration have yet to be determined according to officials with All-Star Ecology and the Morgantown County Commission. Ryan Ward with All-star Ecology informed The Dominion Post that, “the stream will be designed as a two-stage channel, meaning mini floodplains will be cleared on either side of the main channel in order to handle extra capacity. He also noted features like stepped pools will be used to dissipate energy and reduce erosion.” (Conley, 2023)

It was added that, “The project will replace 3,000 feet of 60-year-old clay sewer main, approximately 1, 200 feet of new storm sewers and 2, 800 linear feet of stream restoration for Popenoe Run.” (Nolting, 2022)

This report will make recommendations for the southern leg of Popenoe Run and cover 700 feet of stream corridor using the Rosgen method of natural stream channel design. Cross sectional data was provided by Vaike Haas and LARC 331 students who conducted the stream surveys. These cross sections demonstrate the existing conditions of the stream bed and the bank-side at the locations where the sections were taken.
Natural Channel Design (NCD) is a method of stream restoration that seeks to improve the ecological health of streams and rivers while reducing the impact of human infrastructure.

The principles of NCD were first developed by Dave Rosgen, a leading expert in fluvial geomorphology and stream restoration. Rosgen's work emphasizes the importance of understanding the natural processes that shape streams and rivers and using that knowledge to guide restoration efforts. NCD involves restoring streams to their natural, pre-disturbance state, by focusing on the stream's natural ability to create and maintain habitat, as well as its ability to handle the flow of water and sediment.

Key concepts in NCD include channel stability, stream classification, and hydrologic analysis. The goal of NCD is to create a self-sustaining ecosystem that can maintain itself without the need for ongoing intervention.

NCD has been widely accepted by the scientific community and has been endorsed by organizations such as the American Fisheries Society and the Environmental Protection Agency (EPA) as a best practice for stream restoration (Rosgen, 1994; Thorne et al., 2003; EPA, 2013).

The Rosgen classification system is a widely used framework for stream channel classification that is based on channel morphology and hydraulic characteristics (Rosgen, 1994). The classification system identifies 13 channel types, ranging from Type 1 channels, which are narrow, shallow, and have a smooth, sandy bed, to Type 13 channels, which are wide, deep, and have a highly sinuous pattern (Rosgen, 1994). Each channel type has distinct hydraulic and sediment transport characteristics that influence the type and location of structures that should be used in NCD projects (Rosgen, 1994).

By understanding the characteristics of each channel type, it is possible to design stream channel structures that are appropriate for the specific hydrological and geomorphological conditions of the stream system being restored (Rosgen, 1994).

In the Rosgen classification system, reference reaches are established to serve as benchmarks for natural channel design. These reference reaches are natural stream channels that are unaltered or minimally altered by human activities, such as channelization or impoundment. They represent the natural state of the stream and are used to develop restoration goals and design criteria for degraded or impacted streams.
EXISTING CONDITIONS

Proposed Action

Implement J-Hook.

“A J-hook vane is an upstream pointing line of rocks that originates at one bank and terminates somewhere in the middle of the stream. The most upstream portion of the structure bends back on itself, like a "J," curving into the middle of the channel. This bent portion serves to concentrate flow and scour out a pool while the length closer to the shore deflects flow away from the bank.” (Flow Structures, n.d.)
EXISTING CONDITIONS

Implement revetment

In stream restoration, revetments are often used to help protect stream-banks from erosion and to provide habitat for aquatic organisms. A revetment is a structure that is constructed from natural materials, such as logs, root wads, and boulders, and is strategically placed in and on stream-banks to help stabilize them. Root wads, which are the root balls of trees that have fallen into streams, are particularly useful in revetments because they can help trap sediment and organic material, and provide cover for fish and other aquatic organisms. (Georgia Environmental Protection Division & Georgia Soil and Water Conservation Commission, 2011)
2+00

EXISTING CONDITIONS

Figure 26: cross-vane diagram

PROPOSED ACTION

Implement cross-vane

The cross-vane is a grade management system that directs flow into the channel’s center. The feature preserved channel capacity while establishing grade control, reducing bank erosion, creating a consistent width/depth ratio, and improving sediment capacity. (Rosgen, n.d.)
EXISTING CONDITIONS

The term “live fascines” refers to long bundles of living woody vegetation that are buried in the stream-bank in shallow trenches and positioned in a direction that is perpendicular to the direction of the stream’s flow. The plant bundles germinate and grow into a root mass, which acts as a barrier against soil erosion and helps to preserve the integrity of the stream-bank. (Ohio Department of Natural Resources, n.d.)

PROPOSED ACTION

Live fascines and live staking

The term “live fascines” refers to long bundles of living woody vegetation that are buried in the stream-bank in shallow trenches and positioned in a direction that is perpendicular to the direction of the stream’s flow. The plant bundles germinate and grow into a root mass, which acts as a barrier against soil erosion and helps to preserve the integrity of the stream-bank. (Ohio Department of Natural Resources, n.d.)
PROPOSED ACTION

Implement live fascinces and live stakes

When placed in the bank, live stakes are living plant cuttings made of woody plants that have the potential to root. These stakes, which are typically of the willow species, have the potential to take root and grow into shrubs, which, in time, will offer riparian habitat and maintain the stream-bank or shoreline. (Ohio Department of Natural Resources, n.d.)
**EXISTING CONDITIONS**

Implement live fascines

By using live fascines, the stream’s natural functions and habitat can be preserved. The live plants in the fascines provide additional benefits, such as reducing sediment runoff and filtering pollutants, which can help improve water quality in the stream. (Ohio Department of Natural Resources, n.d.)

**PROPOSED ACTION**

Cross section location on LiDAR
EXISTING CONDITIONS

Provide floodplain access through terracing; implement live fascines, and live staking.

In order to install live fascines, the stream-bank will need to be excavated and built outward to have a slope no steeper than 1:2. A 1:3 slope is the preferable ratio. (Environmental Protection Division & Georgia Soil and Water Conservation Commission, 2011)

PROPOSED ACTION

Cross section location on LiDAR
### EXISTING CONDITIONS

<table>
<thead>
<tr>
<th>XS Riffle 16+00, Maram, Abby, Hayden? Emily? (2022)</th>
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<tbody>
<tr>
<td><img src="image.jpg" alt="Cross section location on LiDAR" /></td>
</tr>
</tbody>
</table>

**PROPOSED ACTION**

**Live Staking**

Cut live stakes to a length of 1 to 3 feet and remove any leaves or side branches that would be below the water line, plant the stakes in a trench along the stream-bank, spaced 2 to 3 feet apart, and bury them to a depth of one-half to two-thirds of their length (CIRB, 2015). Water the newly planted live stakes thoroughly and apply a layer of mulch to conserve soil moisture and suppress weeds. Then, Monitor the site regularly for growth and survival of the live stakes, and maintain the site by controlling invasive species and providing supplemental watering if necessary (USDA, 2010).
The degradation of Popenoe Run’s watershed is evident through the increasing percent impervious area within the region. The development of the Suncrest “Flatts” area, particularly the paving of Patteson Drive and the expansion of the WVU Evansdale campus, has contributed to the diminishing permeable surface in the area. These changes have impacted the stream, leading to channelization and encroachment on the built environment. However, with the planned restoration of the corridor, the stream will be designed to handle extra capacity and reduce erosion, and over 700 feet of the southern leg will be restored using the Rosgen method of natural stream channel design. Recommendations include the use of various techniques such as J-Hooks, cross-vanes, live fascines, live stakes, and excavation based on the state of the bank-side. It is important to prioritize the restoration and preservation of natural resources, such as Popenoe Run, to ensure the longevity of the surrounding infrastructure and community.
ROLE OF TRANSPORTATION IN SUSTAINABILITY

Transportation is a prevalent topic in environmental discussions about urban design. According to Jordan and Horan (1997), sustainable transportation design must have a scale that facilitates social interaction, meaning that it offers a density and form suitable for walking, bicycling, effective public transportation, and human contact. It must make municipal facilities and services accessible while reducing the amount of automotive infrastructure. A sustainable transportation system is defined as “transportation services that reflect the full social and environmental costs of their provision; that respect carrying capacity; and that balance the needs for mobility and safety with the needs for access, environmental quality, and neighborhood livability” (Jordan and Horan, 1997, p. 72).

The ideal sustainable urban transportation system makes use of renewable energy sources to power it, uses as little land as possible, limits emissions and waste, provides equitable access for citizens to services of the city, and is economically practical, functional, and safe. Hence, policy decisions that support sustainable transportation development involve building steps to lessen the demand for travel and create conducive environments for energy-efficient and ecologically friendly modes of transportation. Land use planning in tandem with transportation can also play a valuable role. According to Handy et al. (2002), when there is less distance separating activities physically, there will be less travel demands, which can be readily satisfied by walking, jogging, biking, and other ecologically friendly modes of transportation.

The National Association of City Transportation Officials (NACTO) publication (2018) stated that transportation is the largest single sector of carbon emissions in the US, and implementing projects that reduce reliance on personal vehicles is critical to addressing climate change. The fastest and simplest way to reduce transportation emissions is to drive less. However, driving less is only viable if transit, walking, and biking get you where you need to go safely, conveniently, and reliably. The provision of connectivity through locations that are secure, enjoyable, and accessible for wheelchairs, bicycles, and pedestrians will promote alternatives to driving. Also, they will offer site visitors chances for leisure and physical activity. The best options are sidewalks and bicycle/pedestrian routes that link to local networks and destinations (NACTO, 2018).

The Morgantown Monongalia Metropolitan Planning Organization has already acknowledged that the rise in days with extreme weather events has an influence on our transportation infrastructure. These unavoidable occurrences shock the transportation system, which might impair the movement of people and commodities. Planning ahead and adjusting to interruptions and crises, creating robust transportation networks, and adopting decisions that make the system more resilient helps to reduce these effects (Morgantown Monongalia Metropolitan
Sustainable transportation is critical to reducing carbon emissions and promoting alternative modes of transportation. It involves land use planning in tandem with transportation to create a conducive environment for energy-efficient and ecologically friendly modes of transportation. Creating robust transportation networks and adopting decisions that make the system more resilient helps to reduce the impact of extreme weather events. By incorporating sustainable transportation into urban design, we can create cities that are accessible, equitable, and environmentally friendly.
EXISTING CONDITIONS

MOTORWAYS

Morgantown and Monongalia County have seen population growth over the previous ten years, which contrasts with patterns across West Virginia. Monongalia County grew by 10% between 2010 and 2020. Most Morgantown and Monongalia County residents work in the healthcare and retail industries.

Most Morgantown commuters are drivers. In fact, over 75% of workers drive to their destinations in Morgantown (figure 29). In 2021, the next greatest majority (with carpoolers counted as drivers) worked at home and did not use transportation to get to work. Only 4.6% of individuals walk to work, and a total of 7% take forms of transportation that would be considered more sustainable i.e., public transportation, walking, other (biking, skating, etc.).

The roads and traffic data on the City of Morgantown reflect this phenomenon. (Anywhere USA Profile, n.d.)

Most Morgantown roads fall within the range of experiencing 5000-50,000 vehicles a day (figure 30) While this is a wide range, it is significant because these numbers exist in historic districts of Morgantown where transportation infrastructure and land use planning were likely not originally designed to accommodate large volumes of vehicular traffic.
Volumes of vehicular traffic have increased significantly in Morgantown in recent years, with US 19 (Beechurst Avenue) and the WV 705 corridor (Patteson Drive, Van Voorhis Road, Chestnut Ridge Road) accommodating close to 40,000 vehicles per day (Monongahela - Morgantown Metropolitan Planning Organization [MMMPO], 2020, p. 13).

Other roads experiencing high traffic growth include Fairmont Road (US 19), University Avenue, Earl Core Rd/Sabraton Avenue (WV 7), Cheat Road (HWY 857), and Mileground Road (US 119) (MMMPO, 2020, p. 13).

According to the MMMPO’s analysis, crashes have been on an upward trend in the Morgantown area, although there was a slight decline in 2019. University Avenue is a particularly high-crash corridor, with 8% of all reported crashes from 2015-2019 occurring along the roadway (MMMPO, 2020, p. 13).

Other higher-crash roads include Grafton Road, Monongahela Boulevard, Patteson Drive, and Cheat Road (MMMPO, 2020, p. 13). The majority of crashes occur on weekdays, with Fridays experiencing more crashes than other days (MMMPO, 2020, p. 13).

Figure 30: Morgantown traffic volume reports from WV Department of Transportation Annual Average Daily Traffic (AADT)
PUBLIC TRANSPORTATION
Public transportation is a vital element in improving the sustainability of a transportation network. The Mountain Line Transit Authority bus service is the primary bus service in Morgantown, with a fleet of about 37 vehicles (Mountain Line Transit Authority, n.d.). Each of these buses features a bike rack which can hold two bicycles (Mountain Line Transit Authority, n.d.). Passengers are able to check a live Twitter feed to track a bus’s location and status. These routes carry passengers to shopping centers on the outskirts of town, but allow no more than four grocery bags at a time on the bus, which can make access to food more difficult (MMMPO, 2015, p. 26).

Morgantown is also home to the Personal Rapid Transit (PRT) system, a monorail designed to provide access between the separate campuses for West Virginia University students (Lewis, 2013, p. 48). The PRT was designed in 1967 by Professor of Engineering Samy E. G. Elias, with a proposal submitted to the Department of Transportation for a “computer-controlled, electric, elevated transit system to replace the University's bus system” (Lewis, 2013, p. 48).

The original proposal included six stations, one hundred computer-operated electric cars, and 3.6 miles of elevated railway (Lewis, 2013, p. 48). However, the project had accrued $115 million in costs by 1974, and the system failed during its grand opening event with a broken-down car eventually having to be towed off the track (Lewis, 2013, p. 48). Upon completion of phase I, the PRT was only able to transport 3.5 million passengers a year compared to its projected 14.5 million passengers.
Lewis goes on to illustrate the failures of the system to achieve the original project goals by saying, “As everyone familiar with WVU or Morgantown knows, the PRT did not solve the traffic problems, The University bus service was eliminated in 1976, but the PRT never transported as many students as projected and proved to be far more expensive to operate than the bus system. As student enrollments continued to rise, the WVU bus system was relaunched to operate alongside the PRT.”
The PRT is an automated people mover with five stations, 69 cars and 8.7 miles of elevated railway and carries approximately 15,000 passengers per day for “students, employees and visitors” (West Virginia University, n.d.). The system was designed by Boeing and, in an article describing the project, they provided information of the current state of the system, “Powered by electric motors, the computer-driven cars arrive at a station within five minutes of a passenger swiping a West Virginia University student, faculty or staff ID card. Others can ride for 50 cents” (Morris, 2019). The system operates Monday-Friday 6:30-10:30, Saturday, 9:30 a.m.-5 p.m, and is closed on Sunday and during university holidays.

Boeing provided a software upgrade in 2002, but because of its age, the Morgantown system has become increasingly difficult to maintain. A shrinking market for replacement parts has significantly increased replacement costs. In 2012, a system modernization master plan was established to make PRT system upgrades by refurbishing some systems and replacing others (Morris, 2019).

The university offers information on the sustainable qualities of the system: “With an average of nearly 15,000 riders per day, the all-electric PRT has kept countless automobiles off the road and helped reduce carbon dioxide (CO2) emissions across our campus. In fact, a recent study found the PRT reduces CO2 emissions by nearly 2,200 tons each year” (West Virginia University, n.d.).

Based on a recent study, it would require an additional 34 buses to replace PRT service on an average day. The study also concluded it would require at least 40 buses running on a 2.5-minute headway (the time between bus departures) to achieve the same level of service provided by the PRT during special events, such as football games (West Virginia University, n.d.).

The CO2 emissions savings the PRT created by replacing buses is equivalent to: Removing 377 cars from the road, powering 168 homes, or preserving nearly 19 acres of pine forest.

Mercury vapor lighting that was original to the construction of the PRT was transitioned to LED in late 2016 and early 2017. ~350 lights were replaced in the PRT stations and on the guideway reducing energy consumption by ~50% while providing a 25% increase in light levels for enhanced safety.”

The PRT, is an electrical transit system, but services far fewer than it had originally intended and is specifically geared toward WVU students and employees despite traversing through multiple Morgantown neighborhoods.
PEDESTRIAN AND BIKE INFRASTRUCTURE
According to the West Virginia Department of Transportation (2014-2019), there were 134 pedestrian crashes in Morgantown involving a total of 134 pedestrians. Among those crashes, 23 (17%) involved pedestrians under the influence of alcohol or drugs, while 77 (57%) occurred during daylight hours. Of those involved in crashes, 57 (43%) suffered injuries, and 6 (4%) died from injuries related to crashes. Additionally, 20 (15%) of all pedestrian crashes during the study period resulted in serious injuries. The majority of collisions were caused by pedestrians crossing the street at an area where there was no designated crosswalk, with 88% of these collisions occurring between August and April, and 40% of those involved being between the ages of 18-23 (West Virginia Department of Transportation, 2014-2019).

The Morgantown Regional Bike and Pedestrian Plan, prepared by the Morgantown Monongalia Metropolitan Planning Organization (MMMP), identified 13 preferred specific initiatives and 7 general safety initiatives based on traffic data and pedestrian studies (MMMP, 2020). The committee voted that the most preferred safety initiative would be the implementation of more crosswalks.

Morgantown has minor networks of trails, including the Monongahela River rail trail, also known as the Caperton Trail, which runs north to south for a total of 6 miles on asphalt and 24 miles on compacted limestone (MMMP, 2020). The Decker’s Creek Trail, which connects to the Caperton Trail, runs adjacent to Decker’s Creek for 19 miles from the City of Morgantown to the Town of Reedsville and is a combination of asphalt (3 miles) and compacted limestone (16 miles) (MMMP, 2020). Other trail networks in the region’s parks and green spaces include the Core Arboretum, White Park, Dorsey’s Knob Park, Whitmore Park, and Falling Run (MMMP, 2020).

The Mon Valley Green Space Coalition has produced a greenbelt proposal (MMMP, 2020) that is still in development as of 2023, which aims to connect many of these major recreational assets in addition to linking various neighborhoods with vital points of interest.

Figure 35: Example of degraded sidewalks in Sunnyside neighborhood
Figure 36: MMMPO map of recommendations for improvements to the pedestrian network of Morgantown. Sourced from https://www.plantgether.org/plans-studies
The current transportation infrastructure in Morgantown, WV presents a complex set of challenges that require attention to both safety and sustainability. While the city has made strides in improving pedestrian and bicycle infrastructure, such as through the Morgantown Regional Bike and Pedestrian Plan and the development of shared-use paths, there are still safety concerns related to vehicle-pedestrian interactions. Additionally, the city’s dependence on automobiles for transportation contributes to environmental issues such as air pollution and greenhouse gas emissions. To achieve sustainable development, it is necessary to address these issues by promoting alternative modes of transportation and enhancing safety measures.
SELECTED AREA OF CONCERN

The area of concern that was selected for this project is in the First Ward district of Morgantown at the intersection of Greenbag Road, Dorsey Avenue and Kingwood Pike. This area was selected because it is an area currently under study by the MMMPO and the WVDOT for improvements.

The intersection is in an area that has almost no pedestrian infrastructure, but has potential to connect valuable features, White Park, Oak Hill Cemetery, Giant Eagle and Family Dollar grocery stores, and a day care, an elementary school, a middle school, and a technical college. To recall previous discussion of the role of transportation in sustainability, this area is one that offers services at a scale that facilitates social interaction and could be suitable for walking, bicycling, effective public transportation and human contact in order to make these facilities and services accessible while reducing the amount of automotive infrastructure. The drawback is there is currently no alternative way to travel.

This intersection was also selected for the potential to provide aid to the Mon Valley Green Space Coalition in the development of the Greenbelt Proposal mentioned above, specifically, the branch being referred to as “South Greenbelt.”

Finally, this area was chosen because of the threat imposed upon the Conscious Harvest Cooperative Farm by the existing Department of Transportation Proposal.

The topographic conditions at this intersection are restrictive toward the west due to the steepness of the slope. The skewed angle of the intersection restricts visibility and makes this a dangerous intersection for pedestrians (figure 38). Clockwise from North East, the turn radii are 56' 5", 22' 7", 58' 9", and 41' 10". According to American Association of State and Highway Transportation Officials (AASHTO) and USDOT Federal Highway Administration, street design guidelines, an intersection should meet as closely as possible to 90 degrees at each angle, “There is broad agreement that right-angle intersections are the preferred design. Decreasing the angle of the intersection makes detection of and judgments about potential conflicting vehicles on crossing roadways much more difficult...Intersections with severe skew angles (e.g 60 degrees or less) often experience operational or safety problems...ITE (1999) states that: “Skew angles in excess of 75 degrees often create special problems at stop-controlled rural intersections. The angle complicates the vision triangle for the stopped vehicle; increases the time to cross the through road; and results in a larger, more potentially confusing intersection.”"
Surrounding properties are significant in this case. Formerly, the North Western Parcel was the restaurant “Atomic Grill.” Since its closure, the Atomic Grill has been owned by Little General Inc., but the lot itself has stood vacant. This report has taken into consideration that this business is empty and the design proposal below does not perfectly preserve the integrity of the existing lot. The properties to the East are privately owned and the South Eastern property is the Conscious Harvest Cooperative Farm. Not only is this farm an asset to the property owners and the ecosystem that exists here, it is important to protect this open space in order to preserve the integrity of nearby Cobun Creek.
The West Virginia Department of Transportation has put forth a proposal for this intersection (figure 39) that had been met with strong opposition from the surrounding property owners. The goal of this proposal is to allow for increased traffic flow to divert truck traffic from downtown, and improve upon the aforementioned safety issues associated with the skewed angle of the intersection.

**STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS (SWOT ANALYSIS)**

SWOT analysis is a widely used technique for planning and conceptualizing projects and evaluating ideas (Hill & Westbrook, 1997). The acronym stands for Strengths, Weaknesses, Opportunities, and Threats, and it is commonly used to assess both internal and external factors in a system (Hill & Westbrook, 1997). While it is often used in business analysis, it can be applied to a variety of contexts to identify opportunities and risks (Hill & Westbrook, 1997).
### MMMPO Proposal Analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
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<tbody>
<tr>
<td>Crosswalks are provided.</td>
<td>This project has been rejected by the property owners of Conscious Harvest Farm</td>
<td>This proposal highlights a potential solution to the problem of the skewed angle of the intersection</td>
<td>This rotary has been designed to allow for more large truck traffic through this route.</td>
</tr>
<tr>
<td>This proposal would improve traffic flow and vehicular safety through the region.</td>
<td>A rotary is generally viewed as more unsafe for pedestrians.</td>
<td>This proposal provides a potential solution to diverting traffic flows from downtown Morgantown.</td>
<td>The farm is a valuable greenspace as well as a habitat for insect and bird species. The rotary threatens the micro ecosystem.</td>
</tr>
<tr>
<td>This proposal would improve sight distance and turning radii issues.</td>
<td>Rotary systems are not preferred by truck drivers—the intended users of this route.</td>
<td></td>
<td>The rotary adds to the percentage of impermeable surface in the region</td>
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**Figure 39: SWOT analysis of WV DOT proposal**

### MMMPO Proposal

The Morgantown Monongalia Metropolitan Planning Organization (MMMPO) conducted a thorough analysis of the Greenbag Road corridor, and submitted a proposal for redesign of the existing intersection which would eliminate the roundabout proposal. (figure 40)

![Diagram](image_url)

**Figure 40: MMMPO written proposal for modifications to the intersection**
### Strengths, Weaknesses, Opportunities, Threats (SWOT Analysis)

<table>
<thead>
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<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
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<tbody>
<tr>
<td>This project is favorable for nearby private property owners.</td>
<td>This does not resolve issues with the angled intersection, or issues with sight distances.</td>
<td>This proposal highlights a potential solution for additional bike infrastructure in this area.</td>
<td>No solution is presented to obscured sightlines and keeps the intersection unsafe in this regard.</td>
</tr>
<tr>
<td>Minimal impermeable surface is added and this proposal is least impactful on the landscape.</td>
<td>Pedestrian experience is not included as a priority.</td>
<td>This proposal provides a potential solution by modifying signal timing.</td>
<td>This proposal has been rejected by WVDOT for being incapable of providing to the anticipated level of traffic volumes.</td>
</tr>
<tr>
<td>Extensive studies were conducted on the potential impacts on the landscape.</td>
<td>This proposal is comparably less effective at managing traffic flow.</td>
<td>This proposal identifies benefits of providing turning lanes.</td>
<td>The rotary adds to the percentage of impermeable surface in the region further exacerbating drainage issues that occur at nearby Aaron's Creek.</td>
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*Figure 41: SWOT analysis of MMMPO proposal*

*Figure 42: An image of the landscape under threat*
PROPOSED REVISIONS

The WV Department of Transportation proposal improves the flow of traffic through the region, and addresses the issues with visibility at this intersection. However, roundabouts tend to be more dangerous for pedestrians, and the landowners of Conscious Harvest Cooperative Farm wish to protect their land. Providing some modifications to the intersection will be necessary to accommodate even the current flow of traffic, but adding pedestrian connections and combining elements from both DOT and MMMPO proposals could resolve issues with traffic, equity, and land preservation. The following revisions are recommended in figure 43.

In order to address some of the issues with visibility, the alignment of the intersection has been altered so that the corners are closer to 90 degree angles than they currently are. The roundabout has been omitted here and will allow for the preservation of a greater area of the Conscious Harvest Cooperative Farm. Slip lanes are included in this design in order to maintain some element of the roundabout that will provide for a more effective flow of traffic. A left turning lane has been added on the SE leg of Green Bag Road to accommodate for the volume of traffic.

Figure 43: Proposed revisions to the angles of the intersection and lane modifications
Additionally, opportunities for pedestrian infrastructure have been included. Pedestrian crossings have been added in the safest possible locations available and low lying vegetation has been represented in figure 44 to aid in absorption of storm water and provide visual cues for drivers to slow down. A 7-foot wide sidewalk is also provided here.

Optimal conditions would allow for a 12 foot sidewalk, but 7 feet was chosen here as a courtesy to the landowner. A 3-foot vegetative buffer is included here to provide space between pedestrians and traffic. Two 10-foot wide crossings are added here at the intersection. There is a median refuge for pedestrians between these crossings.

In figure 45, the hatched area demonstrates the overall area of impact of the intersection modifications at 1.2 acres in the immediate area surrounding Conscious Harvest Cooperative Farm.
The proposed modifications to the intersection address the traffic flow issues and visibility concerns, while also providing pedestrian infrastructure and preserving land near Conscious Harvest Cooperative Farm. The design omits the roundabout, includes slip lanes, and adds a left-turning lane for traffic accommodation. The pedestrian infrastructure includes crossings, a sidewalk, a vegetative buffer, and a median refuge for safety. The overall impact of the modifications on the land surrounding Conscious Harvest Cooperative Farm is 1.2 acres. These modifications provide a balanced solution to the challenges faced by the intersection while accommodating various stakeholders’ concerns.
ROLE OF LAND USE/GREEN SPACE PRESERVATION IN SUSTAINABILITY

This facet of sustainability is often referred to in many different terms including, green space preservation, land conservation, open space protection, and more (Kim, 2019). For the purposes of this report, green space preservation refers to the measures taken to save open space and leisure places, safeguard ecosystem services, protect spaces that aid in reducing the effects of climate change, conserve land used for spiritual purposes, and maintain natural locations for solitude and reflection (Chen et al., 2020).

The following chapter will focus on the land use trends in Morgantown, particularly the nature of urban sprawl within the city, the reuse of brownfield sites, and the ways in which they can be remediated to allow for lesser greenfield development and greater preservation of wilderness. For clarity, definitions of the following terms are provided as they will be used in the context of this document.

Land-use planning: Salem Press Encyclopedia of Science defines land-use planning as, “Land-use planning is part of the broader comprehensive planning process that deals with the types and locations of existing and future land uses, as well as their impacts on the environment” (Liu, 2018).

Urban Sprawl: Salem Press Encyclopedia of Science defines urban sprawl as, “The uncontrolled and unregulated development that occurs outside the administrative boundaries of the zoning and land-use authority of municipalities and outside the conscious and deliberate direction of those authorities” (Siderius, 2019).

Brownfield: The Environmental Protection Agency defines a brownfield as, “a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant” (EPA, 2021).

Greenfield: “Vacant or undeveloped tracts of land that are available for business or industrial use. They are referred to as “greenfields” because often their former usage (or in some cases, their current usage) is agricultural production, forest land, or some other undeveloped function. Greenfield sites are most often located in the urban fringe of the path of development or in rural areas where undeveloped land is more likely to be present. Greenfield development refers to the real estate development of land not previously used for residential, commercial, or industrial purposes” (Hester & Harrison, 2019).

Green space/open space: “Marin County, California Ordinance creating an “Open Space District” defines open space as “[a]n area of natural landscape essentially undeveloped, such as ridges, streams, natural shorelines, scenic buffer areas, and agricultural lands” (The County of Marin, 2019).

In 1987 the Regional Plan Association, covering the tristate area of New York, New Jersey, and Connecticut, categorized land as protected open space, developed
land, and unprotected and underdeveloped.

The land that the Regional Plan Association considered protected consisted mostly of publicly owned lands, but nonpublic trust lands and some privately owned property held by organizations such as the Nature Conservancy also met its definition of protected space” (Guswa & Ward, 1989).

In order to address the increased shortage of a healthy environment, green space preservation increasingly necessitates the reduction of pollutants as well as the inclusion of beneficial elements, particularly trees. In fact, a city with high-quality and ample green areas is often viewed as a model of sound design and administration, a safe place for people to live, and a healthy habitat for both plant and animal life (Kuo & Sullivan, 2001).

How much and what kind of open land should be preserved is complex. Protecting water supplies and preserving these lands can also allow them to act as a haven for native species. The preservation of natural open space should be treated as a separate program from the preservation of farmland, which is likewise a key priority for any land preservation program.

Additionally, development of new green space can improve the quality of life in the neighborhoods. For example, “greenways” or “green belts” offer a continuous strip of land along which trails and other forms of mobility might be built. Connecting open areas to a larger system of conservation zones can multiply their benefits. Concerns about physical fitness and health have fueled the greenway movement in suburban and urban areas, helping to meet the need for convenient access to specially created space for recreational activities.

Many metropolitan communities now struggle to offer adequate open space within every community. The aesthetic benefit of open space must be addressed as well. Green space featuring trees and flowers may assist individuals in getting away from the strains of everyday life and the constructed environment. Parks may improve community connections by bringing neighbors together in distinct locations for more frequent social interaction.

From an ecological standpoint, open space may improve the quality of the water and air. To ensure the quality of subsurface water sources, undeveloped, vegetated open land must be preserved as well. Trees lessen the carbon imprint of polluted air and help to reduce the urban heat island effect. Riverbank vegetation helps to filter runoff, and wetlands can collect and store water that would otherwise overwhelm the built area. Fish and wildlife benefit from large areas of open land which provide for important habitat space. Open space also supports the preservation of a diversity of plant species.

Additionally, when determining the worth of open space, it is important not to discount the financial advantages that come from its maintenance. Today’s businesses routinely assess the desirability and acceptability of the communities in which their workers make their homes. Businesses are more likely to locate in areas with higher quality of life. Tourism and economic development are both boosted when there are beautiful landscapes and open areas.
Considering the current state of the environment and demand for sustainable development, humans have realized that population increase jeopardizes the availability of usable land for leisure as well as for life-sustaining purposes, such as freshwater resources. Land has become a critical nonrenewable resource in places with rapid economic expansion.

Therefore, Green space preservation has two components: one focuses on the acquisition of property or development rights to acquire land, and the other on the protection of green space, which has been discussed. The second component, aimed at reducing sprawl, involves a regulatory system that requires low density development to pay for its expenses or utilizes incentives to shift expansion to corridors designated for transit-oriented development and greater residential density.

It is crucial to implement initiatives to control urban sprawl, which will reduce the amount of open space sacrificed to inefficient low density development patterns, in tandem with these preservation-based policies. It will be needed to develop plans to try to channel development into the most suitable possible locations.

- J.C. Griffith (2010) goes on to identify some of the primary causes of urban sprawl.
- The wide dispersion of population in low density development
- Rigidly separated land uses for residences, commerce, and workplaces
- A road network marked by large blocks and poor access
- The lack of downtowns, town centers, or other vibrant activity centers.
- The preference in the United States for owning detached single-family homes with yards
- The price of land is cheaper at the urban edge, housing becomes more affordable as the distances increase from downtown areas.
- Almost universal car ownership has facilitated development into once isolated rural areas.
- Poor federal, state, and local planning policies
- Our fragmented system of local governance that causes the many municipalities in a metropolitan area to compete with one another for tax revenues in ways that produce sprawling developments and automobile dependence.

Sprawl has a multitude of adverse environmental effects. When low density projects transform undeveloped property on the urban perimeter into new business and residential developments, agriculture, open space, and animal habitat become scarcer. Sprawl uses more open space than would be the case with more constrained development. The negative effects of sprawl on air and water pollution and energy consumption are exacerbated by sprawl. It leads to higher automobile emissions, ozone pollution, car deaths, and decreased pedestrian walking and alternate transportation usage. Moreover, dispersed growth necessitates larger infrastructure investments than dense development.
RE-PURPOSING BROWNFIELD SITES

Brownfield redevelopment has a role to play in the mitigation of urban sprawl. A 2020 study conducted by the EPA titled Environmental Benefits of Brownfields Redevelopment – A Nationwide Assessment found that brownfield redevelopment is, “more location efficient than trend growth,” leads to fewer paved, impermeable surfaces, can help prevent damage to the surrounding environment, and can reduce travel times to locations because these sites tend to be centrally located.

While the parameters of what constitutes a brownfield are fairly straightforward, time can transform these spaces making one look very different from another. Even a space that looks relatively healthy on the surface, may tell a very different story underground. Regardless of appearance, all brownfields fall under the definition provided by the EPA which states, “A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.”

As alluded to, these sites range broadly and look very different from one another. Specifically, and most frequently they include abandoned mines, old gas stations, industrial parks, oil tank fields, unused lumber yards, and so on. Generally speaking, the level of hazard or contamination present on brownfield sites is frequently relatively low and poses little risk to surrounding humans and infrastructure therefore they are excluded from The National Priorities List and do not qualify for rehabilitation under the Toxic Substances Control Act of 1976.

Remediation of such sites, because it does not present an immediate risk, can be deemed low-priority and too costly for many municipalities. Furthermore, depending on the nature of the rehabilitation required, disposal of on-site waste can be difficult and expensive as well; it does not benefit the environment as a whole to simply move this debris, particularly contaminated debris, from one location to another. The methods of remediation are numerous and extensive information is available on each method.

They can be categorized as follows:
1. Established: Treatment technologies for which costs and performance information is readily available e.g. removal, incineration, solidification, pump and treat.
2. Innovative: Alternative treatment technologies whose routine use on Superfund and similar sites is inhibited by lack of data on performance and cost e.g. thermal desorption and soil washing
3. Emerging: Alternative treatment technologies whose routine use in remediation sites is inhibited by lack of data and evaluation of claims e.g. phytoremediation, bioremediation

Emerging methods tend to be the most environmentally friendly as they use natural remedies to rehabilitate the sites. Phytoremediation (see figure 2.01) in particular
Phytoremediation in particular involves the implementation of specific plant species that will foster microbes in the underlying soil. With the aid of these microbes, the plants draw contaminants into their anatomy and filter out these pollutants.
SELECTED AREA OF CONCERN

BEAUMONT GLASS SITE
In 1905, the Union Stopper Company bought the former Monongahela Textile Company facilities and adjacent property to use in their production of glass bottle stoppers (Curtin, 2018). In 1918, the business rebranded as Beaumont Glass, becoming well-known for its high-quality glass lamp shades and globes. Beaumont Glass, together with Seneca Glass, was one of Morgantown’s last remaining glass manufacturers (Curtin, 2018).

The city had formerly been home to more than a dozen prosperous glass enterprises. The business failed under new management after leaving Beaumont hands in 1991. The old structure was removed in 1998, leaving the vacant site as a reminder of the dangers posed by glassmaking byproducts. Currently there is a business (Surplus City) in the only remaining building from the former factory adjacent to the site.

The Monongahela Textile Company structure was abandoned for two years after the bank acquired it in 1903. The Union Stopper Company bought the land and buildings for $17,500 on March 8, 1905 (Curtin, 2018). The Union Stopper Company manufactured stoppers for glass vessels and became prosperous.

In 1906, The Union Stopper Company appointed a new manager, Percy J. Beaumont, and by 1918, the company’s name was changed to Beaumont Glass Company. The Beaumont Company “was known for its light shades, inkwells, and light globes,” according to sources describing the glass making industry from the 1920s to the 1960s, manufacturing glass during the Great Depression and becoming one of the county’s premier glass lighting and light-fixture manufacturers (Curtin, 2018). Due to the use of child labor, the enterprise received some unfavorable attention in its early days.

Beaumont controlled the firm until 1988, when it was purchased by Michael Carlow, who also managed the L. E. Smith Glass firm in Mt. Pleasant, Pennsylvania. In the early 1990s, Carlow was suspected of conducting a check-venting scam and received a sentence of up to six years in jail by 1996. While the Smith Glass Company continues to produce glass today, Beaumont had to shut down in 1991 due to a failure to repay any of its loans. SME Industries purchased the Beaumont Company facility and all of its contents for $625,000 on June 30, 1994. SME resold the land to Frank V. Carlow Irrevocable Trust four days later for the same amount they had paid just a few days before, who sold it again a year later for $10.00 (Curtin, 2018).

The contamination of the soil from the harmful chemicals used in the glassmaking operation and the presence of trash glass that is too tiny to recycle made the development of the site complicated.
The Northern West Virginia Brownfields Assistance Center tested the soil along the river in 1989 and the EPA conducted further testing in 1996. Testing on the site has revealed significant amounts of arsenic, antimony, cadmium, lead, polynuclear aromatic hydrocarbons (PAHs) and lead as well as numerous barrels of hazardous material. Rather than attempting to rescue the facility and its contents, it was decided to demolish the main building. Demolition was completed in 1998 (Curtin, 2018)

Figure 46: ‘Detail of window casements along the Railroad track’ 1988; Image courtesy of West Virginia Regional History Center; donated by Six, Dean.

Figure 47: ‘View looking north along Railroad shows additions and original mill portions of east side of building.’ 1988; Image courtesy of West Virginia Regional History Center; donated by Six, Dean.

Figure 48: ‘Original woolen mill portion of building view facing west along Railroad.’ 1988 Image courtesy of West Virginia Regional History Center; donated by Six, Dean.
The EPA Federal On-Scene Coordinator's After Action Report on the Beaumont Glass Site provides additional information regarding the nature of the contaminants on site saying;

"The site was referred to EPA Region III and a Resource Conservation and Recovery Act (RCRA) sampling inspection was conducted on March 17, 1992. The inspection revealed RCRA hazardous sludges in the acid etching room vats and RCRA hazardous contaminated soils beneath the acid etching room. Since its closure in 1991, portions of the buildings on-site had been used for storage of equipment and machinery from other businesses owned by the former owner of the Beaumont Glass Company. Another small outbuilding on-site was being leased out for storage of recyclable materials, e.g., cardboard, old appliances, scrap metal, etc. The current owner of the site, who purchased the property in September 1996 just prior to EPA's involvement at the site, had planned and had begun to use some areas of the building on-site for storage of building materials, e.g., wood, bricks, shingles, etc."

A list of contaminants that were removed from the site at this time was provided in the report (see Figures 49 and 50).

![Table 3: Waste Disposal Summary](image-url)

Figure 49: Environmental Protection Agency table of results on soil testing done on site
This site was host to a significant level of debris and remediation efforts have been estimated to be extraordinarily costly.

Despite this, the site is located in an area of high intensity development as demonstrated in the land use map provided (figure 51) where there currently there is no pocket of greenspace for the myriad of users that the site could potentially host. This site was selected because of the opportunities to provide a necessary green space and to demonstrate the ways in which lands could be reused to provide assets to the community. The following site design functions as a phytoremediation strategy as well as an urban green space that draws conceptual elements from zen garden design, biomimicry, and the industrial history of the area.

<table>
<thead>
<tr>
<th>DOT Shipping Name</th>
<th>Description</th>
<th>Approximate Total Quantity (Pounds)</th>
<th>Unit Weight/Volume</th>
<th>Disposal Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ, Waste Ashbolon (Lead, Cadmium)</td>
<td>11,860</td>
<td>F</td>
<td>Hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>Waste Ashbolon</td>
<td>200</td>
<td>F</td>
<td>Hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>ACBM Category I, Non-Frangible Substance</td>
<td>162.01</td>
<td>T</td>
<td>Hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>Waste Cadmium Compounds (Cadmium Sulfide)</td>
<td>400</td>
<td>F</td>
<td>Hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>RQ, Hazardous Waste Liquid, NOS (Cadmium, Lead)</td>
<td>620</td>
<td>G</td>
<td>Treatment - hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>RQ, Hazardous Waste Liquid, NOS (Lead, Cadmium)</td>
<td>1,060</td>
<td>G</td>
<td>Treatment - hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>RQ, Hazardous Waste Liquid, NOS (Tetrachloroethylene)</td>
<td>75</td>
<td>G</td>
<td>Treatment - hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>Radioactive Material, Exempted Package-Limited Qty</td>
<td>Powdered compounds</td>
<td>955</td>
<td>F</td>
<td>Radiation landfill</td>
</tr>
<tr>
<td>Radioactive Material, NOS - Radioactive Material</td>
<td>Powdered compounds</td>
<td>300</td>
<td>F</td>
<td>Radiation landfill</td>
</tr>
<tr>
<td>Waste Lead Compounds, Soluble, NOS (Lead Monoxide)</td>
<td>1,800</td>
<td>F</td>
<td>Hazardous waste landfill</td>
<td></td>
</tr>
<tr>
<td>Non-hazardous Non-regulated waste (RCRA Empty Drums)</td>
<td>Empty and crushed drums</td>
<td>12,000</td>
<td>F</td>
<td>Non-hazardous landfill</td>
</tr>
<tr>
<td>Soil with Debris (Rock, Wood, Glass, Etc.)</td>
<td>Unscreened soil excavated from the demolition area</td>
<td>392.7</td>
<td>T</td>
<td>Non-hazardous landfill</td>
</tr>
<tr>
<td>Non-hazardous, Non-regulated solid</td>
<td>Laekpaka and/or bulking groups</td>
<td>775</td>
<td>F</td>
<td>Non-hazardous landfill</td>
</tr>
<tr>
<td>Non-Hazardous Material</td>
<td>Laekpaka and/or bulking groups</td>
<td>5</td>
<td>G</td>
<td>Non-hazardous landfill</td>
</tr>
<tr>
<td>RQ, Polybrominated Diphenyl Ethers, Mixture</td>
<td>Large capacitors</td>
<td>522</td>
<td>K</td>
<td>Incineration</td>
</tr>
<tr>
<td>RQ, Polybrominated Diphenyl Ethers, Mixture (Non-bonded)</td>
<td>Used fluorescent light ballasts containing small capacitors</td>
<td>250</td>
<td>K</td>
<td>Recycle</td>
</tr>
<tr>
<td>RQ, Polybrominated Diphenyls</td>
<td>100% PCB ballasts</td>
<td>1,400</td>
<td>F</td>
<td>Recycle</td>
</tr>
<tr>
<td>Waste Sodium Fluoridate</td>
<td>Laekpaka and/or bulking groups</td>
<td>1,500</td>
<td>F</td>
<td>Hazardous waste landfill</td>
</tr>
<tr>
<td>Environmentally Hazardous Substance, Liquid, NOS (CB)</td>
<td>Laekpaka and/or bulking groups</td>
<td>750</td>
<td>G</td>
<td>Hazardous waste landfill</td>
</tr>
<tr>
<td>RQ, Waste Mercury</td>
<td>Electrical switches and grates containing elemental mercury</td>
<td>75</td>
<td>F</td>
<td>Recycle</td>
</tr>
<tr>
<td>Waste Mercury Contained in Manufactured Articles</td>
<td>Mercury glassware</td>
<td>20</td>
<td>F</td>
<td>Recycle</td>
</tr>
</tbody>
</table>

Figure 50: Environmental Protection Agency table of results on soil testing done on site continued
Figure 51: Map of percent impermeable surface throughout the City of Morgantown.


MEA POWER PLANT


SITE LOCATION

WVU PRT
Data on the slope of the site and the contour lines provided demonstrate that this site is relatively flat except for some topographic change bordering the edges of the site location. The nature of the topography at this site makes it more convenient for development.
Considering the slope aspect of the site, it is primarily facing the southwest, south, and west. This is beneficial for establishing planting strategies. The aspect of these slopes will provide for more access to sunlight.
SITE PHOTOS

VIEWS LOOKING NORTH EAST

VIEWS LOOKING SOUTH
Figure 54: Diagram of site considerations
SITE DESCRIPTION AND CHARACTERISTICS

As demonstrated in the visual material provided, the site is located along Beechurst Avenue between 4 1/2 Street and 6th Street. It is intersected by Irwin St. and the extension of 5th St. The site boundary contains 1.7 acres.

The surrounding properties include the Morgantown Energy Associates (MEA) Power plant, the WVU PRT, the Caperton Rail Trail, “Smoke Zone” Smoke Shop, BP gas station, New Foo Sheen Chinese Restaurant, and some other mixed use/commercial facilities. It is located in the Sunnyside neighborhood and therefore surrounded by residential properties that are primarily student housing.

This site is located 0.4 miles from the downtown WVU campus, and about 1 mile from the WVU Evansdale Campus.

It is relatively flat and experiences primarily Southwestern exposure to the elements. Currently, the site functions primarily as a parking lot. There is some existing salvage material on site such as the bricks pictured above.

Anticipated users of the site include the student population, users of the Caperton Rail Trail, and the unhoused individuals living in the area.
DESIGN APPROACH

When establishing an approach to designing this site, there were three primary considerations:

1. Attempt to remediate the site using phytoremediation.
2. Provide a peaceful, naturalistic, green space for the users in the surrounding area.
3. Acknowledge the industrial history of the site through design decisions.

1.PHYTOREMEDIATION

Phytoremediation is a sort of bioremediation whereby plants, such as grasses, bushes, trees, and algae, are employed to breakdown or trap environmental toxins, most often metals (Coyne, 2023; HC Lakshman, 2018).

Phytoremediation is typically utilized in areas where the level of contamination is moderate and the substance needing to be managed is located at a shallow or medium depth. This approach is particularly cost-effective and suitable for both planting and harvesting when dealing with large areas. It is important to note that property owners must be willing to endure a longer rehabilitation period. The plants used for soil remediation can perform one or more of the following tasks:

1. absorb pollutants from the soil particles or fluids into their roots,
2. chemically or physically bind the pollutants into their root tissue, and
3. transport the contaminants from their roots to developing shoots, thereby preventing or prohibiting the contaminants from leaking out of the soil (Coyne, 2023; HC Lakshman, 2018).

Using phytoremediation to clean up polluted sites contributes to sustainable development by preserving soil as a valuable resource, restoring it to a state where it can be used for beneficial purposes, preventing pollution from spreading to air and water, and decreasing the need for development on agricultural or green sites (Kirkwood & Kennen, 2015).

is a viable, cost-effective option for remediating a variety of contaminated sites. However, it is

![Diagram of phytoremediary mechanisms](image-url)

**Figure 56: Diagram of phytoremediary mechanisms**

<table>
<thead>
<tr>
<th>Icon</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Phytodegradation</td>
<td>Plant destroys it</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Rhizodegradation</td>
<td>Soil biodegradation destroys it</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Phytostabilization</td>
<td>Plant turns it into a gas</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Rhizostabilization</td>
<td>Plant uses it in growth, incorporates it into biomass</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Phytocoagulation</td>
<td>Plant takes it up, stores it and is harvested</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Phytohydrolysis</td>
<td>Plant draws it close and contains it with water</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Phytostabilization/Phytocoagulation</td>
<td>Plant caps and holds it in place</td>
</tr>
<tr>
<td><img src="image-url" alt="Icon" /></td>
<td>Rhizofiltration</td>
<td>Contaminant is filtered from water by roots and soil</td>
</tr>
</tbody>
</table>
Phytoremediation is a viable, cost-effective option for remediating a variety of contaminated sites. However, it is most suitable for areas where contamination is close to the surface, resistant to leaching, and widespread (Coyne, 2023; HC Lakshman, 2018).

The diagrams included demonstrate the mechanisms of phytoremediation (figure 56) and the contaminants that are most compatible to be addressed using phytoremediation (figure 57).

There are certain plants that are more effective at phytoremediation than others, and the mechanisms by which they process the contaminants vary by plant type. The mechanisms must also be considered based on the anticipated use of the site. Phytoextraction can be an effective mechanism, but requires more active maintenance, for example. Additionally contaminants are only removed when plant biomass is harvested and properly disposed of.

Considering the contaminants that are polluting the Beaumont Glass Site, phytoremediation will be most effective at treating the chlorinated solvents, PAH’s, arsenic, selenium, and cadmium with the potential to have an impact on the traces of lead on the site as well. The mechanisms that will be used to breakdown heavy metals according to the chart below will include rhizodegradation and phytoextraction. These plants must be maintained, monitored, harvested and disposed of during the decontamination process.

*Figure 57: Diagram of pollutants that can be address using phytoremediation*
2. NATURALISTIC SPACE FOR USERS

Another goal in the design for this site is to provide a necessary green space for the people who live in the area. The primary users this site would potentially attract include:

1. WVU Students and staff
2. Caperton Trail users
3. Unhoused individuals

As demonstrated above, this site exists in an area of high development. Students and the unhoused are people who experience high mental stress, and it has been demonstrated that access to green space can have emotional healing qualities.

With this in mind the design for this space includes zen garden and therapeutic garden elements in order to provide a service to the users of the space.

Hopper, provides extensive guidelines of the development of gardens with therapeutic qualities. He states that a therapeutic garden is, “a bounded landscaped space designed specifically to bring physical, psychological, or social benefit to users or viewers.” (Hopper, 2007)

“Ease of mobility and provision of privacy and social seating in the garden are particularly significant in medial settings. Beyond these basics the following recommendations are of critical importance to all restorative gardens.

- The journey: Invite visual and physical exploration. Emphasize transitions with hidden vistas, changing orientation, and “thresholds” of differing microclimates, light, and shadow, and degrees of enclosure to create movement and an opening for the individual to shift from a painful or unproductive perspective.

- Sensory awakening: Supply a variety of noninvasive sensory stimuli and opportunities to stop and enjoy the sensations. Call particular attention to fragrances and wind—which often go unnoticed. This brings awareness into the moment and reduces the need for mental activity and filtering.

- Self-awareness: Apply the concepts of prospect and refuge, auditory screening, and other protective measures to create physically and psychologically safe areas for quiet reflection or cathartic release. Add small-scale social seating for interactions that can support enhanced self-realizations.

- Spiritual attunement: Incorporate a sense of preciousness through the ephemeral, the unusual, and the intricate, connection with other species...and movement away from the present (through the evocation of memories and opportunities to extend one’s presence into the future). These environmental qualities facilitate a shift from analytical thinking and evoke experiences of transcendence and awareness of the universal” (Hopper, 2007)
3. ACKNOWLEDGE INDUSTRIAL HISTORY
In recent years, post-industrial design has gained popularity as a way to transform abandoned industrial sites into vibrant and thriving public spaces (Dovey, 2016). Post-industrial design is not just about aesthetics, but also about creating a sense of place that reflects the history and culture of the surrounding community (Cooke & Plate, 2017). By incorporating elements of the past into contemporary design, post-industrial spaces can serve as a powerful reminder of a city’s industrial past, while also providing opportunities for growth and renewal.

A sense of place is essential to a community’s identity, as it provides a tangible connection between the past, present, and future (Relph, 1976). A sense of place creates a feeling of belonging, pride, and community ownership that can enhance the overall quality of life for residents. By incorporating post-industrial design elements into public spaces, a sense of place can be created that reflects the unique history and culture of the surrounding community. The idea of sense of place is connected to sociology, anthropology, urban engineering, and human geography. It refers to the impact that certain locations have on individuals. (Ungvarsky, J., 2023).

A sense of place is produced by the distinctive characteristics of a location as well as how learning about and engaging with that location influences the individuals who live or travel there. The term encompasses all features of a location, such as its topography, geology, people, fauna and flora, and history. The way a location looks, smells, and sounds, as well as the meals provided there, all contribute to the “feel” and feeling of a place. Some individuals may refer to it as a location’s personality or character. (Ungvarsky, J., 2023).

The idea of sense of place is essential because it influences how individuals relate with different settings. This has implications for everything from feeling at ease in a location to people’s attitudes about other locations and how affluent a city may become. (Ungvarsky, J., 2023).

One way post-industrial design creates a sense of place is through the use of repurposed materials (Cooke & Plate, 2017). Old factories, warehouses, and other industrial buildings can be transformed into public spaces, such as community centers, art galleries, or parks. By re-purposing these structures, post-industrial design highlights the history and character of the site, while providing new opportunities for community engagement.

Another way post-industrial design creates a sense of place is through the use of industrial elements, such as steel, concrete, and brick (Dovey, 2016). These elements can be used to create art installations, benches, or other design elements that reflect the industrial past of the site. By incorporating these materials into contemporary design, post-industrial spaces can create a sense of continuity between the past and present, while also providing a unique and visually striking aesthetic.
PLANT SELECTION

The following plants were chosen for being native to the region and for their phytoremediary properties. Using these plant species can rehabilitate the soil on the site and make it safer for interaction.

- **Black Willow (Salix nigra)** - Black Willow is a native tree that is known for its ability to uptake and remove nutrients and metals from the soil, as well as to stabilize streambanks and prevent erosion.

- **Switchgrass (Panicum virgatum)** - Switchgrass is a native grass that is known for its ability to uptake and remove heavy metals such as lead, copper, and zinc from the soil.

- **Joe Pye Weed (Eutrochium purpureum)** - Joe Pye Weed is a native plant that has demonstrated the ability to draw out pollutants such as nitrogen, phosphorus, and heavy metals from the soil.

- **Eastern Cottonwood (Populus deltoides)** - Eastern Cottonwood can be effective in removing pollutants such as benzene, toluene, and trichloroethylene (TCE) from contaminated soil and groundwater.

1. **River Birch (Betula nigra)** - River Birch was chosen as it has seen success in the surrounding area and has been shown to have the ability to draw zinc and cadmium out of the soil.

- **American Holly (Ilex opaca)** - American Holly is a native evergreen tree that is known for its ability to absorb and remove pollutants such as benzene, toluene, and xylene from the soil.
The two existing roads, 5th St. and Irwin Ave. are maintained here but reserved only for pedestrian access. An additional meandering path was added to incorporate elements of therapeutic garden design specifically, “the journey” mentioned above and allow guests to navigate the space in a meandering fashion if they choose. Areas of public and private seating are provided and a water feature is included for the sense of peace associated with interaction with water. Additionally plants are arranged in a “Fibonnacci sequence” reminiscent of the arrangement of seeds in a sunflower.

Figure 58: Diagram of planting plan for the site

Figure 59: Proposed Beaumont Glass Site design
This perspective demonstrates an area designated more for private reflection. The area depicted is near the WVU PRT structure. An overhead arbor-like structure provides a feeling of enclosure and intimacy as well as a sense of shelter. Additionally it replicates the form of the PRT. Benches are intended to be simple rectangular forms to replicate the form of PRT cars, enhance the industrial feel of the site, and prevent from alienating unhoused individuals sleeping in the area.
Here, in this eddy, the intent behind the water feature is demonstrated. This feature is a large pipe contained within a spiral steel and concrete structure. Water can be pumped and flow out of the end of the structure. This is an interactive feature that activates the space and brings the therapeutic element of water into the design.
The rock garden space is represented in this image. The rock garden provides an opportunity to choose rocks that mimic the structure of the Morgantown Energy Associates Power Plant. The power plant itself is a large modular form. Rock gardens are traditionally an element in Japanese garden design. In Japanese gardens, the large boulders often represent islands in the sea, but here they provide a chance to be referential to silhouette of the factory and the industrial history of the site. Crushed rocks in this location, once cleaned, can be recycled from the existing brick and concrete that is on site rather than importing new materials.

Figure 62: Rock garden inspired by MEA factory
CONCLUDING STATEMENTS

This report has demonstrated the importance of sustainability in the context of the City of Morgantown, West Virginia. With a focus on three key areas of sustainability - stormwater management, transportation, and land use - this report has highlighted the challenges faced by the city in accommodating its fluctuating population and the need for sustainable infrastructure planning to meet the increasing threat of climate change. By synthesizing existing data and proposing design solutions for selected areas of concern, this report has demonstrated opportunities for a sustainable approach towards resolution for city officials. Ultimately, this report serves as a model planning document, providing proactive measures for sustainable infrastructure planning and design that will benefit both the city’s local residents and its student population.

Based on the research and planning conducted in this report it is clear that there has been a historic lack of focus on environmental sustainability in previous development plans for the City of Morgantown. The Sustainability Management Plan incorporates best management practices and green infrastructure practices into development. The visioning process for this project resulted in the identification of the need to preserve open spaces, and establish a general vision for the impact of climate change and urbanization on the landscape of Morgantown. Storm water management, transportation, and land use are not the only factors in the realm of sustainable planning, but with the implementation of these plans and concepts, the City of Morgantown can begin to take proactive measures to create a sustainable future for its residents and the environment.
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LIST OF FIGURES

Figure 1: CSO Overflow events

Figure 2: Map of percent impermeable surface and existing green space

Figure 3: Map of Popenoe Run watershed provided by Vaike Haas with West Virginia University.

Figure 4: Map of percent impermeable in the Popenoe Run watershed

Figure 5: Aerial image of Christian Missionary Alliance as it exists currently

Figure 6: An example of providing vegetated buffers in parking areas

Figure 7: Existing conditions

Figure 8: Section AA′

Figure 9: Perspective image

Figure 10: Plan view image; an example of adding vegetation to the watershed

Figure 11: Patteson Drive being graded into the landscape ca 1959; Image courtesy of WV Regional History Center

Figure 11: Krepps Family Farm ca 1902 Image courtesy of WV Regional History Center

Figure 12: Car in a snowstorm; Image courtesy of WV Regional History Center

Figure 13: Aerial image of Patteson Drive; WV Regional History Center

Figure 14: Suncrest Flatts area; Image courtesy of WV Regional History Center

Figure 15: USGS Topography 1902

Figure 16: USGS Topography 1925

Figure 17: USGS Topography 1931

Figure 18: USGS Topography 1957

Figure 19: USGS Topography 1994

Figure 20: USGS Topography 2019

Figure 21: Popenoe Run during a rain event; Image taken by author

Figure 22: Popenoe Run during a rain event; Image taken by author

Figure 23: Reference Reach: Laurel Run, WV State Research Forest

Figure 24: J-Hook diagram

Figure 25: Root ball diagram

Figure 26: Cross-vane diagram

Figure 26: Live fascines diagram

Figure 27: Live staking diagram
Figure 27: Live fascines bundle detail.

Figure 28: “Fowler Map” of Morgantown, WV; Image courtesy of WV Regional History Center

Figure 29: Chart of Morgantown commuters; chart created by author

Figure 30: Morgantown traffic volume reports from WV Department of Transportation Annual Average Daily Traffic (AADT)

Figure 31: MMMPO adjusted traffic volume map

Figure 32: WVU PRT under construction; Image courtesy of WV Regional History Center

Figure 34: Example of a Mountain Line Bus route

Figure 35: Example of degraded sidewalks in Sunnyside neighborhood

Figure 36: MMMPO map of recommendations for improvements to the pedestrian network of Morgantown. Sourced from https://www.plantogether.org/plans-studies

Figure 37: Mon Valley Green Space Coalition Green Belt Proposal map provided by member JoNell Strough and presented to Morgantown Municipal Green Team.

Figure 39: SWOT analysis of WV DOT proposal

Figure 40: MMMPO written proposal for modifications to the intersection

Figure 41: SWOT analysis of MMMPO proposal

Figure 42: An image of the landscape under threat

Figure 43: Proposed revisions to the angles of the intersection and lane modifications

Figure 44: Proposed additions to the pedestrian infrastructure of the intersection

Figure 45: Acres of impact on the landscape

Figure 46: ‘Detail of window casements along the Railroad track’ 1988; Image courtesy of West Virginia Regional History Center; donated by Six, Dean.

Figure 47: ‘View looking north along Rail road shows additions and original mill portions of east side of building.’ 1988; Image courtesy of West Virginia Regional History Center; donated by Six, Dean.

Figure 48: ‘Original woolen mill portion of building view facing west along Rail Road.’ 1988 Image courtesy of West Virginia Regional History Center; donated by Six, Dean.

Figure 49: Environmental Protection Agency table of results on soil testing done on site

Figure 50: Environmental Protection Agency table of results on soil testing done on site continued

Figure 51: Map of percent impermeable surface throughout the City of Morgantown

Figure 52: Map of percent slope on the site

Figure 53: Map of slope aspect on the site

Figure 54: Diagram of site considerations

Figure 55: Image of the Beaumont glass site; Image courtesy of WV Regional History Center

Figure 56: Diagram of phytoremediary mechanisms
Figure 57: Diagram of pollutants that can be address using phytoremediation

Figure 58: Diagram of planting plan for the site

Figure 59: Proposed Beaumont Glass Site design

Figure 60: PRT bench seating area

Figure 61: Spiral seating area/water feature

Figure 62: Rock garden inspired by MEA factory