

G r o w i n g G r e e n
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P h y t o r e m e d i a t i o n

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Growing Green with Phytoremediation

A Design Thesis Submitted to the Department of Architecture and
Landscape Architecture of North Dakota State University

By

Kyla Witz

In Partial Fulfilment of the Requirements for the
Degree of Bachelor of Landscape Architecture



Primary Thesis Advisor



Thesis Committee Chair

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May, 2012



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Abstract

Educating interactively about phytoremediation

This thesis is premised on the basis that students benefit from both theoretical and practical applications. In this project, I have created an outdoor, interactive space that demonstrates the intersection between the science of phytoremediation and its practical benefits. In this project I have designed an outdoor classroom space for a school in South Beach, Miami, where elementary school children, as well as their teachers, parents, and the community, can experience the science of phytoremediation at work.

Problem Statement

How can landscape architects create an interactive, educational, and beautiful space that explores phytoremediation and its many benefits?

Statement of Intent

Project Typology

Educational design using concepts of phytoremediation.

The Claim

Creating an outdoor science classroom in a school environment is an effective way to educate students and the broader community about the benefits and applications of phytoremediation.

Actors

Landscape architects, elementary school children, teachers, parents, engineers, community members.

The Action

Using available resources to design an outdoor interactive space, will enhance the education of elementary school children, and many others, about the science of phytoremediation. This will also provide practical information about plants that uptake toxins in the environment.

The Object Acted Upon

Publically accessible outdoor space.

Theoretical Premise/Unifying Idea

By creating an outdoor interactive space in a school district we can enhance education about phytoremediation and its many benefits. The public generally are not aware of the accessibility of plants that can uptake toxins in their built environment. By educating children from the elementary school level, we can expand public knowledge.

Project Justification

Education about phytoremediation is crucial for our global environment. Educational institutions generally have trash disposal activities, asbestos management activities, drinking water supply facilities, and grounds maintenance activities. These usually produce substantial quantities of a wide variety of waste, including inorganic acids, organic solvents, metals and metal dust, photographic waste, waste oil, paint, heavy metals, and pesticides. The toxins produced from waste generation can be remediated through the use of phytoremediation to clean and improve air, water, and soil quality. The cleaning process can be integrated into an interactive and educational experience.

Narrative

Everybody benefits from a healthy environment and all of us can make a contribution if we understand more about the concept of phytoremediation. Therefore, designing a site that incorporates education about the benefits of phytoremediation, and how it works, is extremely important.

When school children are given the opportunity of learning about phytoremediation as part of their daily educational experience, they are more likely to incorporate phytoremediation in their later lives. Making phytoremediation fun and interventional enhances the entire educational experience.

User/Client Description

Users

The site will be designed for elementary school children, teachers, parents, and other community members who are willing to get involved and learn more about the science of phytoremediation. This public educational space will bring school children, parents, and community members together for the benefit of the entire community.

Providers

This site will be operated and owned by the City of Miami. It will be an educational space located at a public school, which will be accessible for field trips and after-school activities. People from surrounding areas will also be able to visit this site.

Major Project Elements

Scope

The major elements of this project include designing and creating a public educational space to enhance education about phytoremediation and its benefits. This project will provide a space where students and community members can come together and learn about the science of phytoremediation in an outdoor, interactive environment.

Elements- Open/Public Space

This educational experience will include environmental and scientific elements.

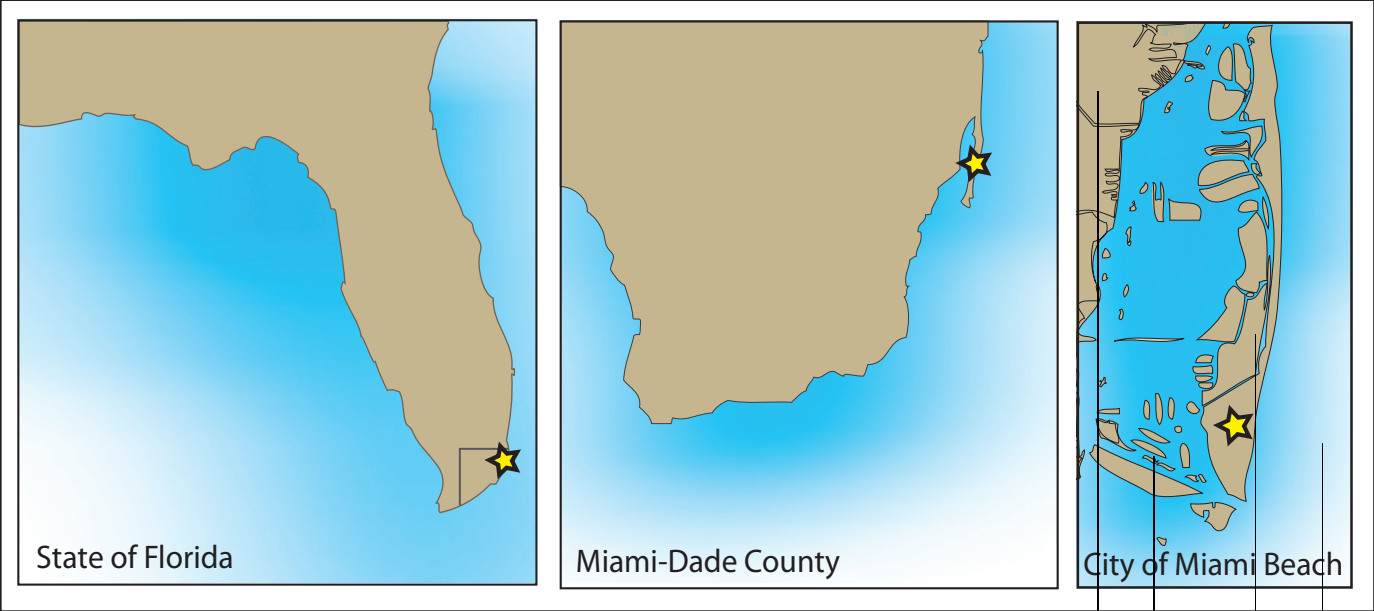
Educational

The educational elements include a green wall, interactive playground, and multiple water features that will demonstrate how we can improve our environment by incorporating phytoremediation into our everyday lives.

Environmental

Students and the wider community will discover how the use of appropriate plant selection can connect the benefits of science to the everyday lives of communities in their built environments.

Site Information



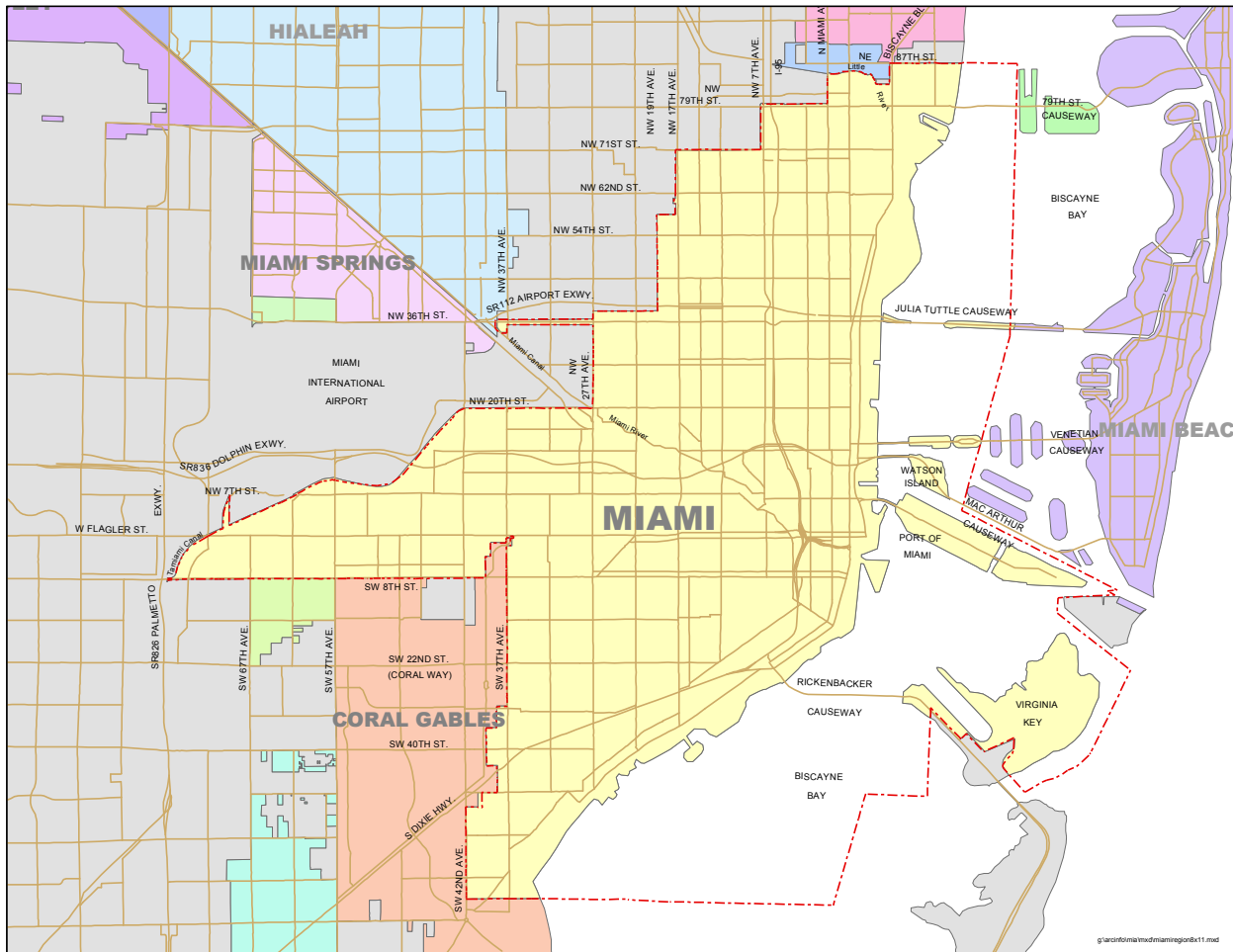
- Atlantic Ocean
- Miami Beach
- Biscayne Bay
- Miami

Project Emphasis

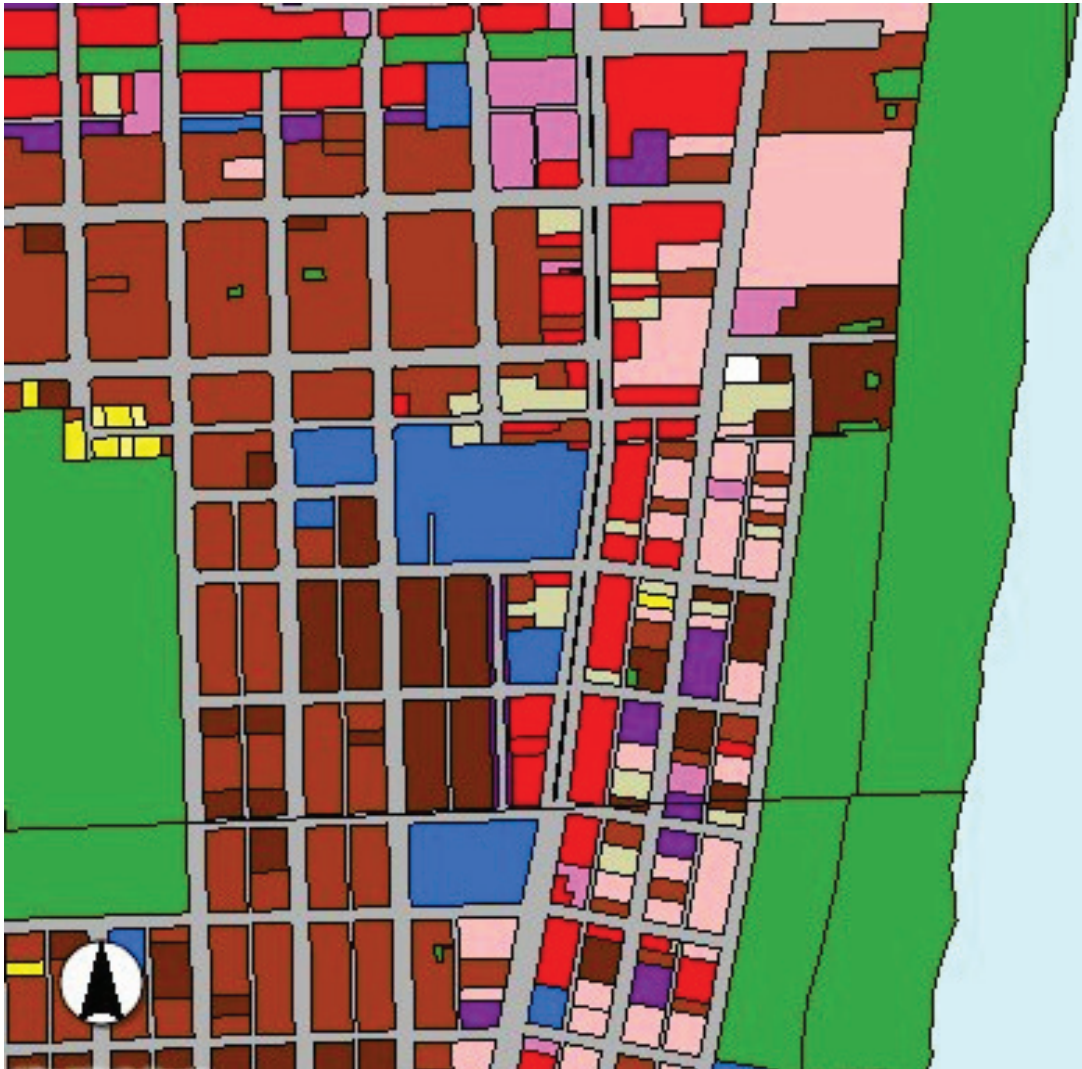
Theoretical Premise

By increasing the desire and opportunity to learn more about the science of phytoremediation, we are also increasing the possibilities to vastly improve our environment. By designing and developing an interactive educational space, we are providing increased opportunities to bring people together for a rewarding educational experience.

City of Miami General Boundary Map



Land Use Map



- Single-Family
- Commercial, Shopping Centers
- Industrial
- Communications, Utilities, Ports
- Parks, Preserves, Conservation Areas
- Office
- Transient-Residential (Hotels, Motels)
- Vacant, Protected, Government Owned
- Low-Density Multi-Family
- High-Density Multi-Family

Plans for Proceeding

Project Typology

Educational design with phytoremediation.

Design Methodology

The design uses mixed methods that integrate quantitative and qualitative data.

The quantitative data used throughout my project will include information about plants that uptake specific toxins. Qualitative data will include how I use the design elements to create an interactive educational outdoor space. Data will be gathered from various public databases to obtain information to create this interactive and educational experience.

I will present my project through the use of public resources, a series of digital media, 3-D modeling, and practical examples of the design features.



Studio Experience

Second Year

Fall- Kathleen Pepple
Tea Project- Fargo, North Dakota

Spring- Mark Lindquist
Design Project- Winnipeg, Canada

Third Year

Fall -Stevie Famulari
Ice Sculpture Installation Project
Regent site design- Regent, North Dakota

Spring- Kathleen Pepple, Jay Kost
Roosevelt Neighborhood- Fargo, North Dakota

Fourth Year

Fall-Jay Kost
Duluth Master Plan- Duluth, Minnesota

Spring-Stevie Famulari
Phytoremediation implementation- Fargo, North Dakota

Fifth Year

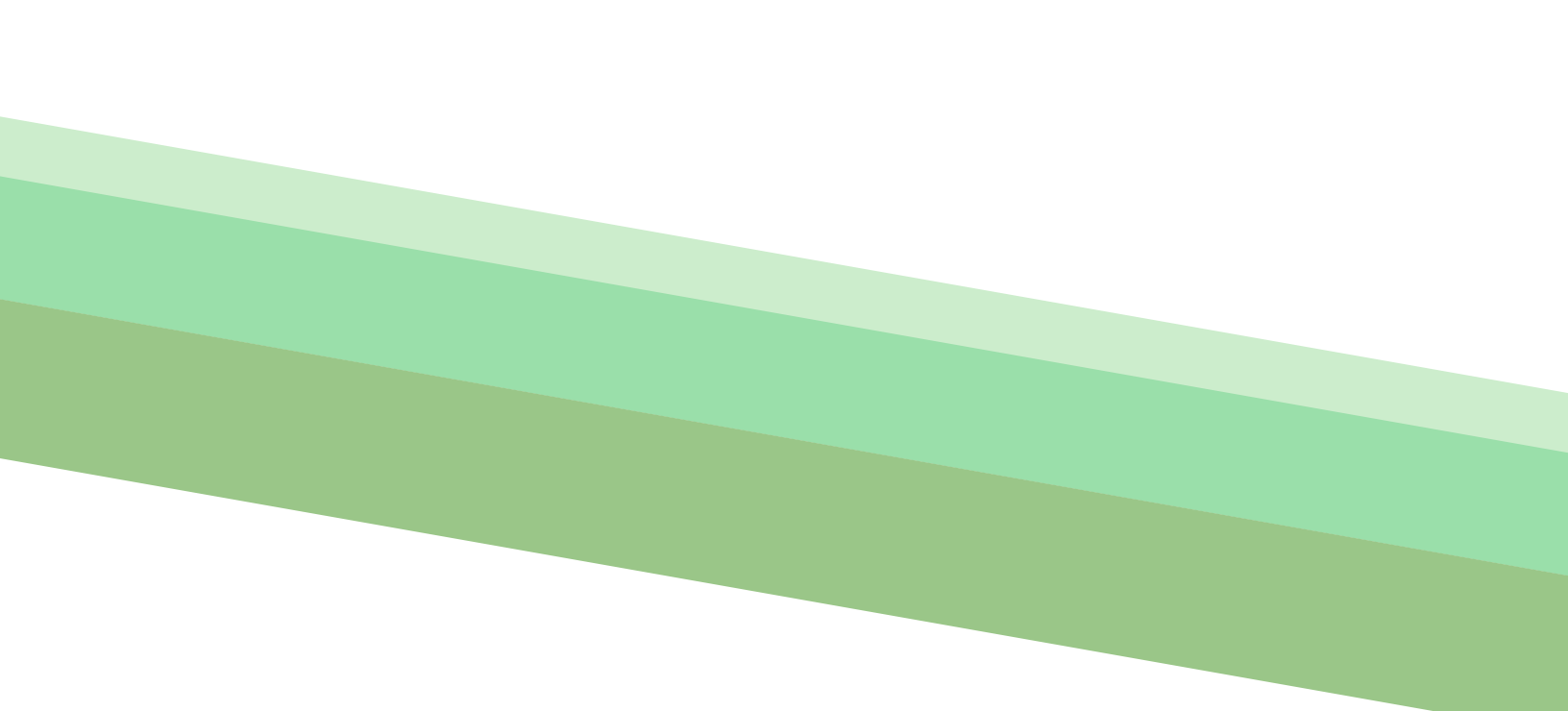
Fall- Catherine Wiley and Dominic Fischer
Sketch Project- Seattle, Washington

Research Results

Phytoremediation and its applications

The journal titled *Introduction to Phytoremediation*, published by the United States Environmental Protection Agency (EPA) gives a broad overview of the science of Phytoremediation, its uses, benefits, site requirements, and application to specific projects. It is a guide to the available literature and research studies. The publication supports how phytoremediation and its applications can be used to improve our environment, because this is one of the mandates of the EPA. The EPA seeks to protect human health and the environment from the toxic effects of contaminants and hazardous waste sites. The agency also encourages the use of phytoremediation as a process of remediating the environment. It supports and encourages the use of phytoremediation by making its knowledge base available as an educational tool that the EPA hopes will help guide future research in the science of phytoremediation. Because the EPA is also an administrative agency, it wants the publication to be used to guide new administrative regulations. The publication also cites published and unpublished work in an effort to bring together the full range of research that has been conducted in the field.

The idea is to prevent researchers from doing what has already been done, and to encourage new research rather than a repeat of existing papers. This is why the publication refers extensively to unpublished papers that may not be available otherwise. This publication also supports phytoremediation by providing examples of specific projects that have been proposed or applied to restore our ecosystem.



This publication demonstrates how plants improve the soil, water, and air quality. Based on results from field trials, phytoremediation has also been shown to be a cost saving method compared to conventional treatments. Ultimately, this publication supports phytoremediation by enhancing our knowledge of the science of this process.

Phytoremediation has many applications. These applications cover sites that have different levels and areas of contamination, such as soil, water, or air. Wildlife diversity restoration can also benefit from phytoremediation by incorporating habitat growth as well as helping in the remediation of soil and water. This can be achieved by converting contaminated sites into parks or low intensity outdoor spaces, which benefits the environment and the public. Another application of phytoremediation is in commercial environments, including well-developed landscape plans for businesses to control stormwater run-off and provide long term treatment, and enhanced ecological habitats.

There are several elements to consider when applying phytoremediation. Some of these include site characterization, problem identification, such as the media or contaminant that is present. Regulatory requirements also need to be addressed, and potential plants that can be used in the application of the science need to be identified. The Introduction to Phytoremediation document supports the idea that there are multiple reasons to design a site that will educate the public about phytoremediation, its benefits, applications, and the overall concept. This form of education and knowledge can impact the public in positive ways, starting with educating elementary school children and expanding the knowledge to the general public. (1)

The EPA's book titled *Road Map to Understanding Innovative Technology Options for Brownfield's Investigation and Cleanup* discusses how the U.S. (EPA) established a Brownfield's Economic Revitalization initiative to encourage states and communities to work together to redevelop brownfield sites for the benefit of the environment. The redevelopment of land in communities would benefit and inform communities about ways to clean and re-use contaminated sites. This publication also provides information about the different site activities and contaminants that result from research activities or that may be generated by educational institutions. The *Road Map to Understanding Innovative Technology Options for Brownfield's Investigation and Cleanup* states that educational institutions typically generate a variety of wastes, including inorganic acids, organic solvents, metals and metal dust, photographic waste, waste oil, paint, heavy metals, and pesticides. The importance of educating the public about phytoremediation to remediate contaminated sites is supported in this document. Educating communities about site remediation and its ecological benefits encourages the redevelopment of brownfield sites. It is important to encourage the idea and the message that small changes in a community can make a significant difference. This sends the message that a project does not have to be large scale to be effective. The publication encourages communities and educates people to recognize that whatever the size of the project, we can all benefit from the results. It helps people understand that anyone can make a difference. (2)

Phytoremediation and its benefits are supported in the document titled *Planning and Promoting Ecological Land Reuse of Remediated Sites*. This journal emphasizes the many environmental and economic benefits of the process of phytoremediation. By restoring or creating new ecosystems, both during the process of remediation, and after the remediation of a site is complete, there are multiple environmental and financial benefits. On the remediated site, as well as off site, the soil, surface water, sediment and ground water quality are improved. For example, the publication explains that the remediation of various contaminated sites by planting vegetation encourages and creating wildlife habitats can decrease contaminants and benefit the environment. In this process, dust and erosion are controlled, stream banks are stabilized, and the ground water is recharged. This is cost efficient because financial resources can then be allocated to other areas.

By remediating land, harvestable resources are also created and educational opportunities are developed to engage public interest and participation. Recreational and aesthetic areas, as well as public networks can be designed and implemented. These too can enhance education of the science of phytoremediation. Education can also expand knowledge about the economic effects and benefits of phytoremediation. The publication points out that the process is cost effective, provides functional use of limited resources, creates educational opportunities, generates revenue based on design goals of the site, increases property values and provides a source for recoverable resources. (5)

Benefits of creating connections between phytoremediation and landscape Architecture

Landscape architecture plays an important role in the science of phytoremediation. Phytoremediation sites are usually isolated from urban life and the general public which can create physical distance and barriers. By creating a connection between landscape architecture and phytoremediation, the aesthetic quality of phytoremediation sites would be improved, and there would be an increase of phytoremediation knowledge among the public. This creates an important link between the science and public awareness of the science, and it is landscape architects who can build that link. By implementing designs with the goal of remediation, the public will also be educated by landscape architects about ways to improve the environment by using phytoremediation. Another important connection that ties landscape architecture with phytoremediation is designing a site specifically to educate the public about the process of phytoremediation, while the site is being remediated.

The article demonstrates how, by using plants as a visual medium to explain the various stages of the remediation process, a meaningful, educational, and interactive transformation of public spaces can be achieved. By drawing the public into a space that provides an interactive, aesthetic experience, we are encouraging the decrease of negative impacts on the environment, and increasing the level of knowledge to prevent or limit further contamination. This establishes an understanding of the importance of the remediation of contaminated sites. Also, by implementing designs that visually inform the public about how phytoremediation can be cost effective, we can get the public to recognize the benefits of using phytoremediation to create minimal disturbance of a site, and to avoid the future expense of remediation by appropriate planning. All of these objectives use landscape architects to create knowledge about phytoremediation, and in the process they can demonstrate to the public how it would help their communities in many areas – environmental, financial and aesthetically.

An example of the success of connecting phytoremediation and landscape architecture was done by the UMass Urban Design Laboratory. They used a site located in the Elbe Islands in Hamburg and Wilhelmsburg, close to residential areas. The UMass study ties phytoremediation to green infrastructure and urban design. The site named “Rhizotopia” was a former oil refinery that was contaminated with toxic organic materials as well as heavy metals. By implementing a green infrastructure, the contaminated landscape that was useless before was transformed into a functional, educational urban landscape in which the public can interact and benefit. The site now functions as a stormwater treatment system, with street boulevards, pedestrian walkability, and a connection to the existing neighborhood. With the implementation of this remediation infrastructure a habitat for wildlife is also created. An educational aspect that is incorporated into this specific study is the underground public stations that consist of glass windows to allow the public to view and understand the process of phytoremediation. By connecting landscape architecture with the process of phytoremediation, an aesthetic, educational, and interactive experience is created for the public to engage in.

Another site that connects landscape architecture to phytoremediation was also implemented by the UMass Urban Design Laboratory. This site was once a highly contaminated industrial canal located in the Elbe Islands. The site now functions as an urban greenway with a trail system for pedestrians and bicyclists. It benefits the environment by collecting stormwater from the surrounding neighborhoods, and directs the water into the canal.

Landscape architects can create and implement designs that allow the public to experience phytoremediation as an enjoyable learning opportunity, while encouraging people to become involved and demonstrate that they do not need to be scientists to help the environment. By showing the results of phytoremediation in their own environment, people will be more likely to want to see it implemented more often. Educating the public is achieved by creating visual experiences about the process and successes of phytoremediation. The results will encourage increased use of designs that educate people, help economic growth, and stimulate the revitalization of neighborhoods. (4)

The importance of the education about phytoremediation

The Planning and Promoting Ecological Reuse of Remediated Sites

publication supports the idea that education about phytoremediation is important in demonstrating some of the public benefits of remediating a site. Organizations can use the ecological restoration of a site to provide educational opportunities, create aesthetic value, and provide natural resources to local communities. Some aspects of phytoremediation that provide areas for public interaction and education are biology, horticulture, ecology, wetland hydrology, plant identification, and the general process of phytoremediation. These sites can also become functional breeding grounds or seed banks as well as serving as an educational tool. During the remediation or development of a site, local community members can be influenced to make ecological enhancements by incorporating the reuse of resources into their everyday lives and the community as a whole. By educating the public about the benefits of phytoremediation, people will be encouraged to increase outdoor recreation, and to enjoy the enhanced livability and walkability of their cleaner communities. The effects of implementing remediation sites will increase property values which will benefit the community as a whole. Another aspect that can increase property value is the improved aesthetics that remediation projects can contribute to a community. (5)

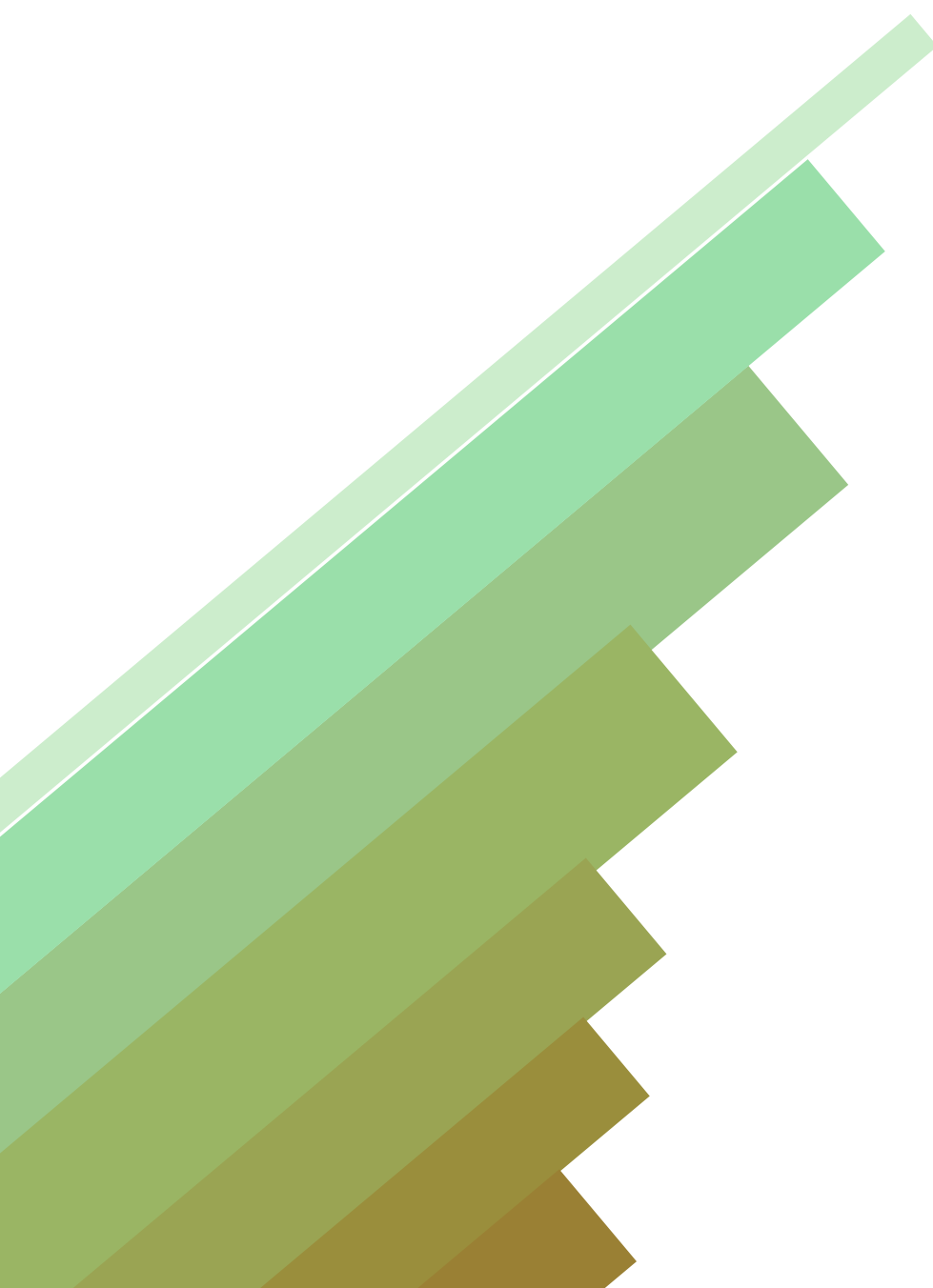
In conclusion, phytoremediation and its connection to landscape architecture: the importance of education about the process of phytoremediation, and the benefits and applications of this science are all supported by a wide variety of sources. All these elements can be connected to create a cycle to benefit our ecosystem and the people who share it. Landscape architects begin with the design and implementation of a site plan that will remediate and improve the soil, water, and air quality. This design will be aesthetically pleasing, and will engage the public. Once the public is interacting with the site and its design features, they will be educated about how and why the processes take place. Science can become accessible to more people. The cyclical benefits of phytoremediation will become visible as the plants grow and mature. Once the public sees and engages in the practical benefits of this science, it will enhance their understanding of how we can use nature to our advantage. This understanding will help change our environment to improve our communities. It will become apparent that the benefits extend to environmental, aesthetic, lifestyle, and financial gains. As a result, communities will benefit from a decrease in the negative effects of pollution and toxins in our ecosystem. As nature renews itself, we can expand remediation sites.

Historical Context

This section explores how the science of phytoremediation was developed over the years.

Phytoremediation is a science that has developed from an unknown naturally occurring process to a scientific and technological concept. By the 1870's, natural resources were depleting because of destructive practices such as mining, overgrazing, timber cutting, and monocrop planting. In order to try to protect and preserve America's natural resources, several environmental organizations formed. This resulted in the rise of modern environmentalism. Persistent organic pollutants (POP's) were developed in the early 1920's. In the 1940's and 50's, POP's become a necessary resource regarding agriculture and industry. The harmful effect that these POP's would one day cause was not considered. As science and technology advance, the wide usage of POP's and the damaging consequences, awareness and education is extremely important for the regulation of additional destruction of our ecosystem. The knowledge of the remediating qualities of plants in the environment has existed for more than three centuries. However, it was not until 1948, when the hyperaccumulation of nickel was first reported in *Alyssum bertolonii* by Italian researchers.

The environmental movement began in the late 19th and early 20th century and aimed to create awareness of air and water pollution. It wasn't until the 1960's that this movement began to thrive as a result of the social activism movement. Ecological awareness increased in the areas of organic gardening, urban and rural community living, and the establishment of community-based recycling centers. The In the 1960's, farm workers in California fought for the right to be protected from toxic pesticides in farm fields.



The beginning of modern environmentalism began with the publication of Rachel Carson's thesis, *Silent Spring* in 1962. This publication brought public awareness to the dangers of environmental pollution to human health. Carson examined the ecological impacts of contaminants, such as, pesticides, that were found to pollute our natural and human environments. However, modern environmentalism is different from the conservation and preservation of our environment because conservation and preservation focus on managing the natural environment and modern environmentalism is based on remediating the environment and controlling pollution.

In the 1970's plants were tested for the treatment of soil infiltrated with metals and other contaminants in wetlands. The establishment of the federal Environmental Protection Agency (EPA) created an administrative agency to enforce laws to protect human health and the natural environment. In 1972 the use of the toxic pesticide DDT was banned by the United States. The EPA became increasingly active, and in 1973, it created rules to phase out lead in gasoline. This caused levels of lead in the air to decrease by 90%. Further EPA action for environmental protection included the recognition that there were large amounts of toxic chemicals buried underground in neighborhoods in Niagra Falls and New York. As a result, hundreds of families were evacuated to protect them from cancer and birth defects. These events highlighted the need for an effective method of remediation. Both the Civil Rights Movement and the Environmental Movement had an impact on creating the Environmental Justice Movement in the 1980's. Regulations against toxic dumping, municipal waste, and incorrect land use decisions were also the result of the impact of the Environmental Justice Movement.

The science of phytoremediation became common in the 1980's due to the successful treatment of wetlands, and use of phytoremediation applications by federal and state governments. By the late 1990's, phytoremediation expanded due to newer scientific technologies.

The awareness of and education about contaminants is important because as knowledge of contaminants and its effects becomes more common, this knowledge can be shared, and science can be used to remediate it. This includes keeping contaminants out of our environment and food sources. Since 1990, the market for organic food has grown 20% each year. This correlation is based on the increase of education about the concept of chemicals and their dangers. One of the main reasons this technology continues to increase with popularity and usage is due to the wide variety of pollutants that can be targeted. A few of these include crude oil, metals, explosives, pesticides, chlorinated solvents, and other contaminants.

Despite use of the science, the term phytoremediation was first used by Raskin in 1991. Raskin was funded by the U.S EPA Superfund Program. Today, the science of phytoremediation combines elements derived from multiple fields. Some of these fields include agronomy, forestry, chemical and agricultural engineering, and microbiology, but phytoremediation remains an independent field, as well as a widely applicable technology. In 1999, the U.S. market for phytoremediation was estimated at between \$30 and \$49 million. (3) (6) (13-18)

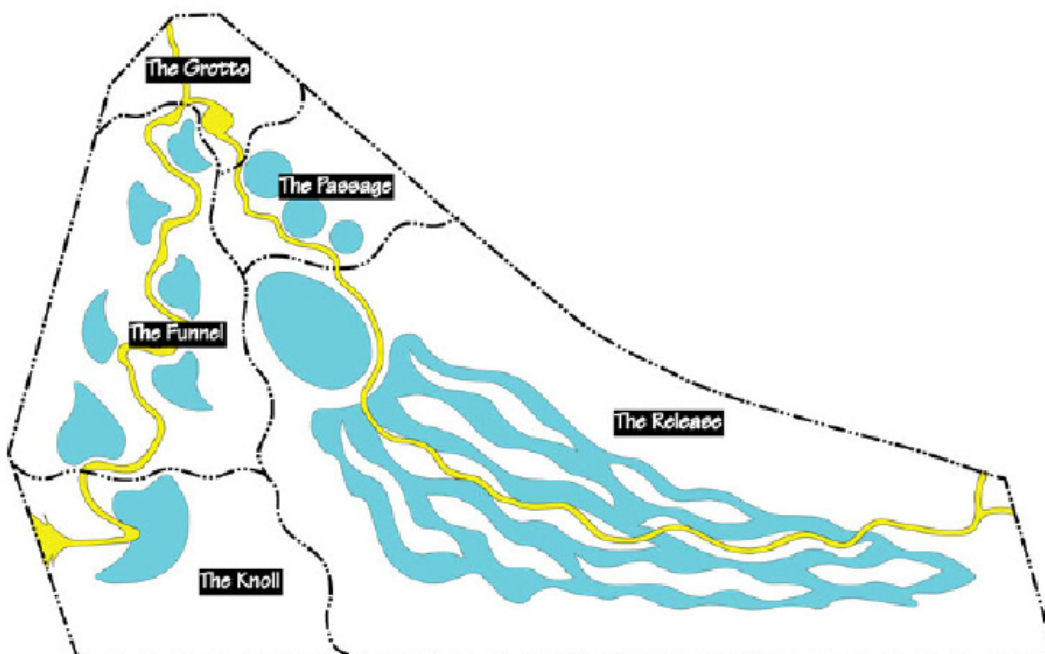


Case Studies

Lorna Jordan- Waterworks Garden

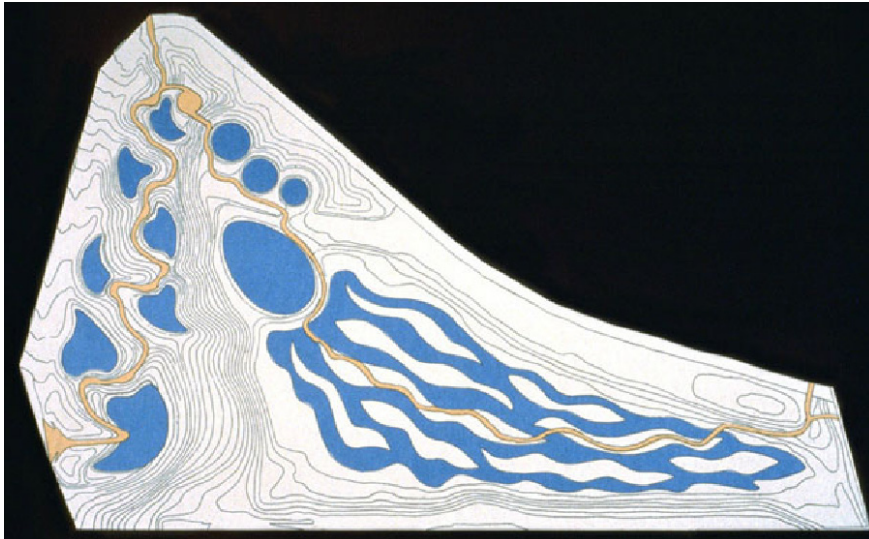
Lorna Jordan is an environmental artist who works with a combination of sculpture, ecology, architecture, and theater. Her art aims to get communities to interact and engage with places. Her pieces include a combination of form and process in relation to an event. Most of her artwork is based on sustainability and green infrastructure. Some of her designs focus on elements of watersheds, educate about the process of water and its many working components. She aims to create relationships between our urban infrastructure and natural infrastructures relating to water, such as creeks, rivers, wetlands, ponds, and estuaries. Sustainable buildings are also sometimes included in Lorna's artwork. Lorna Jordan's projects have meaning behind them because they consist of ideas, places, and actions. Lorna Jordan's work also educates by revealing natural processes and highlighting how they enhance ecosystems. Through her art, Lorna Jordan creates connections between people and systems while keeping her work interactive and by producing engaging pieces of artwork.

Garden Rooms



One specific environmental piece of Lorna Jordan's artwork that I found interesting is located on the border of a water reclamation plant. This piece is a water and earth sculpture. This project treats stormwater naturally, and also functions as an on-site wetland. The site also contains a large amount of space for public use. This project aims to educate the public about the purification of water, as well as being an interactive environmental art piece. The design incorporates five different garden rooms, each representing a different part of the water cycle. By incorporating the functions and steps of the water cycle as interactive parts in the design, it allows the public to engage in the piece and become educated on the subject in a more interesting and unique way.

Grading Plan



The Model



Lorna Jordan's Waterworks Garden and work in general relates to my thesis project in several different ways. Jordan aims to design spaces that create a strong connection between an important environmental issue and how the public will be educated on and engaged in this issue. The main goal of my thesis design is to create an outdoor interactive space that educates elementary school children and community members about the concept of phytoremediation. This concept consists of many different aspects and has great environmental impact. In the design of Waterworks Garden, Lorna Jordan creates various interactive spaces, each representing a different step in the water cycle. This unique way can be applied to my thesis design. Each aspect of phytoremediation can be represented in a different space. All of these interactive spaces will connect and result in the creation of an engaging, informative garden.

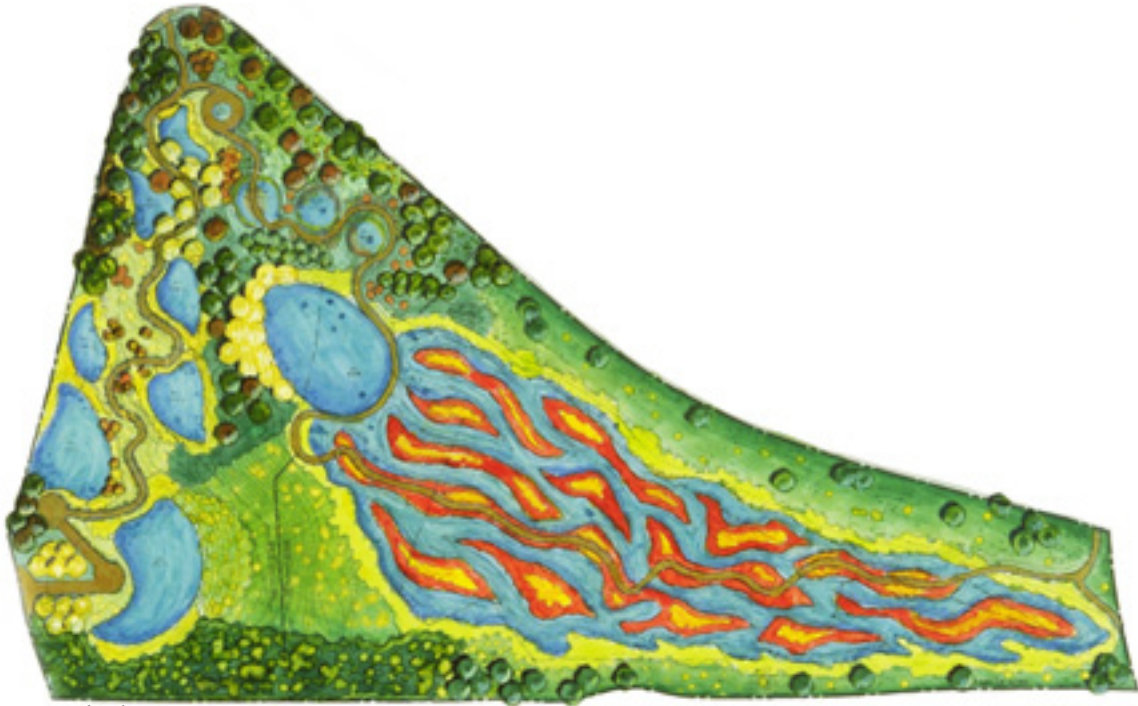
Pre-existing Artwork Site



Waterworks Gardens—Pre-existing Artwork Site

Another example of how Lorna Jordan's Waterworks Garden can be applied to my thesis design is that the garden actually functions as an on-site wetland, and treats stormwater naturally. The various vegetation that will be planted on my site that will educate about the corresponding toxin and contaminant remediation will also uptake those toxins from the air, water, and soil. The various spaces that this educational outdoor space will be representing and enhancing the quality of the air, water, and soil. Jordan also aims to bring people together with her designs. The design of my thesis project will also be bringing people together through the education about phytoremediation. By choosing my site location near an elementary school, a variety of people will be brought together to use this space, including elementary school children, teachers, parents, and community members.

Illustrative Plan



spiralcage.com

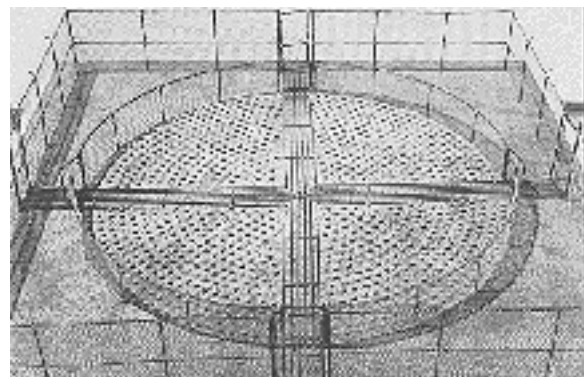
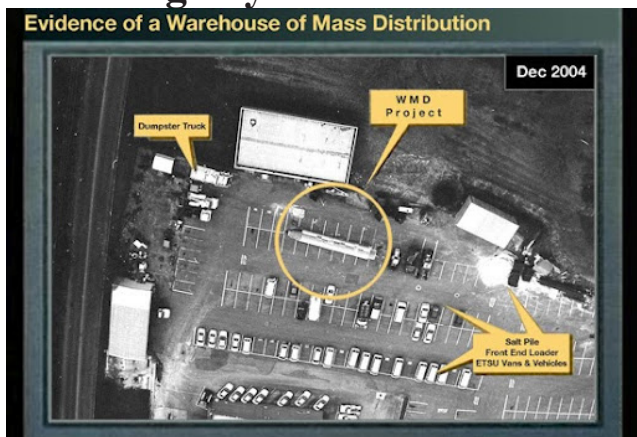
Lorna Jordan's art pieces focus on ideas, places, and action. These elements can be incorporated into my thesis design by creating a space that focuses on the idea of phytoremediation, the places it can be used, the opportunities for remediation that are available through the science of phytoremediation, and the actions that can be taken to implement phytoremediation to benefit the environment. Presenting phytoremediation concepts to elementary school children can make science fun and interactive, and can demonstrate how even elementary school children can become stakeholders in their future environment. (6)

Mel Chin-Revival Field

Mel Chin is a conceptual visual artist and sculptor. His artwork is motivated by political, cultural, and social circumstances. He aims to create meaning with art. He accomplishes this by using spaces such as galleries, museums, outdoor landscapes, and public spaces. Mel Chin believes that an important function of art is about making choices and creating possibilities. Mel Chin accomplishes these bold statements and ideals by promoting social awareness with his art. His work also focuses on improving habitat devastation, restoration, and sustaining biodiversity.

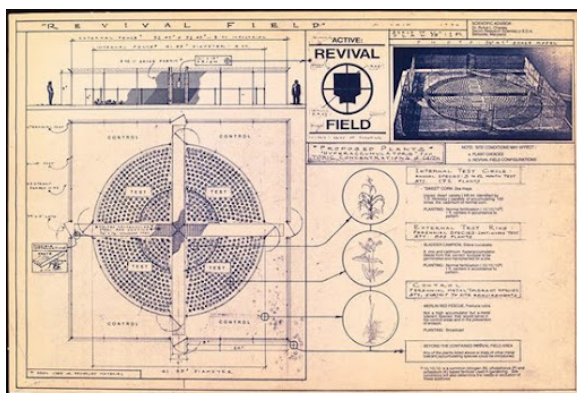
One of Mel Chin's famous projects is called Revival Field, located on an old landfill near downtown St. Paul, Minnesota. The site is divided into an "x" form made up of plants. The divisions of the site design were functional, as well separating different varieties of plants to make studying these plants easier. In 1990, Mel began working with scientists to create the installation Revival Field. This project consists of gardens that were designed using hyperaccumulating plants. These plants can uptake heavy metals from contaminated soil.

Site Image by Mel Chin



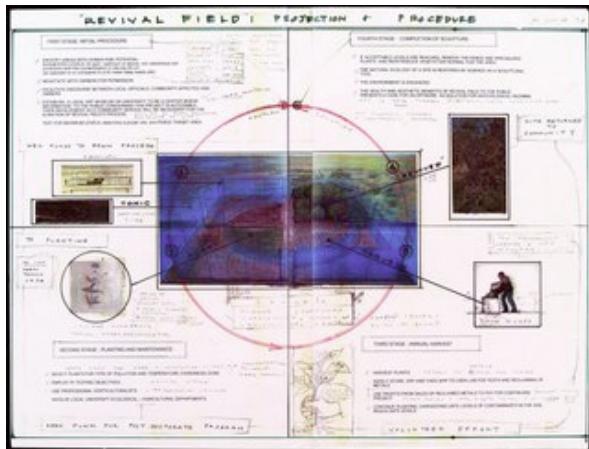
lamar.colostate.edu

Plan



throughstones.wordpress.com

Projection and Procedure

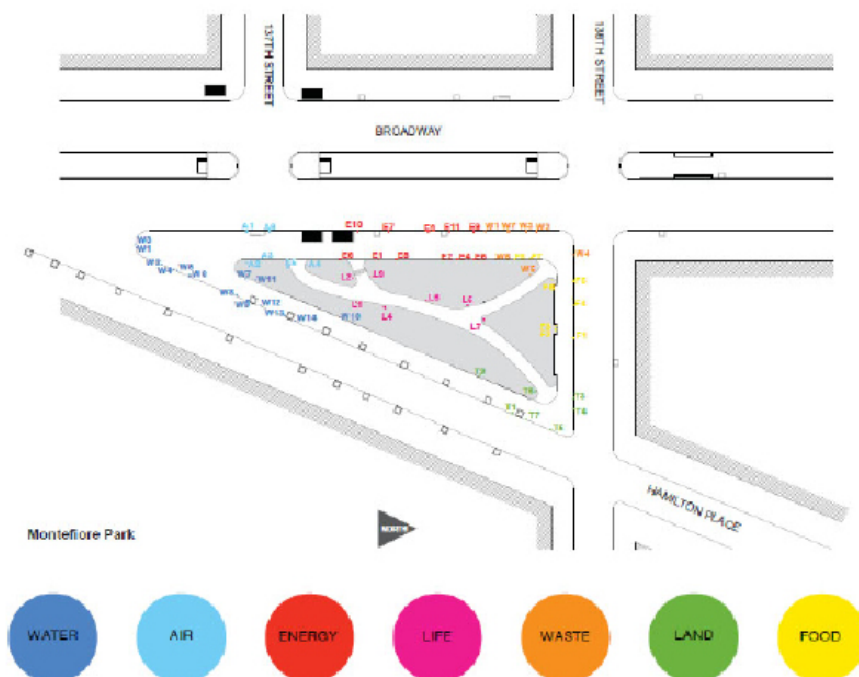


Mel Chin's Revival Field relates to my design thesis because it contains both elements of art and science and shows how these two can work together to create a unified design that will benefit our environment. The art and remedial aspects of Revival Field will eventually be revealed with the regrowth of the soil and plantings in a design formation. Mel Chin also uses art to explore ideas of organic growth and green remediation, and how certain materials affect the environment over time. This resulted in a new natural method of cleaning up toxic waste. Through the use of art and visually pleasing design, Mel Chin is educating and creating awareness of the importance of bioregions and more ecological ways of living. The science aspect of Mel Chin's Revival Field consisted of research and testing new techniques of green remediation technology, using plants to remove heavy metals from contaminated soils, and how these technologies have moved from the lab to field testing. By combining art, history, and science, Mel Chin creates awareness through his projects and makes the public think about current environmental and what can be done to help.

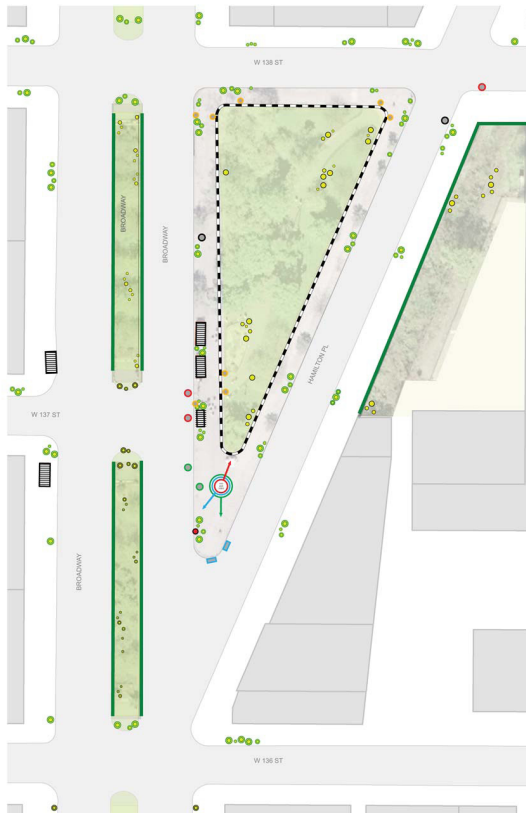
The education and implementation of phytoremediation is a concept that will be explored in my design thesis. The way Mel Chin combined art and science to create a project beneficial to our environment, as well as stimulating awareness of the concept and the current issues of the environment, can be used in my outdoor educational space. The art aspect of my design will be the design itself and how the different elements of phytoremediation are aesthetically represented. The science aspect will be the way phytoremediation works on my site to remediate contaminants and toxins and the invisible processes that take place to make this possible. (7) (8) (9)

Mary Miss

Mary Miss is an artist and a sculptor who uses a site's history, ecology, or unnoticed environmental aspects to create large-scale public art. The combination of sculpture, architecture, landscape architecture, and art are used as a framework for Mary Miss's designs. Some issues that Mary Miss focuses on when creating art pieces are water resources, the movement of water, and how it can reduce water erosion. One of the goals of Mary Miss's artwork is to make a statement about sustainability to the public, and to educate people on environmental issues so that positive action can be taken. One of Mary Miss's projects, Broadway 1000 Steps, focuses on the variety of systems that are part of our cities. Some of these include transportation, public health, history and preservation, biodiversity, and climate change. Other issues include land, energy, water, waste, and air. She uses various elements to represent these specific issues in an interactive, unique way that will engage and educate the public. Some engaging elements consist of mirrors, green vertical poles, pavement markings, visual quantifications, walking maps, short text blurbs, and audio elements. These techniques spark interest and raise public awareness. One element in particular caught my attention, the use of a walkable diagram pointed out different directions, such as connections to drinking water sources, power plants, and the directional source of air pollution from other locations.



Aerial Plan



Plan: 137th Street test hub

This aerial plan shows sites where markings were placed around Montefiore Park. The primary topics at 137th Street included air, water, waste, life, energy, and food.

Mary Miss's designs relate to my thesis in the way she uses different elements to get the public's attention and educate them on the important issues in the environment and the environmental challenges that society faces today. An important aspect that I plan to incorporate into my thesis design is to create an outdoor space that makes learning more interactive, interesting, and unique.(10) (11)



Mapping Hubs



Developing hubs along Broadway:

Each hub will have a coordinator to gather site information and make contact with community groups.

Of the twenty hubs of Broadway: 1000 Steps, seven are in preliminary stages of development:

- Bowling Green
- Canal Street
- Union Square
- 112th Street
- 137th Street
- Broadway Bridge - Harlem River
- 240th Street

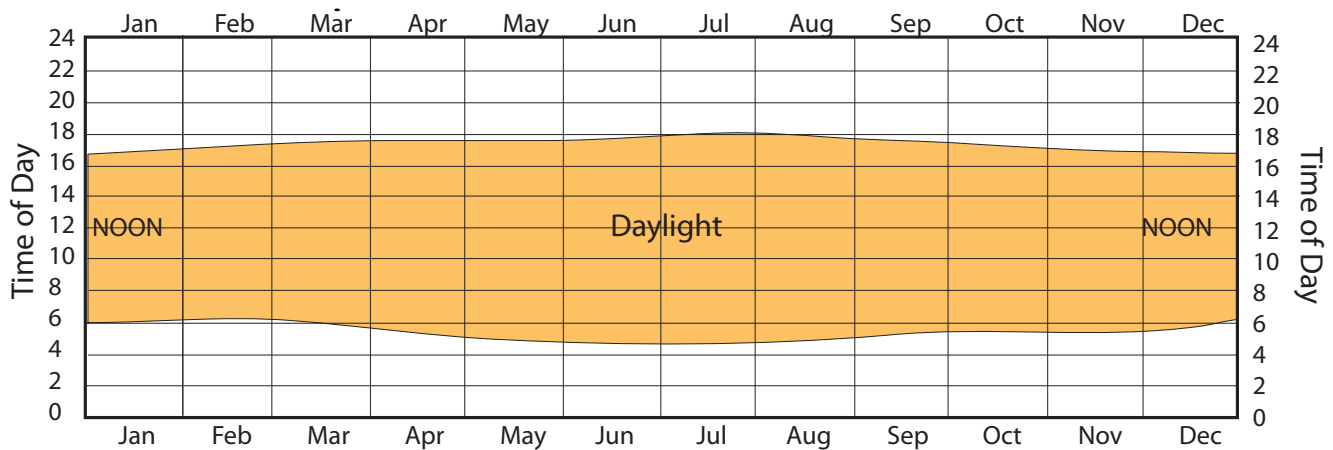
Hubs along Broadway



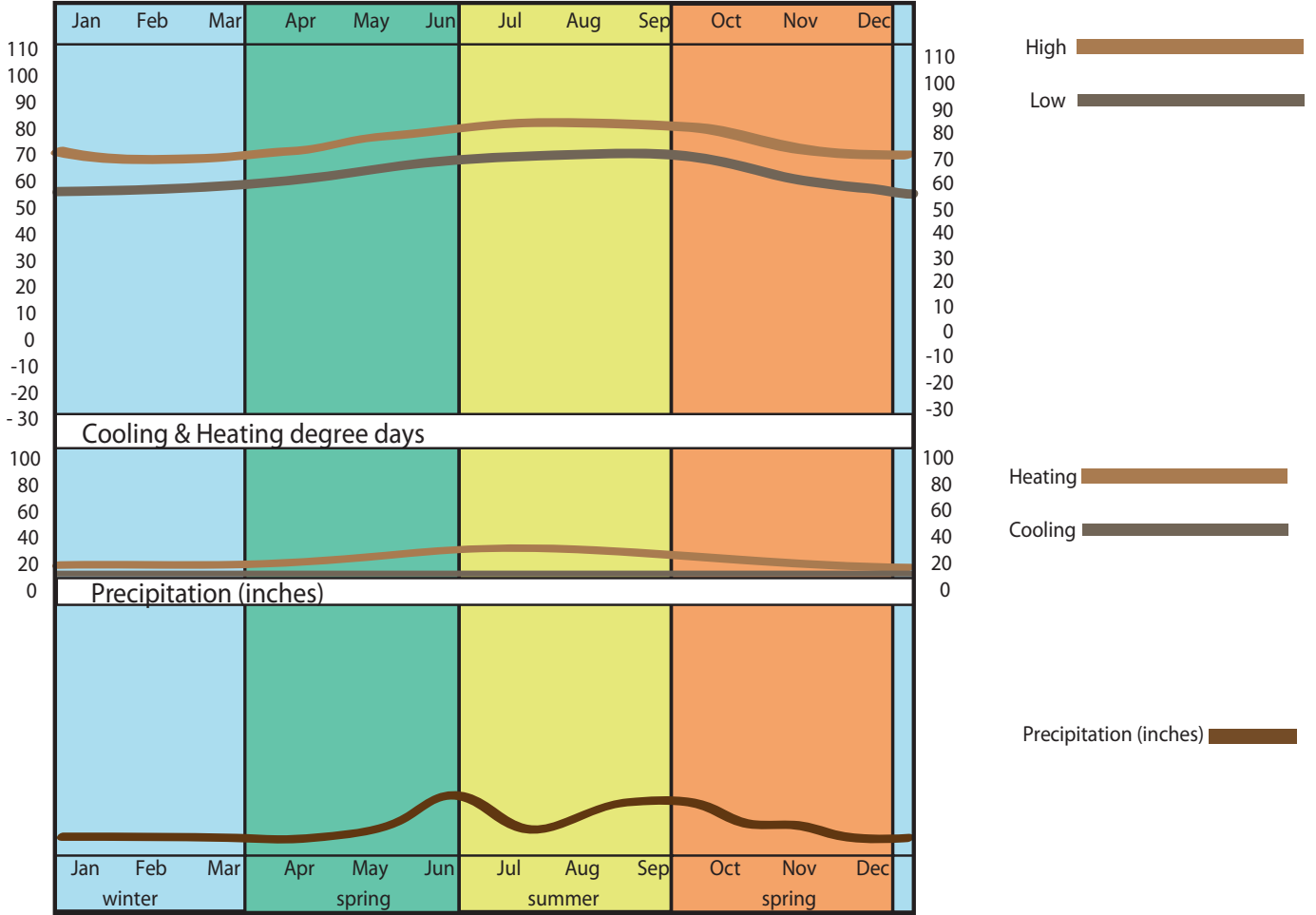
Climate Mapping

NOAA Station Id: FL085658 Latitude: 25°47'00N Longitude: 080°08'00W Elevation: 5'

Climate (Average Weather) Data														
Statistic	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum Temperature	°F	62.6	63	66.4	69.8	73.8	76.7	78.3	78.3	77.6	74.5	70.1	65	71.34
Maximum Temperature	°F	73.2	73.4	75.3	78.5	82.1	85.5	87	87.2	85.9	82.5	78.4	74.8	80.32
Heating Degree Days		59	39	18	1	0	0	0	0	0	0	1	23	11.75
Cooling Degree Days		134	128	199	274	401	482	547	550	503	419	278	175	340.83
Monthly Precipitation	inches	2.44	2.14	2.2	2.81	4.9	6.9	3.63	5.44	6.31	4.53	3.32	1.98	3.88

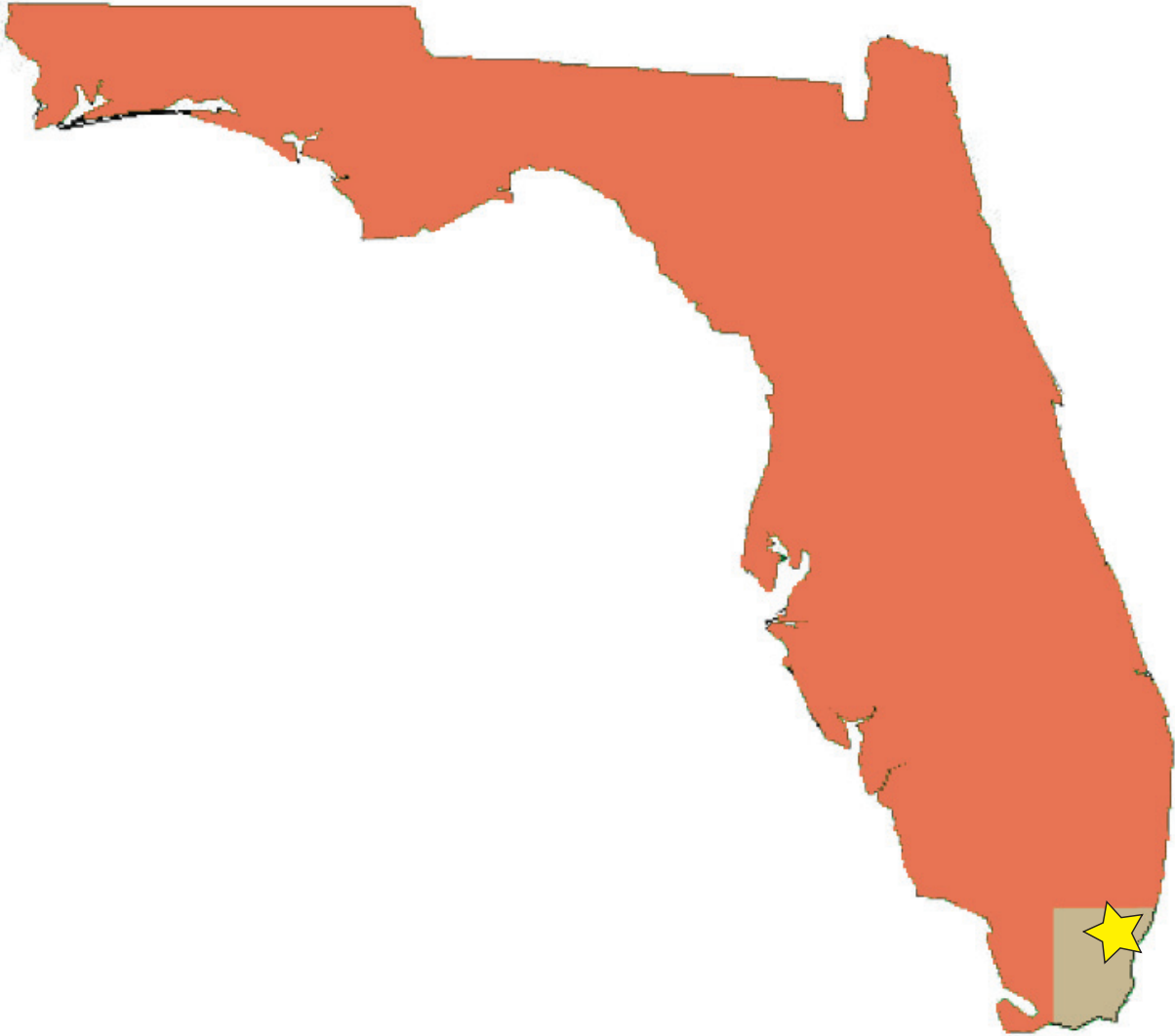


High & Low temperature F

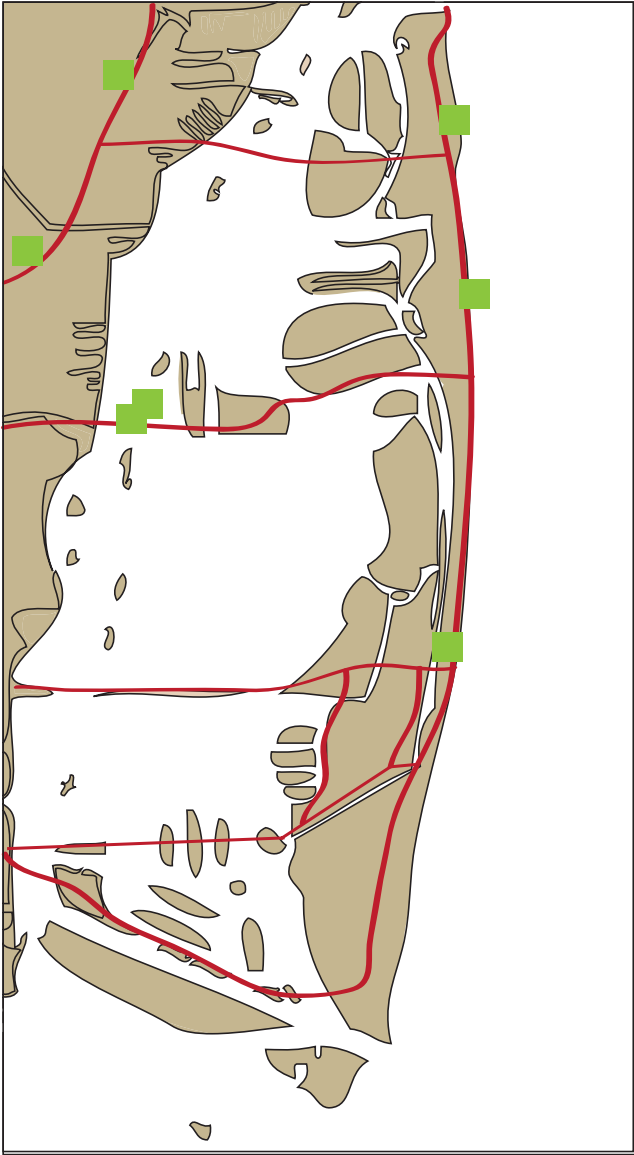
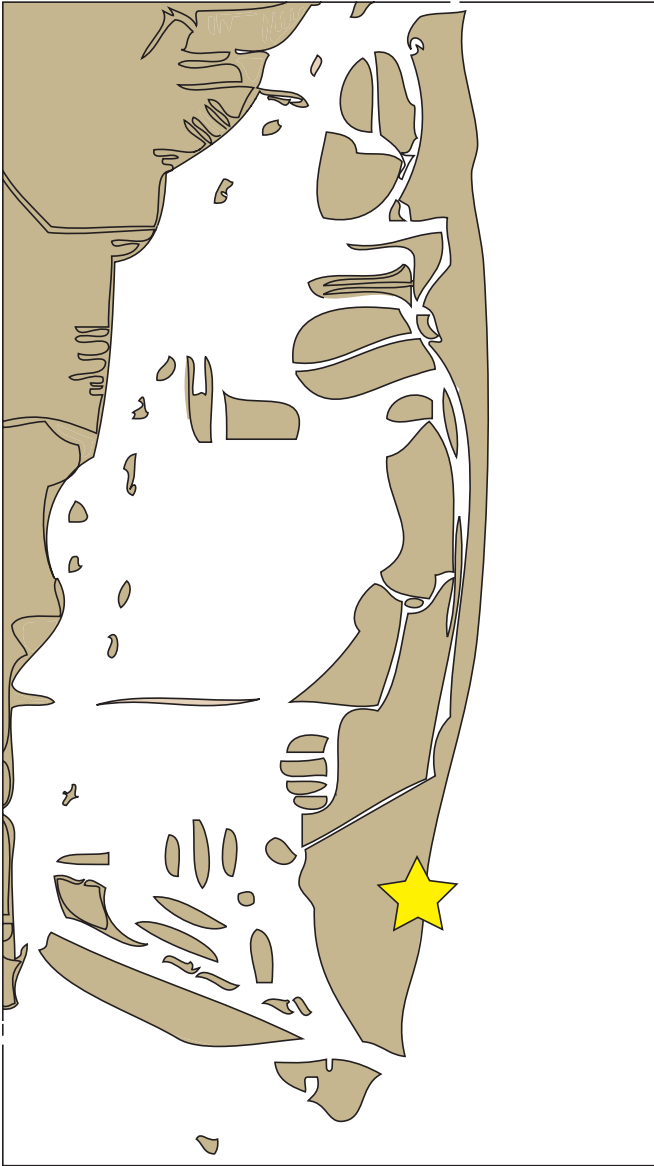


Site Analysis

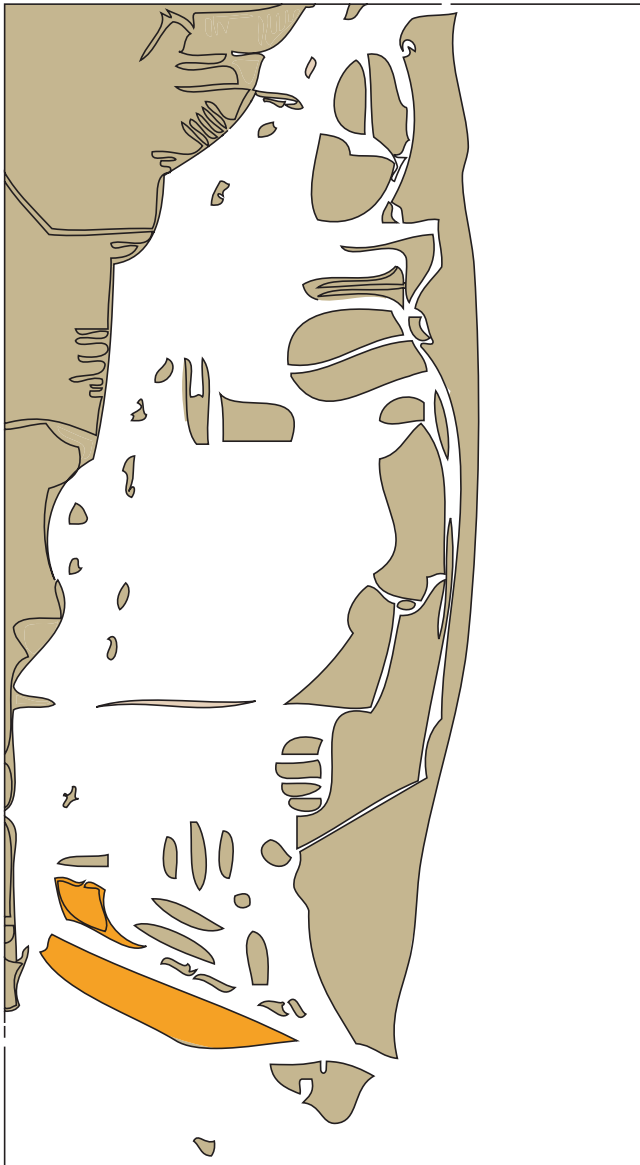
Miami-Dade County, Miami, Florida



Miami Beach, Miami-Dade County



— Highways
■ County Parks



■ Brownsfield Sites



- Colleges and Universities
- Private Schools
- Public Schools
- Daycare Centers

Site Uses

This site is currently the location of the Fienberg Fisher K-8 Center. This elementary school focuses on academic excellence, community involvement, social and emotional growth, art, international education, and technology, as well as being an eco-friendly school.

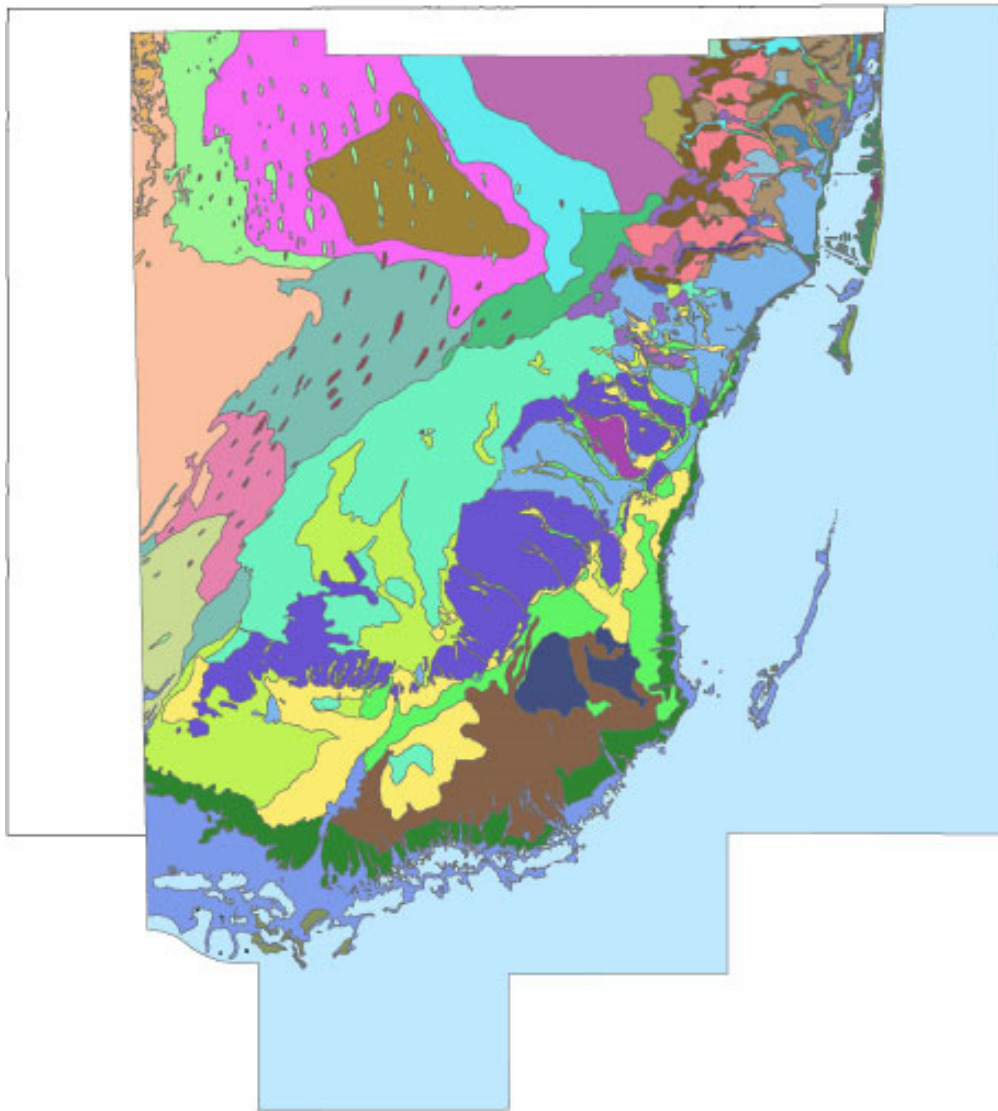



















































Business in the Area

Most of the places located in this area are industrial and commercial.
A few of these places include:

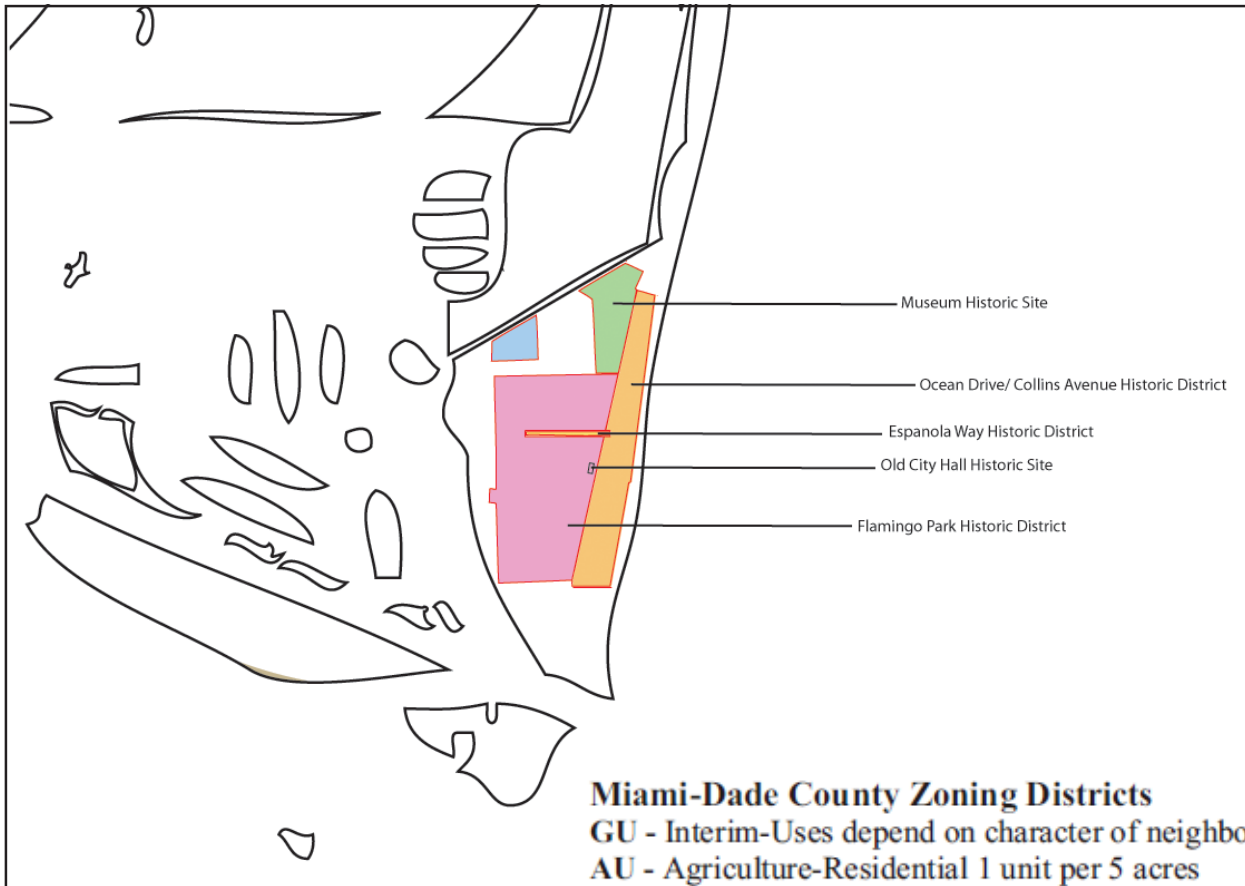
- Sushi Place
- Sandwich Shop
- Jerry's Famous Deli
- Thrifty Car Rental
- Surf Style
- BLT Steak Restaurant at the Betsy Hotel
- A La Foile Cafe
- Tapas Tintos
- Miami Ink Tatoos
- Juice and Java
- Starbucks
- Cardozo Hotel South

Miami-Dade County Soils Map



Legend			
	Water		None
SOIL			
	Aa		Lb
	Ba		Lc
	Ca		Le
	Ca/Ma		Lf
	Cb		Ma
	Da		Ma/Mc
	Da/Dd		Mb
	Db		Mc
	Dc		Oa
	Dd		Pa
	De		Pb
	Ea		Pc
	Eb		Pd
	Ec		Pe
	Ed		Pf
	Ee		Pg
	Ef		Ph
	Fa		Ra
	Ga		Rb
	Gc		Rc
	Ha		Rc/Ra
	La		Rd
	Land		Re
			Sa

Miami Beach Historic Districts



Miami-Dade County Zoning Districts

GU - Interim-Uses depend on character of neighborhood

AU - Agriculture-Residential 1 unit per 5 acres

EU-2 - 1 unit per 5 acres

EU-1C - 1 unit per 2.5 acres

EU-1 - 1 unit per acre

EU-5 - 1 unit per 25,000 ft. lot

EU-M - 1 unit per 15,000 ft. lot

RU-1 - 1 unit 7,500 ft. lot

RU-1M(b) - 1 unit 6,000 ft. lot

RU-1M(a) - 1 unit 5,000 ft. lot

RU-2 - 2 units 7,500 ft. lot

RU-TH - Townhouse-8.5 units per acre

RU-3M - Apt. Townhomes-12.9 units per acre

RU-RH - Rowhouses/Townhouses-12 units per acre

RU-4L - Apartments-23 units per acre

RU-4M - Apartments-35.9 units per acre

RU-4 - Apartments-50 units per acre

RU-4A - Apartments, Hotels-75 units per acre

BU-1 - Neighborhood Retail

BU-1A - Limited Retail

BU-2 - Special Retail

Site Location

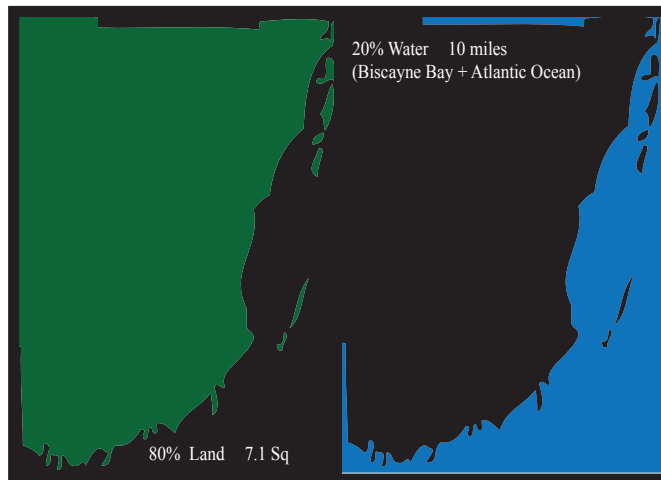


Miami, Florida

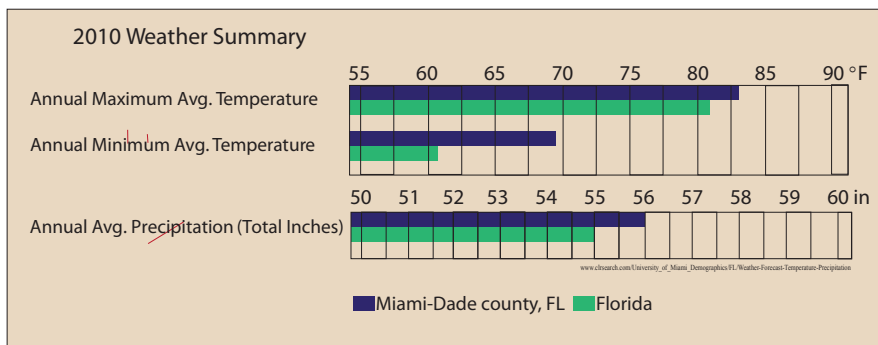
Demographics

Population 2010 for Miami-Dade County - 2, 496, 435

Miami-Dade county is made up of.....



Climate Data



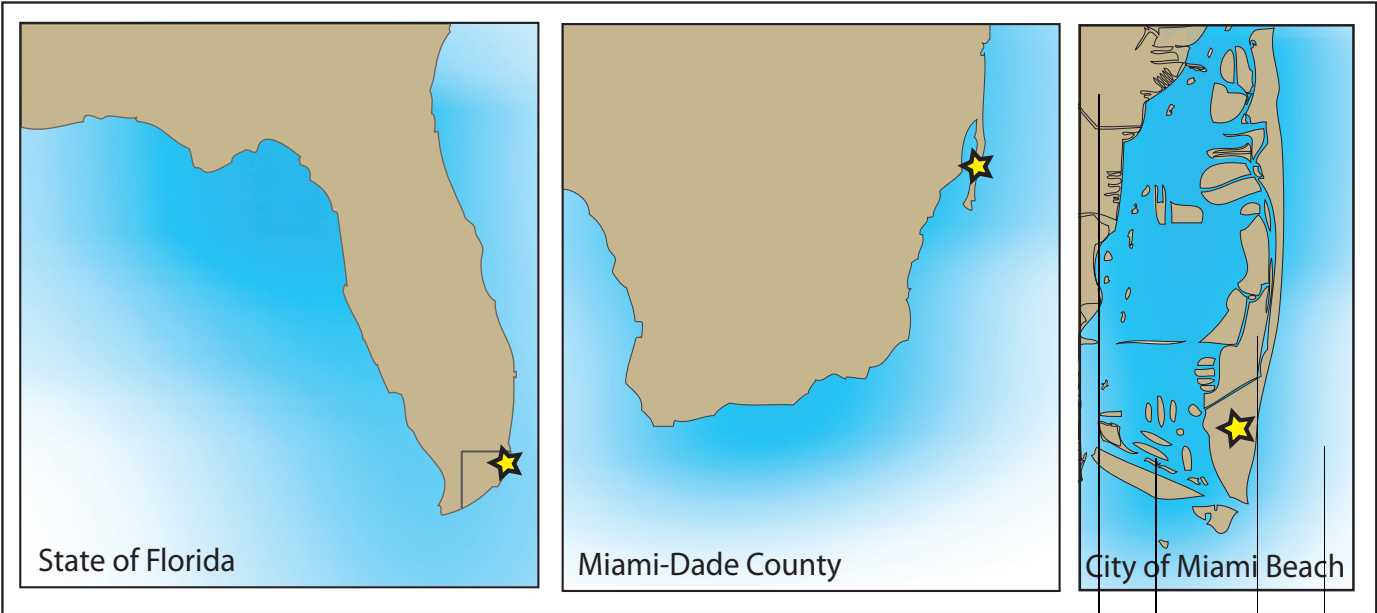
Because of Miami's tropical climate, the planting zone is 10b

Programming



This space will consist of an educational, interactive science classroom for elementary school children, as well as surrounding community members.

Site Information



State of Florida

Miami-Dade County

City of Miami Beach

Atlantic Ocean

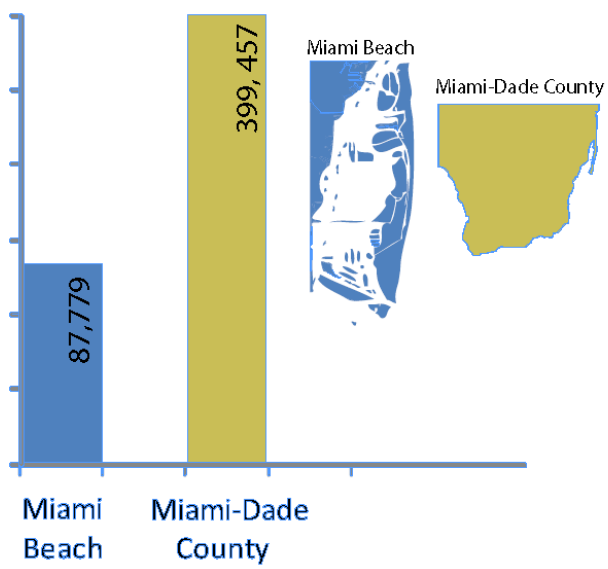
Miami Beach

Biscayne Bay

Miami

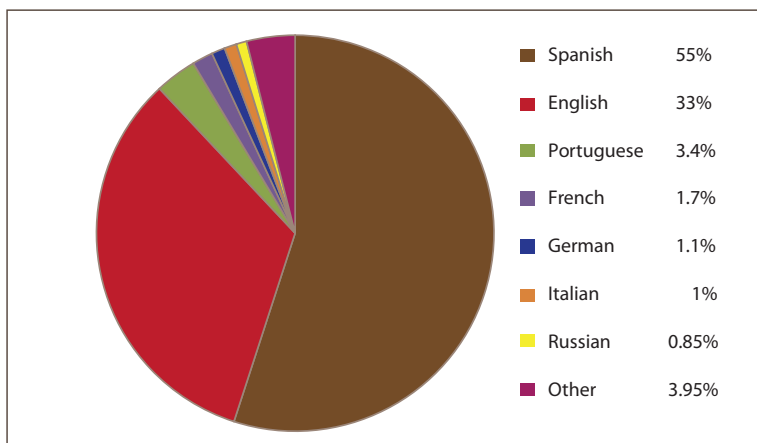
Population Demographics

Total Population



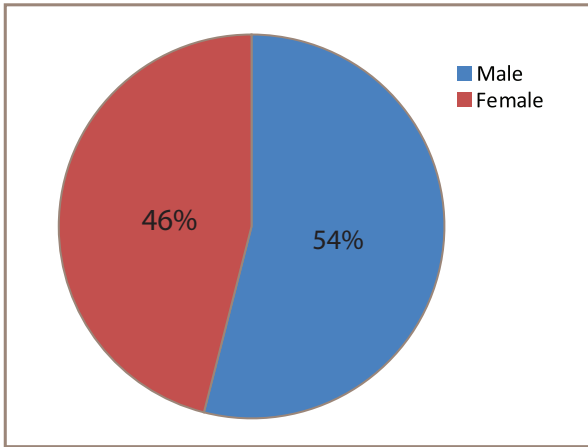
Languages

Based on the population diversity there are several common languages spoken in Miami Beach.

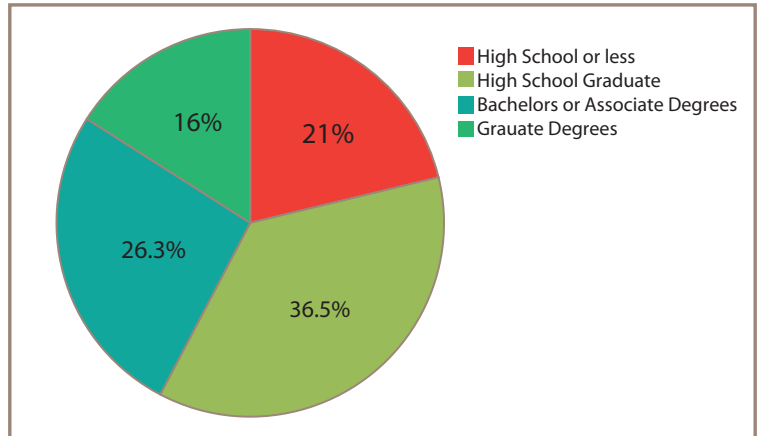


<http://www.movoto.com/neighborhood/fl/miami-beach/33139.htm>

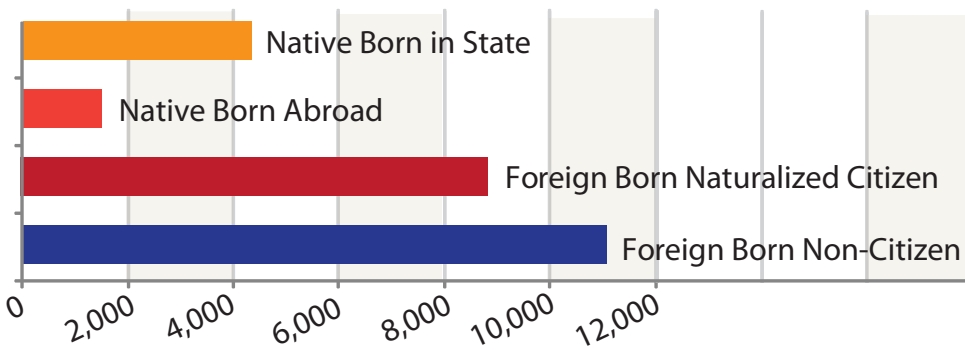
Population by Sex



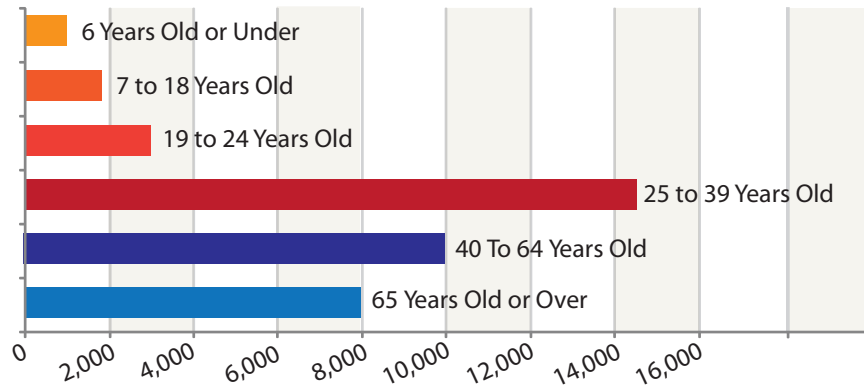
Population by Education Level



Citizenships by Birthplace

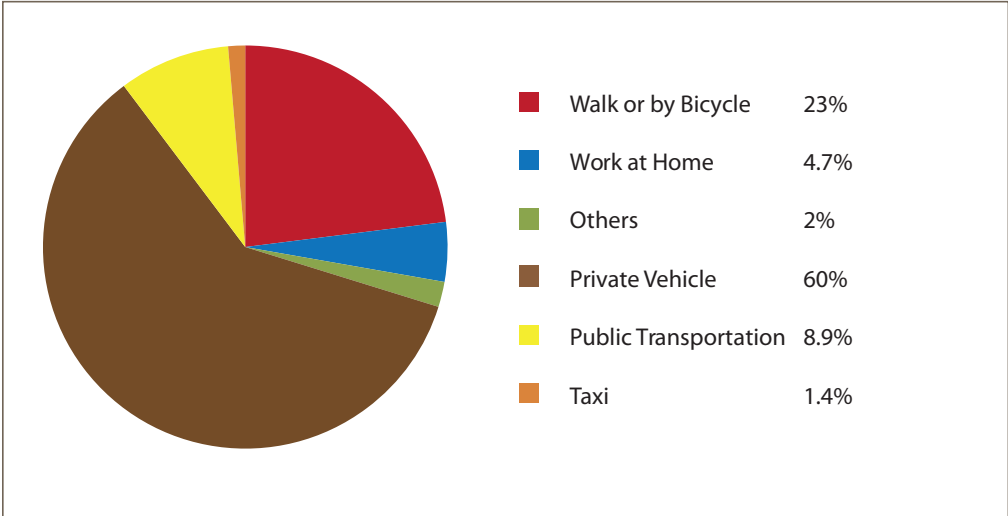


Population by Age



Public Transportation

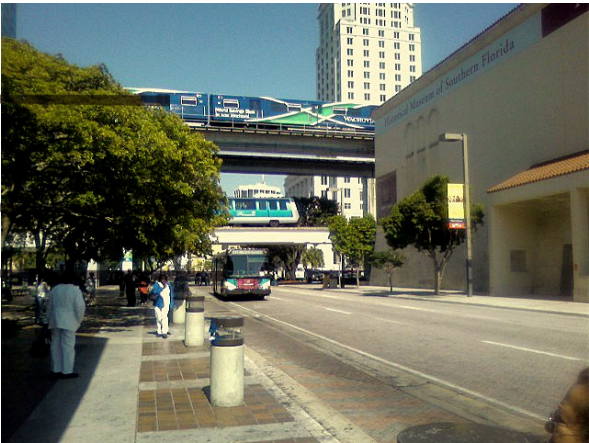
Means of Transportation to work



Metrorail

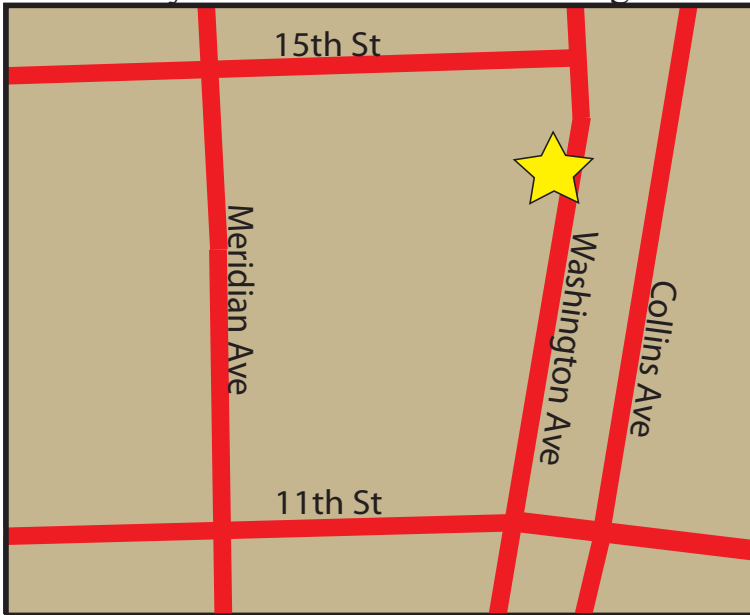
Metromover

Metrobus



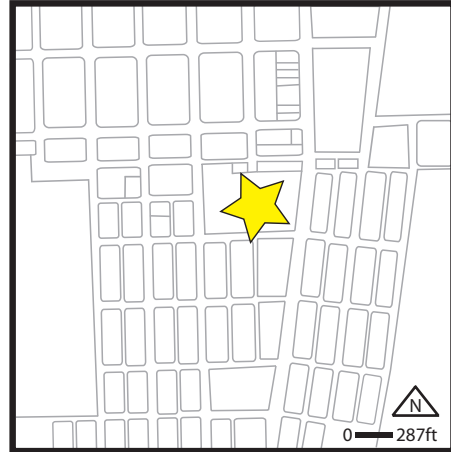
Site Location

Elementary School Fienberg Fischer



1420 Washington Avenue, Miami Beach, FL 33139

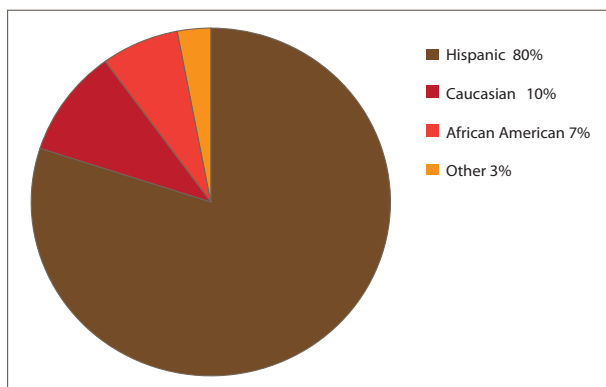
School Information



This site is currently the location of the Fienberg Fisher K-8 Center. This elementary school focuses on academic excellence, community involvement, social and emotional growth, art, international education, and technology, and is an eco-friendly oriented school. The site of the campus is historically preserved, and is surrounded by native vegetation. The School offers kindergarten through 8th grade.

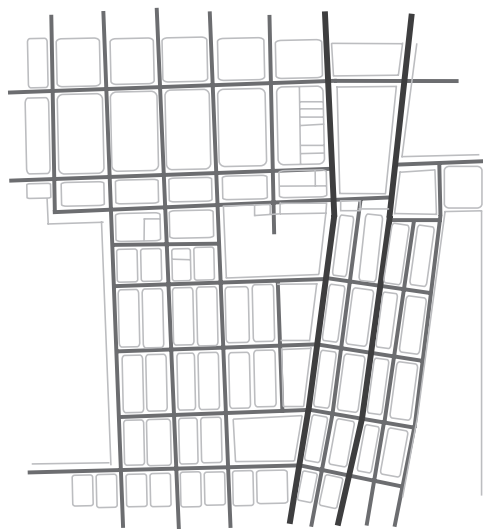
<http://fienberg.dadeschools.net/Eco%20Friendly.htm>

Student Population



Total Enrollment: 839

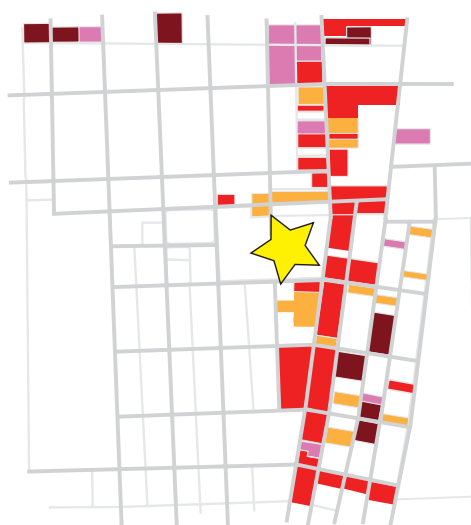
Surrounding Area



- institutional
- parks, preserves, conservation area



- single family
- two family duplexes
- residential-hotels, motels
- low density multi-family
- high-density multi-family



- commercial shopping
- office
- airports
- vacant

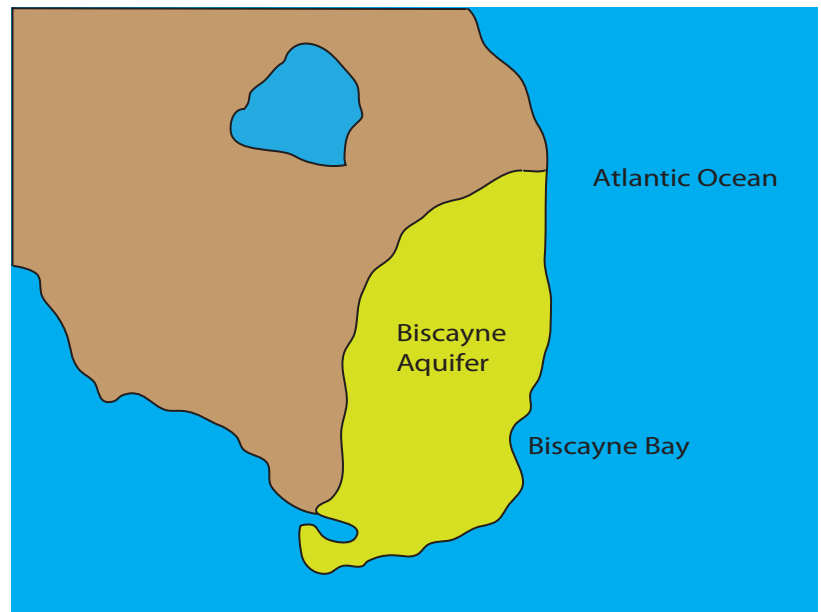
Water Supply

The Biscayne Aquifer

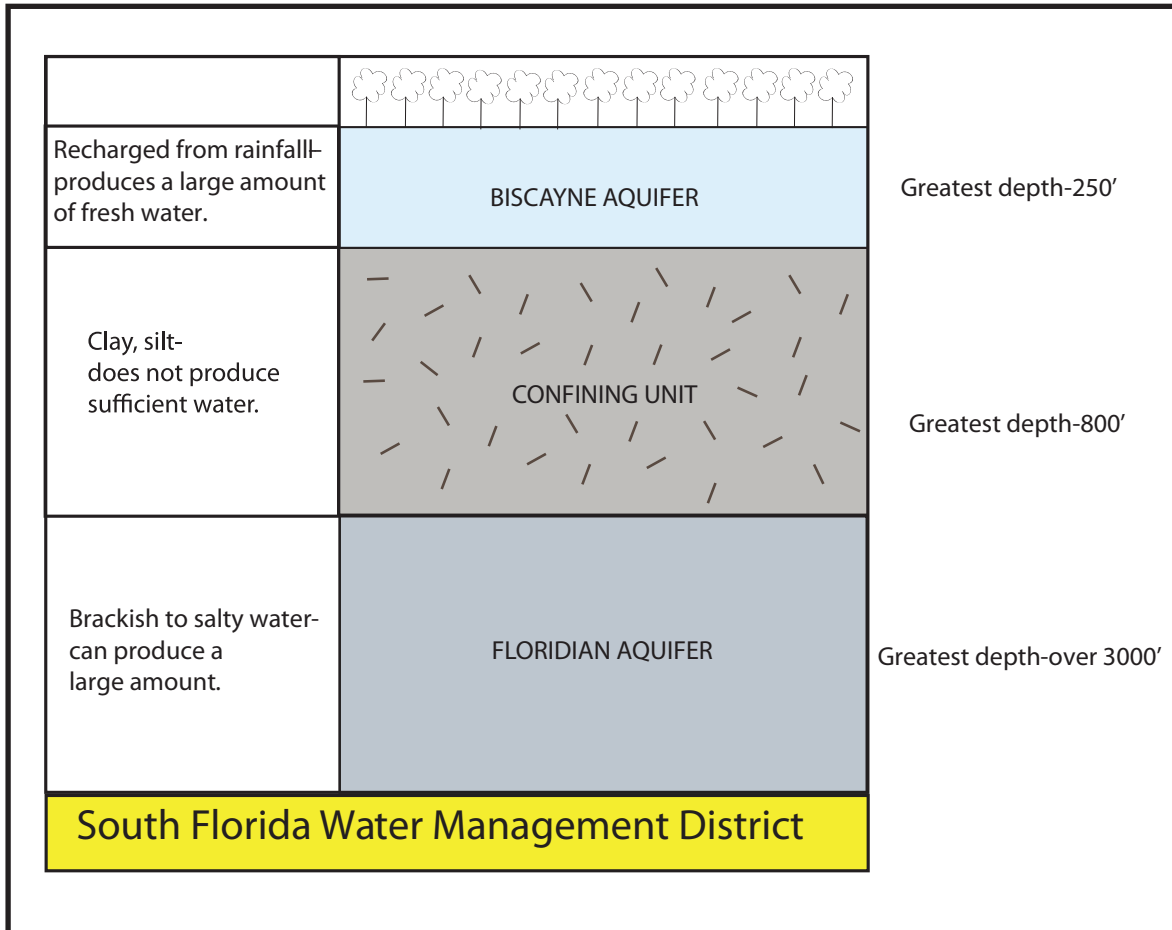
Miami-Dade's source of water is ground water from wells. The wells withdraw solely from the Biscayne Aquifer.

Location:

The Biscayne aquifer is located just below the earth's surface in south Florida. It is made out of porous rock with tiny cracks and holes. The water seeps in and fills these tiny cracks and holes. This water provides virtually all of the water used by south Florida residents, visitors, and businesses. The water usually travels in a southeast direction at a rate of about 2 ft per day. The flow rate of the water increases where large openings or man-made canals are present.



Approximately 330 million gallons of water are drawn everyday from the Biscayne Aquifer for consumer use.



Water Quality

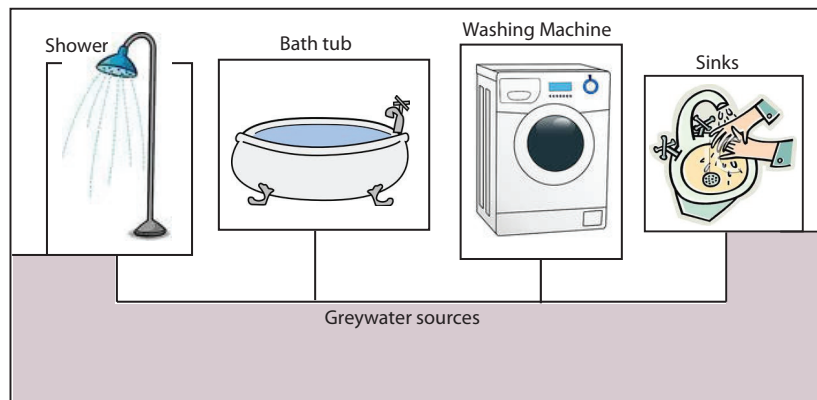
This water is generally clean due to the effects of natural filtration, but in 2009 the Department of Environmental Protection performed a Source Water Assessment on the system. Forty six potential sources of contamination were identified in this system, with low to moderate susceptibility levels.

	Health Risks:
Chlorine:	Affects the respiratory system, coughing and chest pain, water retention in the lungs, and irritation of the skin and eyes.
Arsenic	Irritation of the stomach, decreased production of red and white blood cells, skin changes and lung irritation, increased chances of skin cancer, lung cancer, and liver cancer development, infertility and miscarriages with women, heart disruptions and brain damage in both men and women.
Barium:	Breathing difficulties, increased blood pressure, heart rhythm changes, stomach irritation, muscle weakness, changes in nerve reflexes, swelling of brains and liver, kidney and heart damage.
Copper	Irritation of the nose, mouth, and eyes, headaches, stomachaches, dizziness, vomiting and diarrhea, liver and kidney damage and even death.
Fluoride:	Can cause death at very high concentrations. Low concentrations cause eye and nose irritations.
Lead:	A rise in blood pressure, kidney damage, miscarriages, disruption of nervous systems, brain damage, declined fertility, diminished learning abilities of children, behavioral disruptions in children, such as aggression, impulsive behavior, and hyperactivity.
Nickel:	Higher chances of developing of lung cancer, nose cancer, larynx cancer, and prostate cancer, sickness, dizziness, lung embolism, respiratory failure, birth defects, asthma and chronic bronchitis, and heart disorders.
Sodium:	Skin, eye, nose, and throat irritation, sneezing and coughing. Difficulty breathing, coughing, and chemical bronchitis. Contact to the skin may cause itching and permanent damage. Contact with eyes may result in permanent damage and loss of sight.
Uranium:	Damage to the kidney cells, kidney failure, increased risk of cancer and possibly death.
Radium:	Teeth fracture and anemia. Increased exposure can lead to cancer.

Greywater Sources:

Surrounding schools, residential, commercial, and office

- *Bath Water
- *Shower Water
- *Washing Mashine



Plant species that treat Greywater: Zone 10b

Common Duckweed
Lemna minor



Water Hyacinth
Eichhornia crassipes



Bearded Iris
Iris germanica



Virginia Willow
Itea virginica



Blue Flag
Iris virginica



Duck Potato
Sagittaria lancifolia



Golden Canna
Canna flaccida



Pickerelweed
Pontederia cordata



Leather Fern
Acrostichum danaeifolium



Baker's Cord Grass
Spartina bakeri


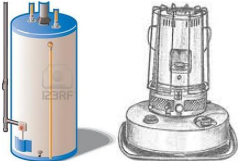
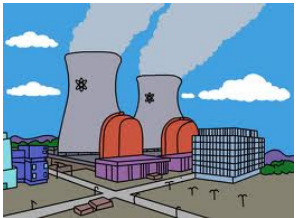




Air Quality

Air Quality Index:		Air Quality Index	
Percentage of days with good air quality:	88	0 - 50	Good
Percentage of days with moderate air quality:	12	50 - 100	Moderate
Percentage of days with unhealthy air quality:	0	100 - 200	Unhealthy
Maximum AQI level in 2003	116	200 - 300	Very Unhealthy
		300 - 500	Hazardous

2003 Summary of Pollutant Concentrations:		
Pollutant	NAAQS Standard	Highest Recorded Concentration
Carbon monoxide		
1-hour average	35 ppm	6.3 ppm
8-hour average	9 ppm	3.6 ppm
Nitrogen dioxide		
Annual arithmetic mean	0.053 ppm	.01 ppm
Ozone		
1-hour average	0.12 ppm	.1 ppm
8-hour average	0.08 ppm	.09 ppm
PM-25		
24-hour average	65 ug/m3	28 ug/m3
Annual arithmetic mean	15 ug/m3	9.4 ug/m3
PM-10		
24-hour average	150 ug/m3	50 ug/m3
Annual arithmetic mean	50 ug/m3	27 ug/m3
Sulfur dioxide		
3-hour average	0.50 ppm	.006 ppm
24-hour average	0.14 ppm	.004 ppm

Causes and risks of toxins found in the air

	Caused by:	Health risks:
Carbon monoxide		Headaches, dizziness, nausea, unconsciousness, and inhibits the blood's ability to carry oxygen to body tissues, including vital organs such as the heart and brain.
Nitrogen dioxide		Eye, nose, and throat irritation, impaired lung function, and increased respiratory infections in young children.
Sulfur dioxide		Effects on the respiratory system, and aggravation of existing heart disease.
Ozone		Irritation of the respiratory system, premature death, asthma, bronchitis, heart attacks, and harmful effects on the respiratory systems of animals.
PM10 and PM25 (Particle Matter)		Asthma, lung cancer, cardiovascular issues, birth defects, and premature death.

Plant species that improve air quality: Zone 10b

Rubber Plant
Ficus elastica



Castor Bean
Ricinus communis



Boston Fern
Nephrolepis exaltata



English Daisy
Bellis perennis



Ivy Geranium
Pelargonium pelta-



Janet Craig Dracaena
Dracaena deremensis



Peace Lily
Spathiphyllum wallisii



Weeping Fig
Ficus benjamina



Kimberly Queen
Nephrolepis obliterated







Site Location:



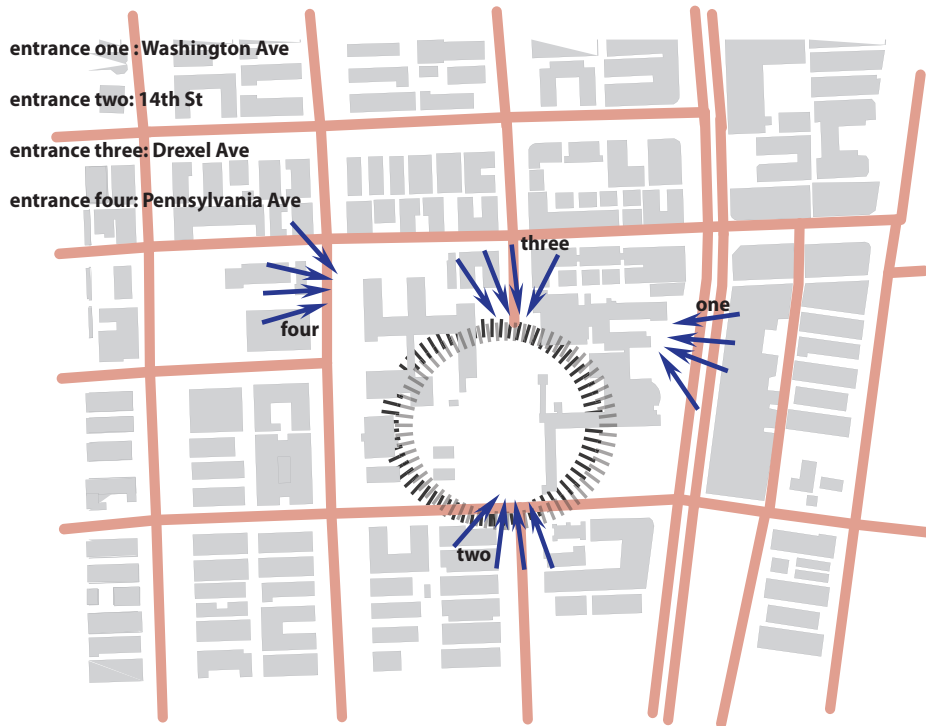
 1420 Washington Ave, Miami Beach, FL

Site Location + Surrounding Area

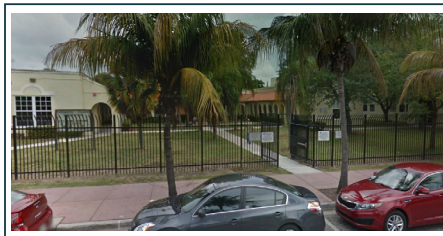
-  : institutional
-  : commerical shopping
-  : low- density multi family
-  : high- density multi family



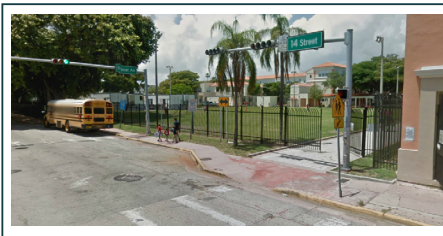
Site Entrances



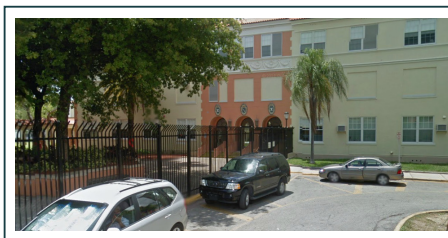
entrance one: Washington Ave



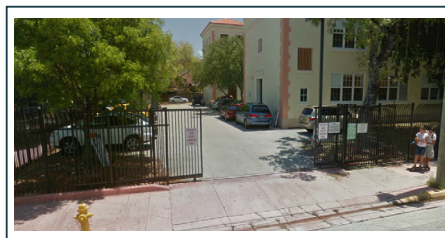
entrance two: 14th St



entrance three: Drexel Ave



entrance four: Pennsylvania Ave



Design Approach

- + Design to educate students and community members about the benefits of phytoremediation.
- + Incorporate the use of phytoremediation as part of the daily educational experience.
- + Demonstrate how phytoremediation can improve the quality of greywater produced in a school.
- + Identify how phytoremediation can assist in enhancing air quality.
- + Develop an understanding of how stormwater can indicate the level of toxins in our environment.
- + Use design elements to enhance student learning.



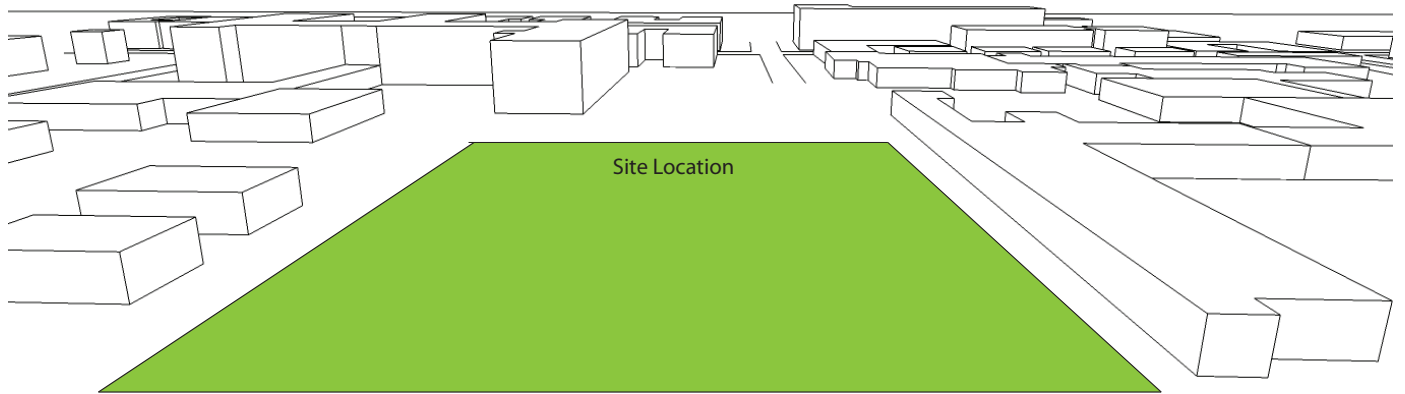


Narrative

Everybody benefits from a healthy environment and all of us can make a contribution if we understand more about the concept of phytoremediation. Therefore, designing a site that incorporates education about the benefits of phytoremediation, and how it works, is extremely important.

When school children are given the opportunity of learning about phytoremediation as part of their daily educational experience, they are more likely to incorporate phytoremediation in their later lives. Making phytoremediation fun and interactional enhances the entire educational experience.

Building Heights



Site Images

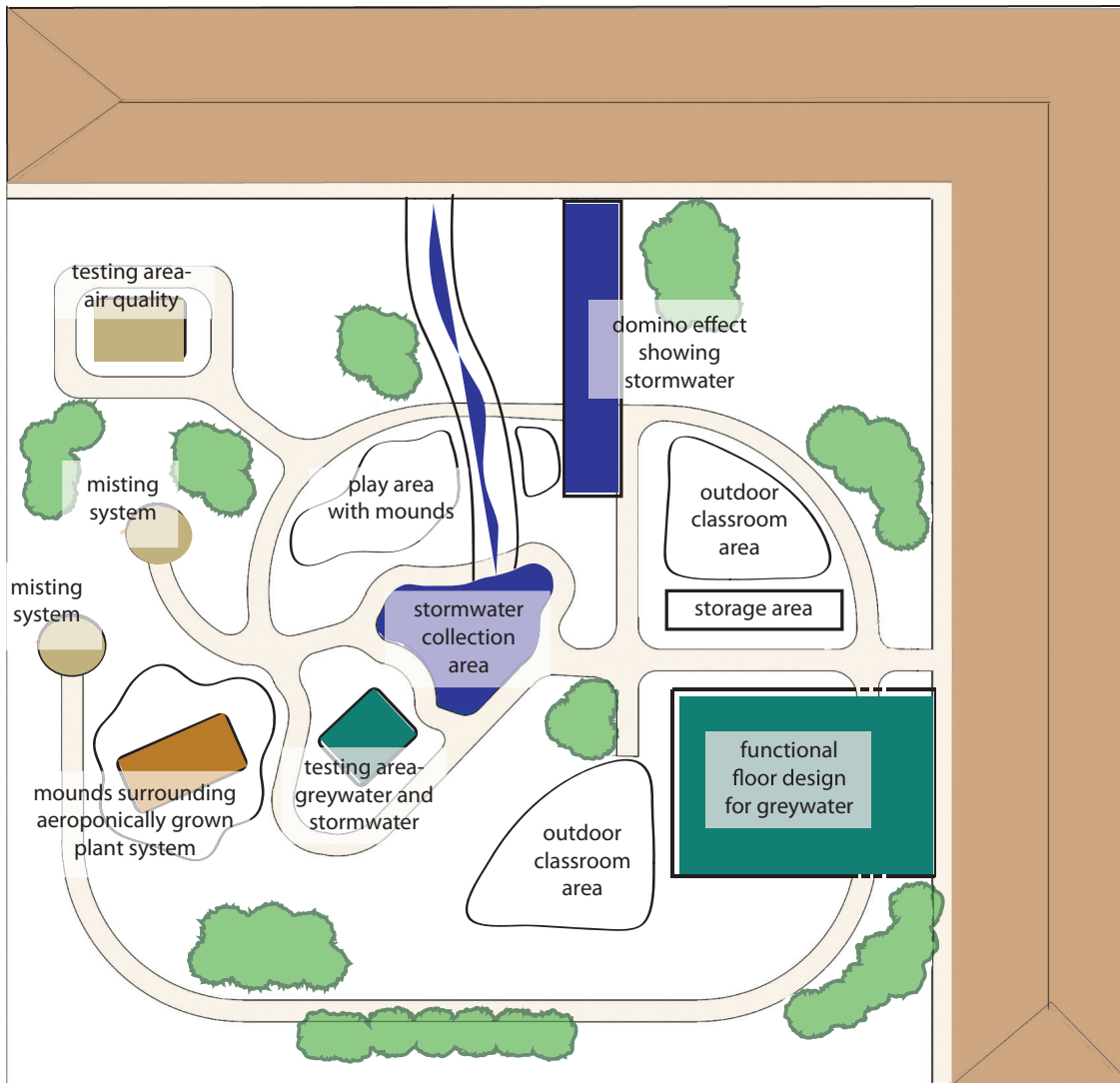


View from 14 St. across the site to the neighboring building

View from 14 St. toward school buildings

Walkway separating site from school building

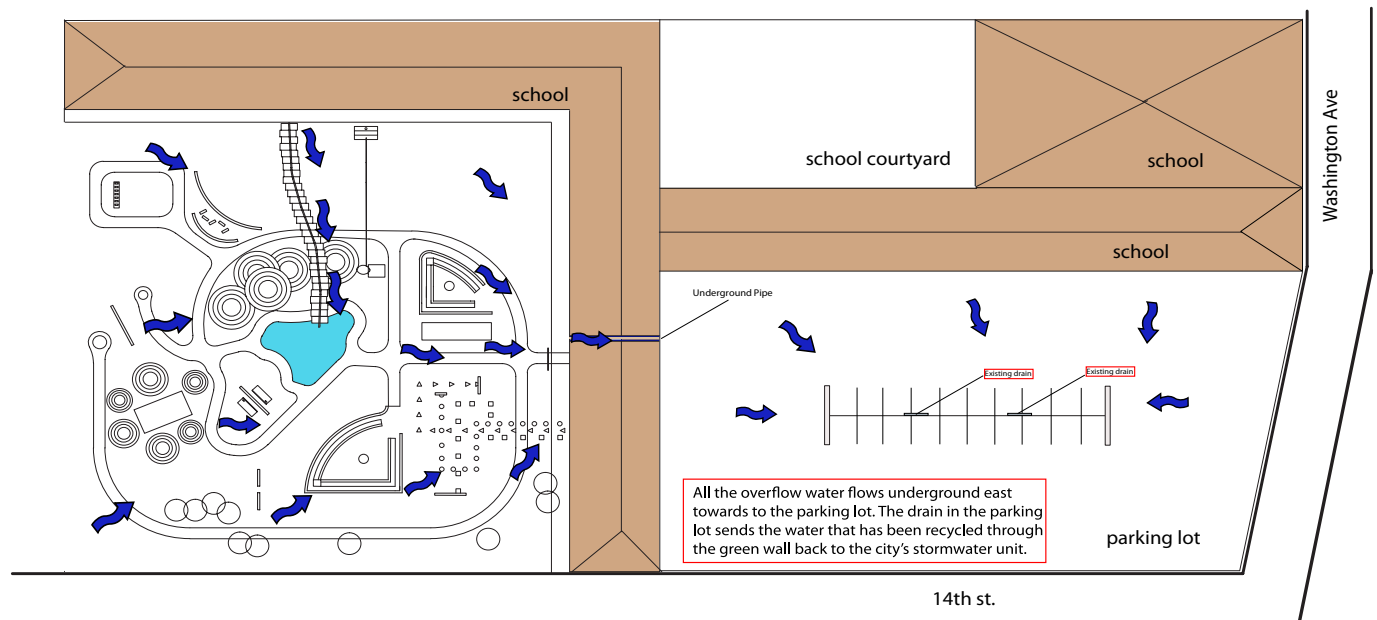
Schematic Plan



The educational experience covers four areas:

- Phytoremediation/Root System
- Greywater
- Stormwater
- Air Quality

Stormwater Flow



Curriculum

Curriculum

Four areas of educational focus:

**Phytoremediation/
Root System**

Greywater

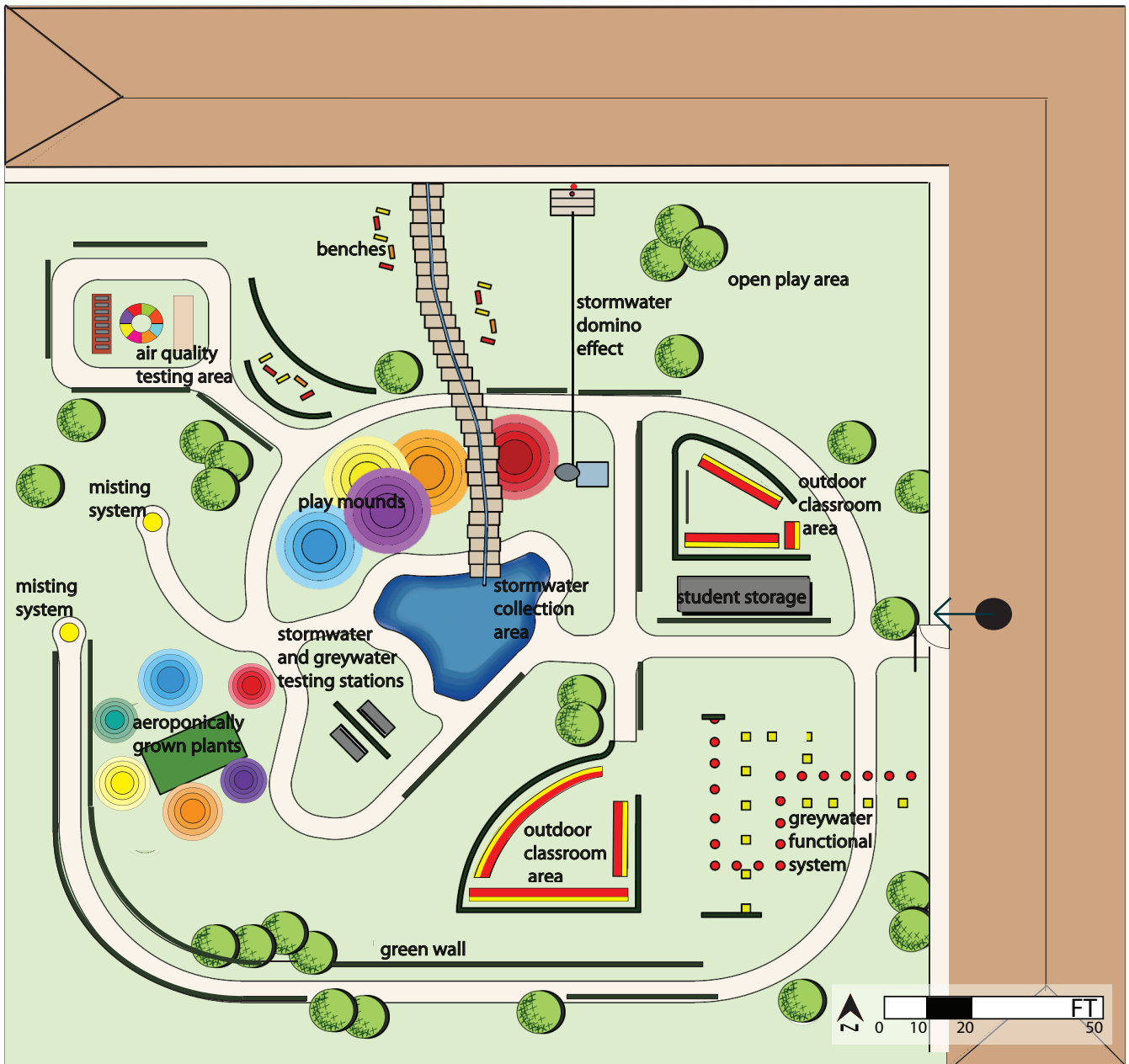
Stormwater

**Air Quality/
Green Walls**

Fienberg Fisher teaches kindergarden through 8th grade. This curriculum is for grades 1-5

Grades/Ages:	Learning Concepts:
1st grade: 6-7 years old	What is Phytoremediation Why is Phytoremediation important What is Stormwater
2nd grade: 7-8 years old	Why is Greywater important to clean How is Greywater cleaned Benefits of cleaning Greywater What are Green Walls
3rd grade: 8-9 years old	How do green walls help Air Quality Benefits of Green Walls Where does Stormwater come from Where does Greywater go
4th grade: 9-10 years old	How is Greywater calculated How is Stormwater calculated How do you collect Stormwater Benefits of collecting Stormwater
5th grade: 10-11 years old	How to test plants for toxins - Air Quality Amount of Greywater being cleaned How Phytoremediation works How do Green Walls work

Master Plan



Entrance to site from the school building



Materials – Permeable Paver Walkway



These permeable pavers will be used for the walkway. They will intrigue the school children to question how permeable pavers work.

Plant Choices

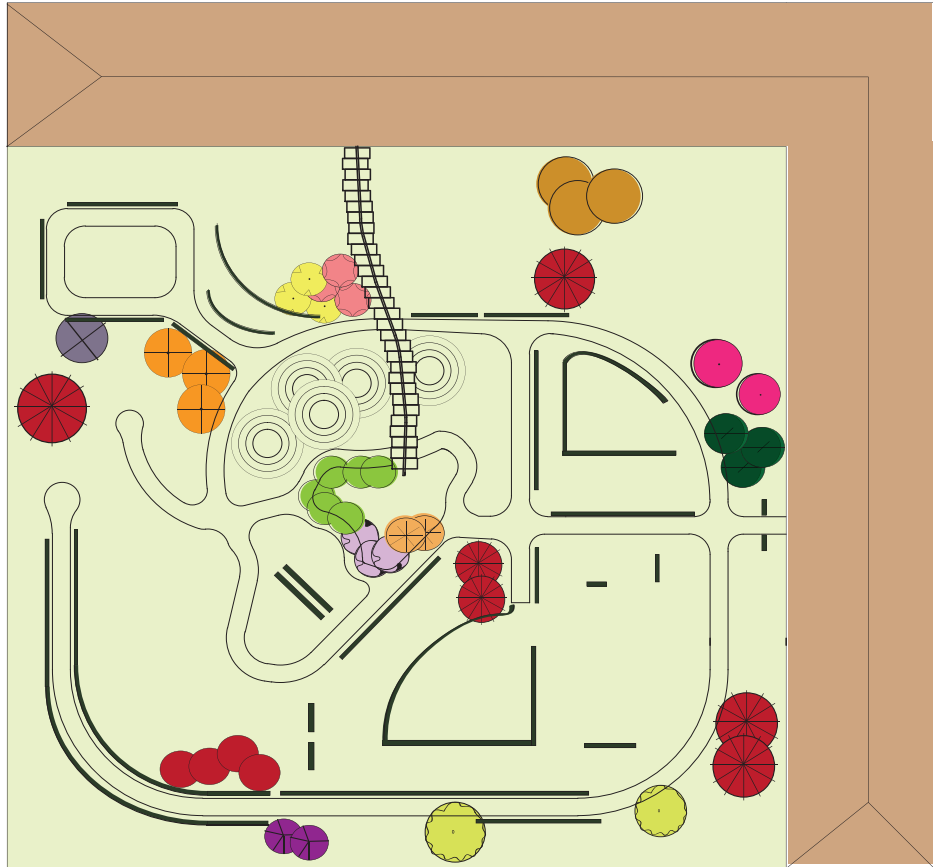
Plants that uptake toxins on the site and surrounding area

	Plants	● Planting Plan ● Green Wall		
Greywater >Arsenic (Occurs naturally in the environment) >Flouride (Naturally occurs in tap water) >Chlorine (Added to water to kill bacteria) >Lead (Found in plumbing pipes) >Formaldehyde (Found in household cleaning products)	The following plants are appropriate for planting zone 10b Baker's Cord Grass <i>Spartina bakeri</i> Bearded Iris <i>Iris germanica</i> Blue Flag <i>Iris virginica</i> Common Duckweed <i>Lemna minor</i> Duck Potato <i>Sagittaria lancifolia</i> Golden Canna <i>Canna fladccida</i> Leather Leaf Fern <i>Acrostichum danaeifolium</i> Pickerelweed <i>Pontederia cordata</i> Spider Plant <i>Chlorophytum comosum</i> Virginia Willow <i>Itea virginica</i> Water Hyacinth <i>Eichhornia crassipes</i>	● ● ● ● ● ● ● ● ● ●		
	Stormwater All toxins below are found in Asphalt >Petroluem >Polycyclic Aromatic Hydrocarbon (PAH) >Carbon >Sulfur >Nitrogren >Fuel Oil >Crude Oil	English Ivy <i>Hedera helix</i> Lavender Trumpet Vine <i>Clytostoma callistegioides</i> Leather Leaf Fern <i>Rumohra adiantiformi</i> Spider Plant <i>Chlorophytum comosum</i> Narrow Leaved Cattail <i>Typhha angustifolia</i> New Zealand Flax <i>Phormium tenax</i>	● ● ● ● ● ●	
		Air Quality >Benzene (Formed by natural process and human activity) >Polycyclic Aromatic Hydrocarbon (PAH) (Found in roofing tar) >Polychlorinated Biphenyl (PCB's) (Used until 1970's, still exist in the air) >Carbon monoxide (Formed from incomplete combustion of fuel) >VOC's (Released into the air as gases) >Arsenic (Caused from emission sources) >Cobalt (Occurs naturally) >Lead (Occurs naturally) >Manganese (Occurs naturally) >Nickel (Occurs naturally)	Boston Fern <i>Nephrolepis exaltata</i> Castor Bean <i>Ricinus communis</i> English Daisy <i>Bellis perennis</i> Ivy Geranium <i>Pelargonium peltatum</i> Janet Craig Dracaena <i>Dracaena deremensis</i> Peace Lily <i>Spathiphyllum wallisii</i> Rubber Plant <i>Ficus elastica</i>	● ● ● ● ● ● ●

Planting Plan

Planting Plan

-  Acacia choriophylla
-  Castor Bean
-  Common Duckweed
-  Duck Potato
-  Narrow Leaved Cattail
-  New Zealand Flax
-  Orange Cordia
-  Pickerelweed
-  Pink Floss Silk Tree
-  Queen's Crepe Myrtle
-  Red Powderpuff
-  Silver Trumpet Tree
-  Water Hyacinth



Plants

-  Acacia choriophylla Tamarindillo
-  Castor Bean Ricinus communis
-  Common Duckweed Lemna minor
-  Duck Potato Sagittaria lancifolia
-  Narrow Leaved Cattail Typha angustifolia
-  New Zealand Flax Phormium tenax
-  Orange Cordia Cordia sebastena
-  Pickerelweed Pontederia cordata
-  Pink Floss Silk Tree Chorisia specios
-  Queen's Crepe Myrtle Lagerstroemia speciosa
-  Red Powderpuff Calliandra haematocephalla
-  Silver Trumpet Tree Tabebuia caraiba
- Water Hyacinth Eichhornia crassipes

Green Wall Plants



Baker's Cord Grass *Spartina bakeri*



Bearded Iris *Iris germanica*



Blue Flag *Iris virginica*



Boston Fern *Nephrolepis exaltata*



English Ivy *Hedera helix*



Golden Canna *Canna fladccida*



Ivy Geranium *Pelargonium peltatum*



Janet Craig Dracaena *Dracaena deremensis*



Lavender Trumpet Vine *Clytostoma callistegioides*



Leather Leaf Fern *Acrostichum danaeifolium*



Peace Lily *Spathiphyllum wallisii*



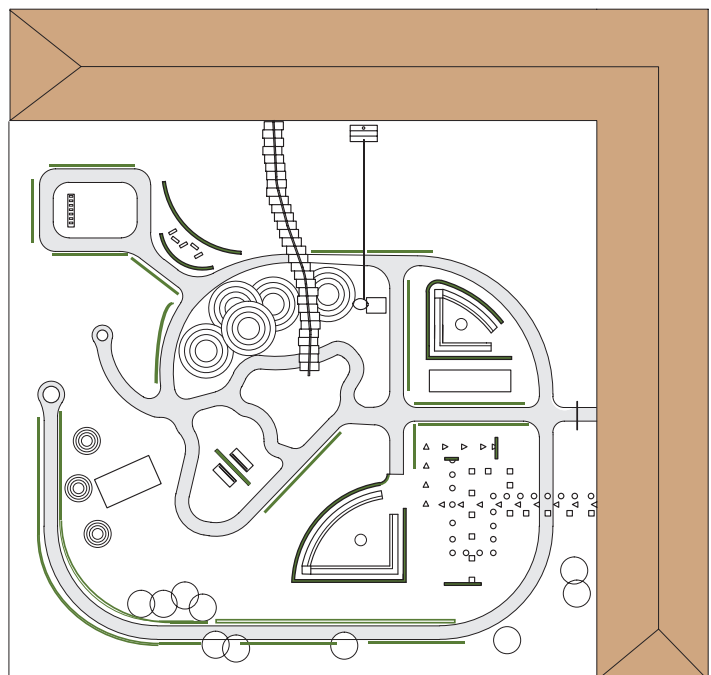
Rubber Plant *Ficus elastica*



Spider Plant *Chlorophytum comosum*



Virginia Willow *Itea virginica*



The four aspects of teaching about phytoremediation in an educational environment:

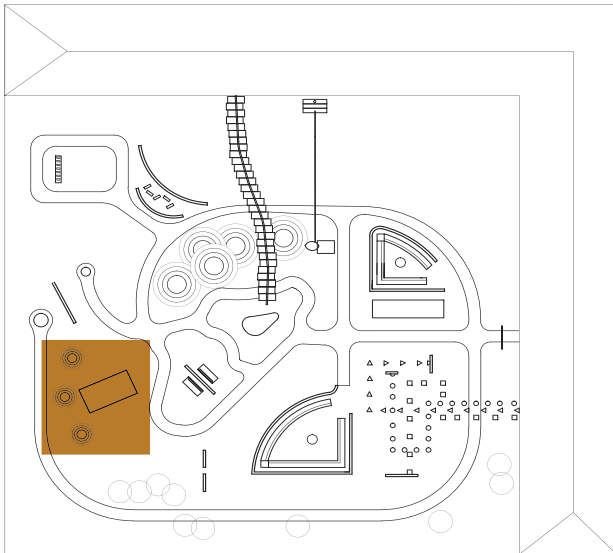
- I. **Phytoremediation**
- II. **Greywater**
- III. **Stormwater**
- IV. **Air Quality**

I. PHYTOREMEDIATION

School children learn best by seeing and doing.

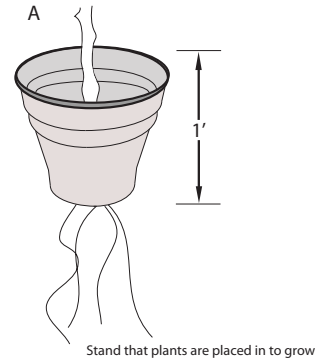
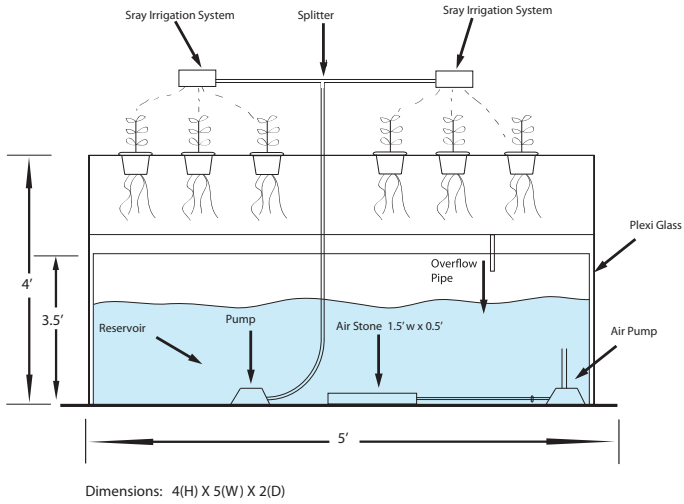
At the Fienberg Fischer Center the school children will learn about phytoremediation by interacting with aeroponically grown plants and experiencing the science of phytoremediation in action.

Location of Phytoremediation element on site



Construction Document of Aeroponic System

AEROPONIC SYSTEM



Phytoremediation Educational Element



II. GREYWATER

Greywater Math and Corresponding Green Walls

Greywater from Student hand-wash sinks
Florida law requires 1 sink per 30 students*

841 students /30 sinks = 28.03 i.e 29 sinks

Each sink uses 10 gallons/day from September- May (School Year)***

Each sink uses 1gallon/day from June-August (Vacation)

School Year usage/day = 29 sinks x 10 gallons/sink /day = **290** gallons generated

Vacation usage/day = 29 sinks x 1 gallon/sink/day = **29** gallons generated

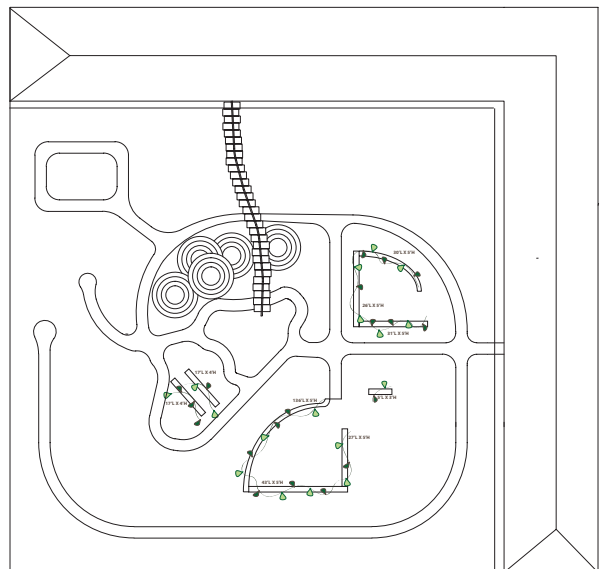
The design incorporates **3,072** sq ft of green walls that recycle greywater
x **0.09** gallons/sq ft = **276** gallons of water used by green walls**

95% of greywater is used by green walls

*Florida Department of children and families

**0.09 galucation derived from information on <http://www.gardenbeet.com/living-walls.html>

***http://wiki.answers.com/Q/How_much_water_does_the_sink_use_per_minute

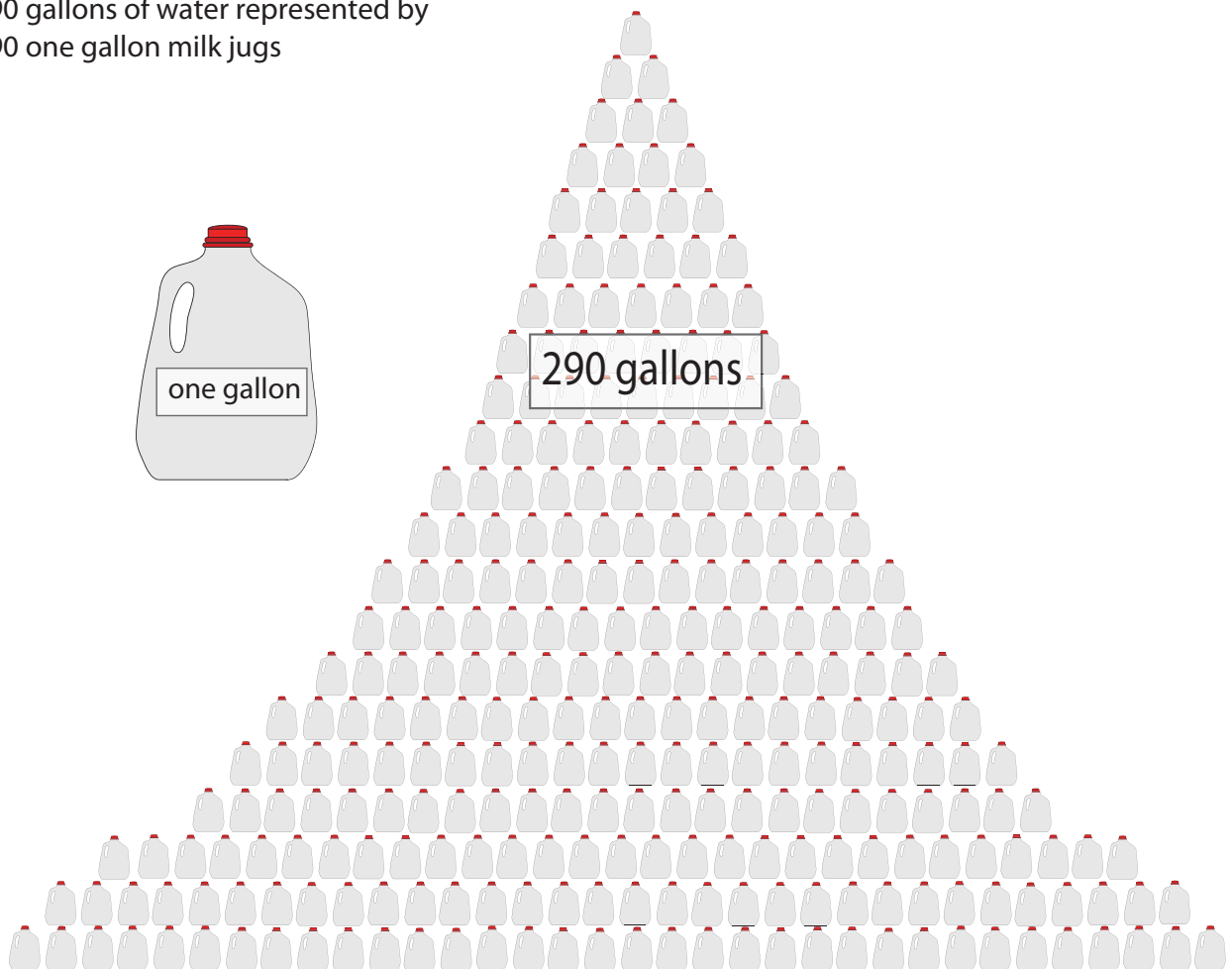


Visualize

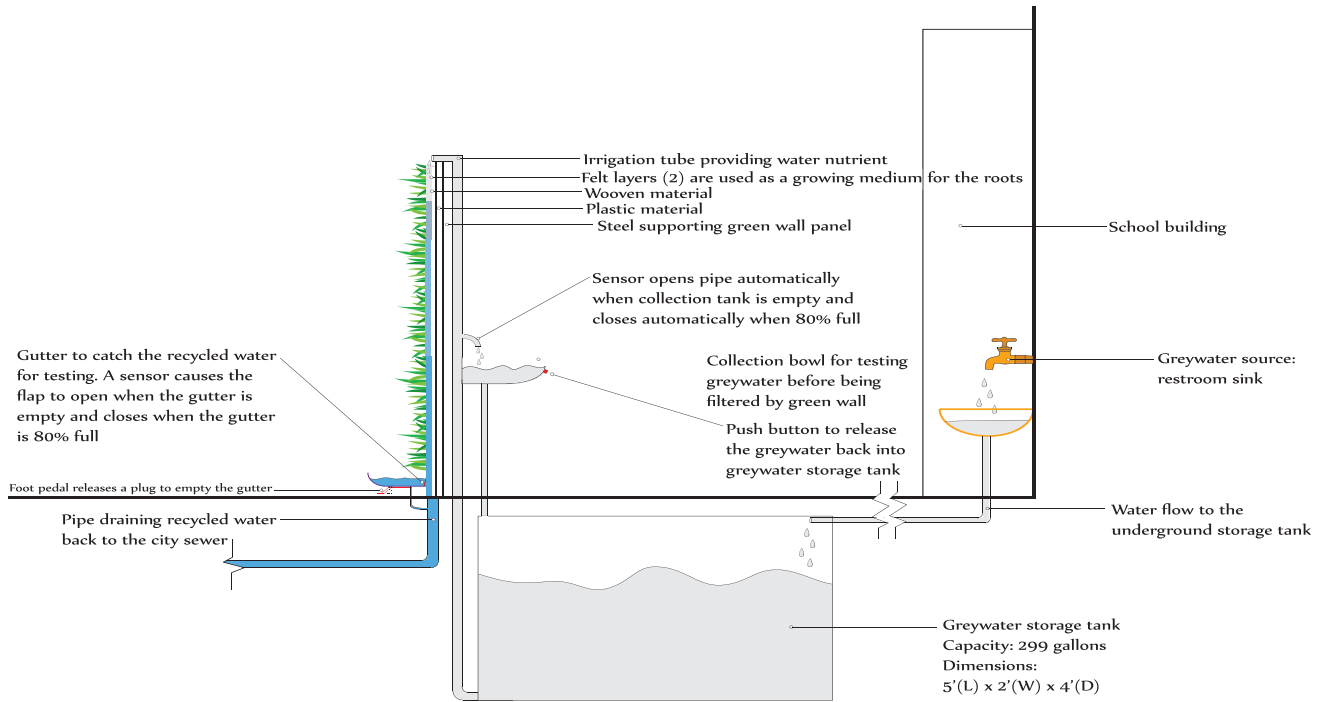
School Year usage/day = 29 sinks x 10 gallons/sink /day = **290** gallons generated

290 gallons of water represented by

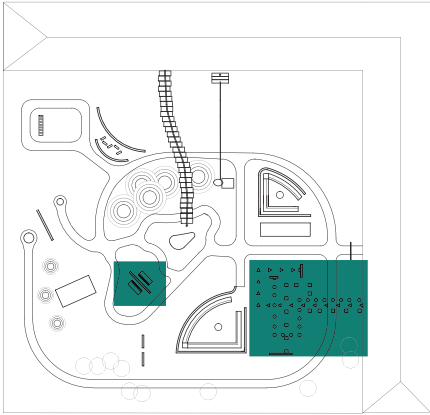
290 one gallon milk jugs



Section of Greywater System



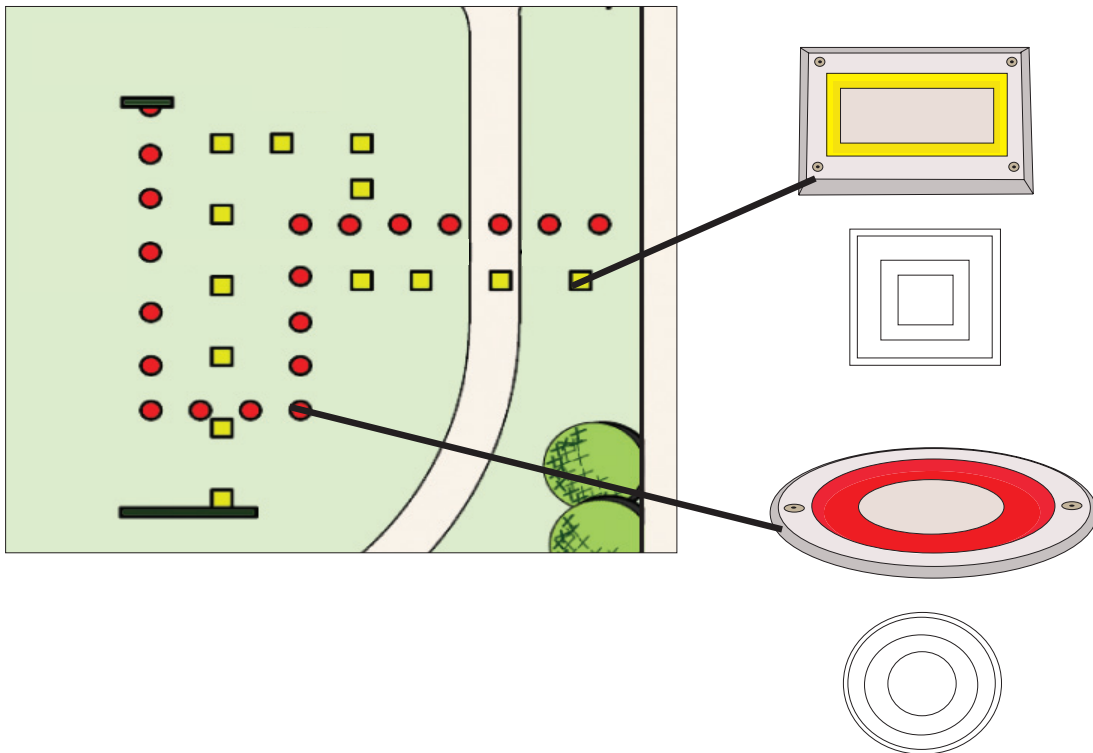
Location of Greywater Educational Elements



The first step in the phytoremediation process is demonstrated when the red light flashes. This indicates that the boy's bathroom sink is being used and greywater is flowing through the system. The yellow light flashes when the girl's bathroom sink is being used.

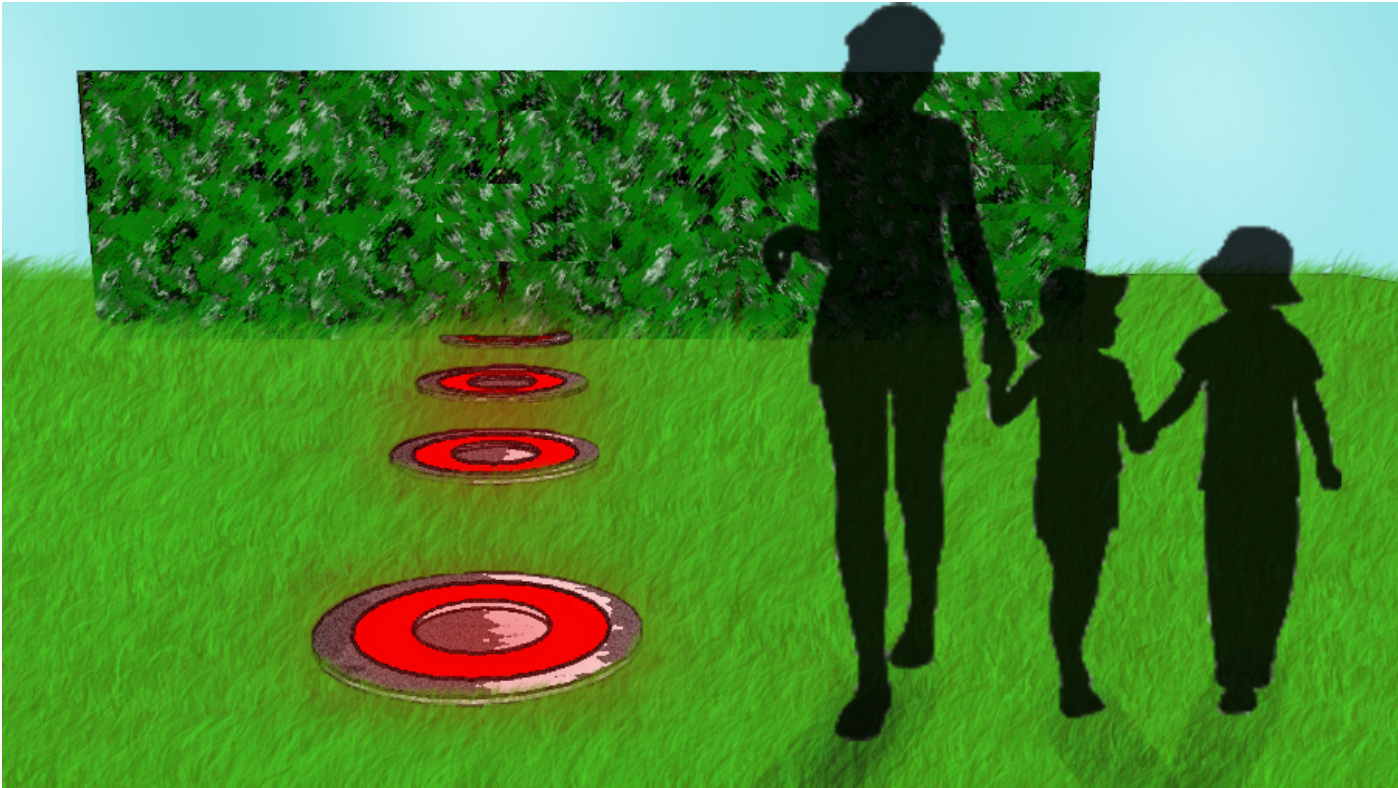
This highlights the educational aspect of a simple daily activity that produces greywater, having a scientific consequence through phytoremediation.

PlanView of Greywater Functional Lighting



- Lighting symbol to represent the use of a sink in the Girl's Bathroom
- Lighting symbol to represent the use of a sink in the Boy's Bathroom

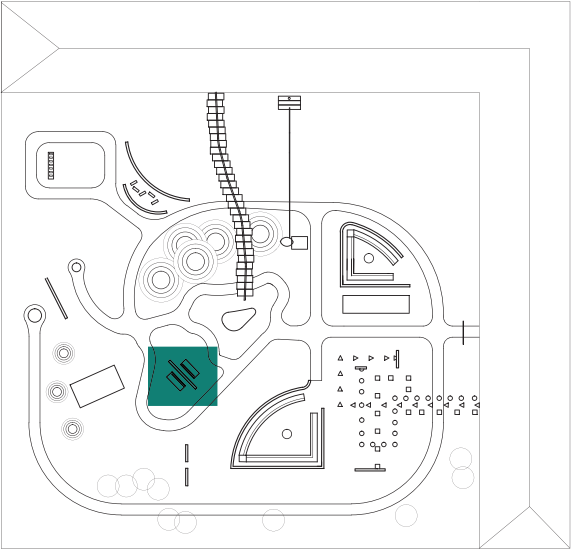
View of Greywater Functional Lighting Element



View of Greywater and Stormwater Testing Station



Location of Testing Station Element on Site



When greywater is removed from the collection bowl it is tested at this testing center which is designed to create a fun learning environment for the school children. The children can sit on the grass, or on tall stools in front of a green wall when they test the grey water and the recycled water while being able to see the physical results of the science at work.

Another part of the learning experience is to carry the stormwater in buckets to this testing area for testing purposes.

Supplies needed for testing water quality:

*enough supplies for 5-10 people at a time

>sample collection jar

>1 ph test tube

>1 dissolved oxygen vial

>2 temperature strips

>color chart

>pencils

>100 dissolved oxygen reagent tablets

>gloves

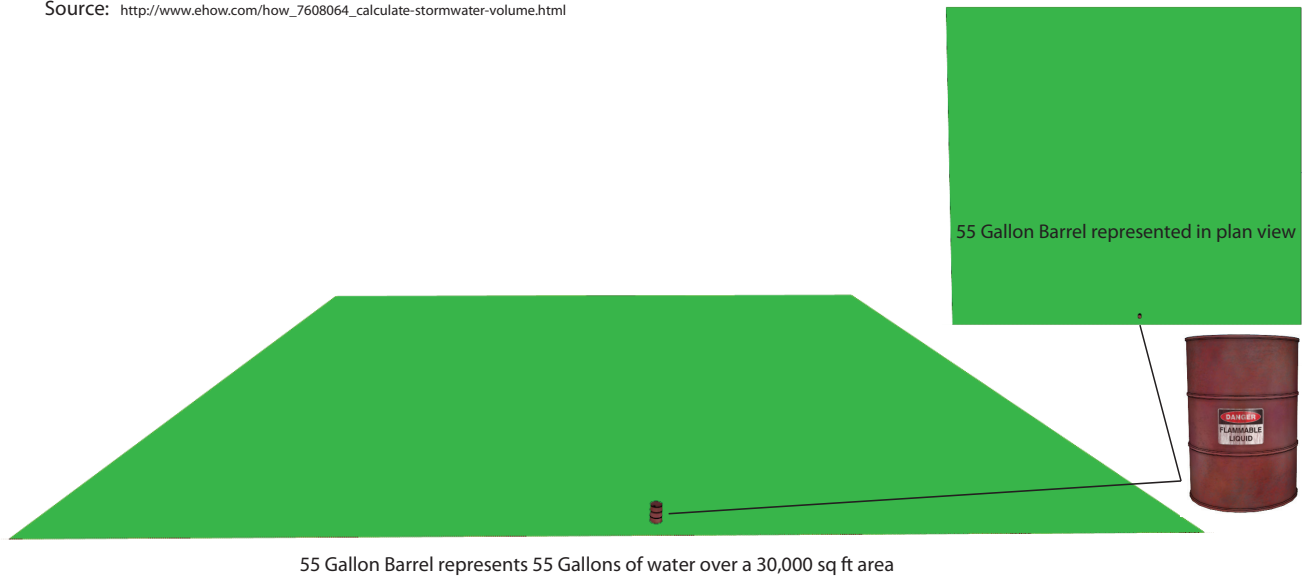
>hand wash station

III. STORMWATER

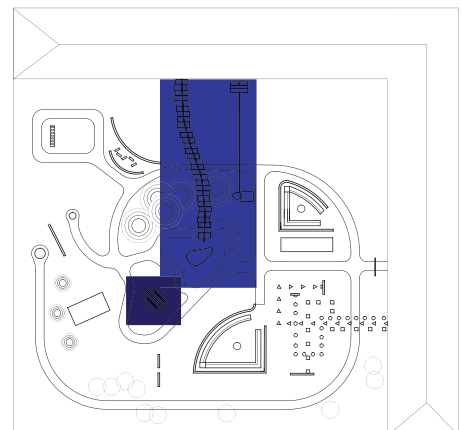
Stormwater Volume Calculation

- Average Monthly Rainfall: 5 Inches
- $5/30=0.16$ (Average Daily Rainfall)
- $0.16/12=0.0138$ (Average Daily Rainfall per foot)
- $0.0138 \times 30,000\text{sq ft}= 416.664$ (Stormwater Volume in Cubic Feet per day)
- $416.664/7.48 = 55.70$ gallons per day (Average Stormwater Volume of gallons per day over the **30,000** sq ft area.)

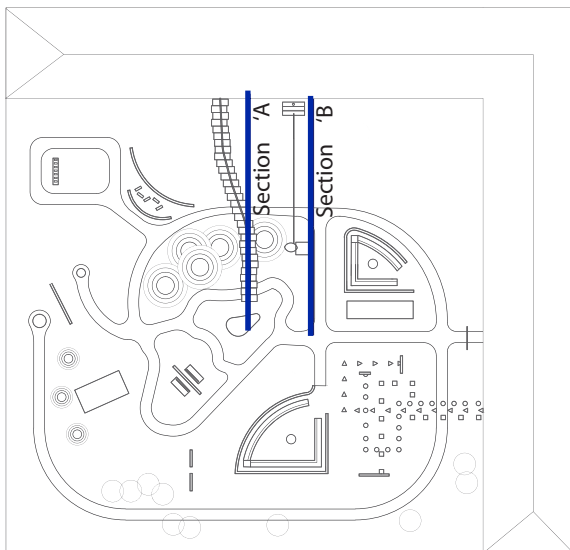
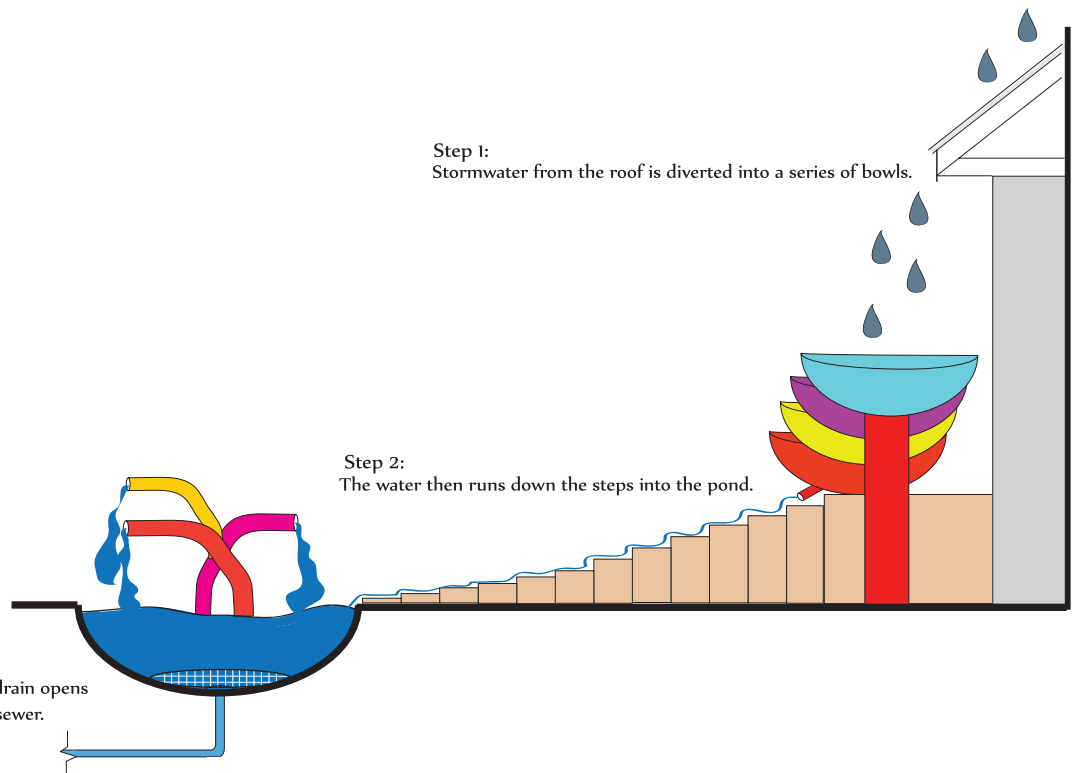
Source: http://www.ehow.com/how_7608064_calculate-stormwater-volume.html



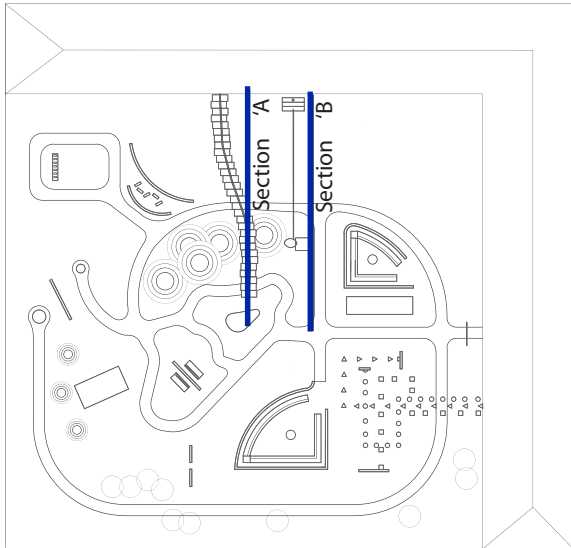
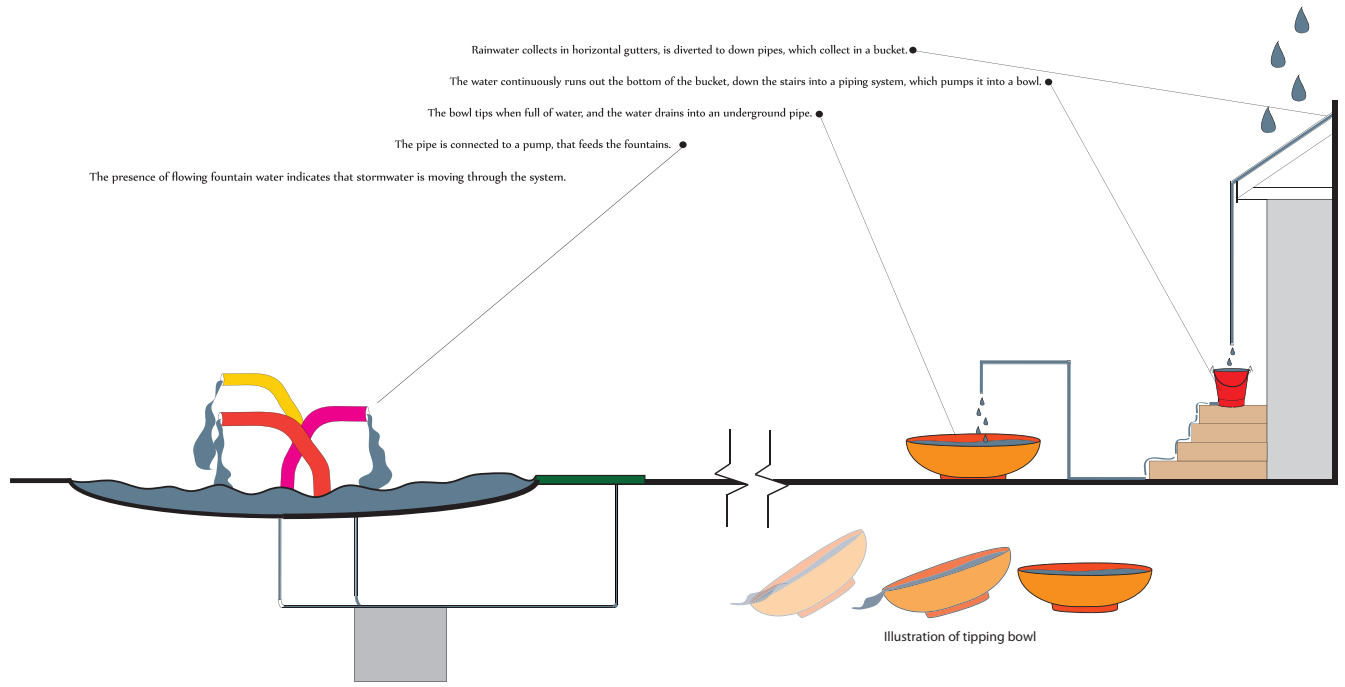
Location of Stormwater Elements on Site



Section 'A - Stormwater Process



Section 'B - Domino Effect Element



View of Stormwater Educational Element

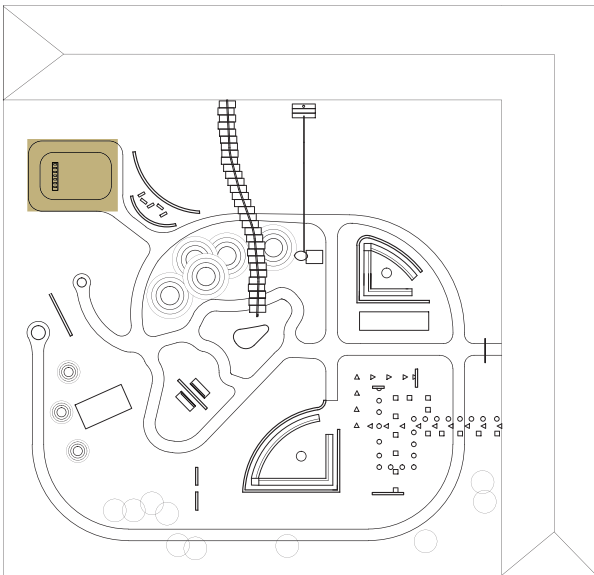
School children have an opportunity of playing in this area, while watching the water flow from the bowls into the pond. They can also watch the activation of the fountain which is triggered when water runs into the stormwater collection area. All these activities link science with education.



IV. AIR QUALITY

Children learn better when they are in a clean and safe environment. This includes educating them about the air that they breathe. This section creates a fun and interactive way to test air quality.

Location of Air Quality Educational Element on site



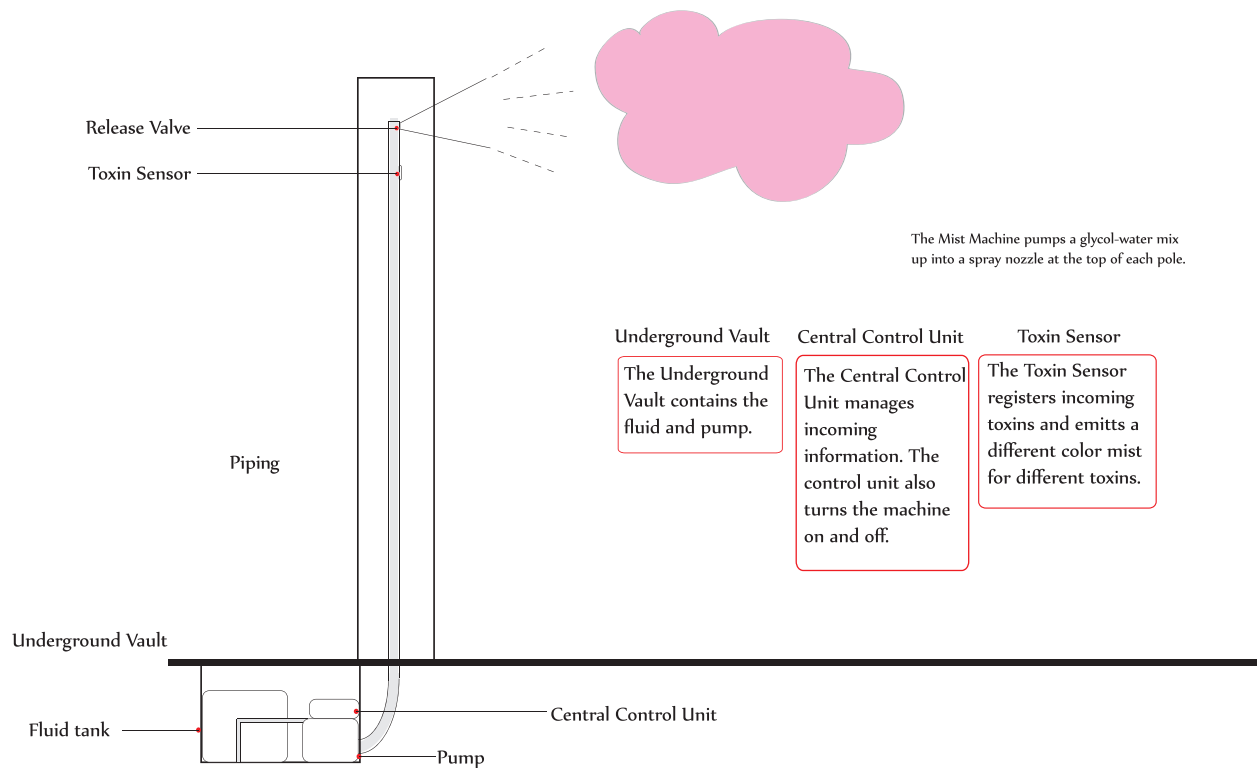
Air Pump Used for Testing Air Quality

Supplies needed for testing air quality:

- >Portable air sampling pump
- >Batteries



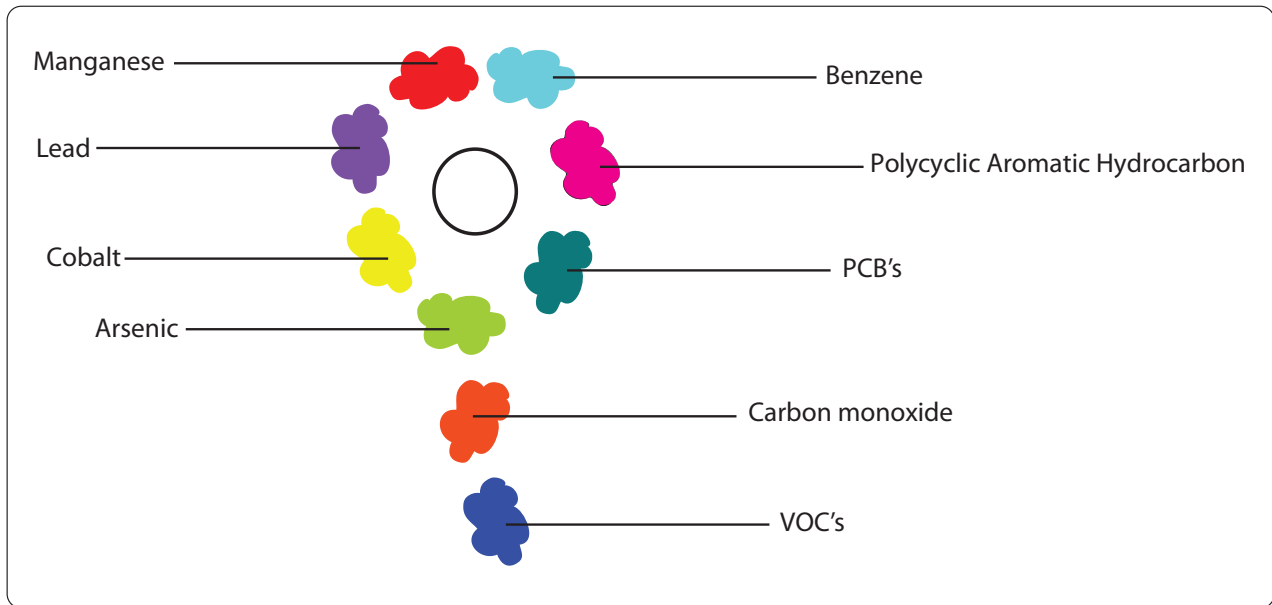
Air Quality Misting Station



Case Study: Living Systems. Innovative Materials and Technologies for Landscape Architecture. Birkhauser

The Misting Station is automatically activated when sensors detect toxins in the air. When activated, the station emits a colored mist that corresponds to a color coded toxin identified on the walkway. This educates the children about the names and presence of toxins in their environment.

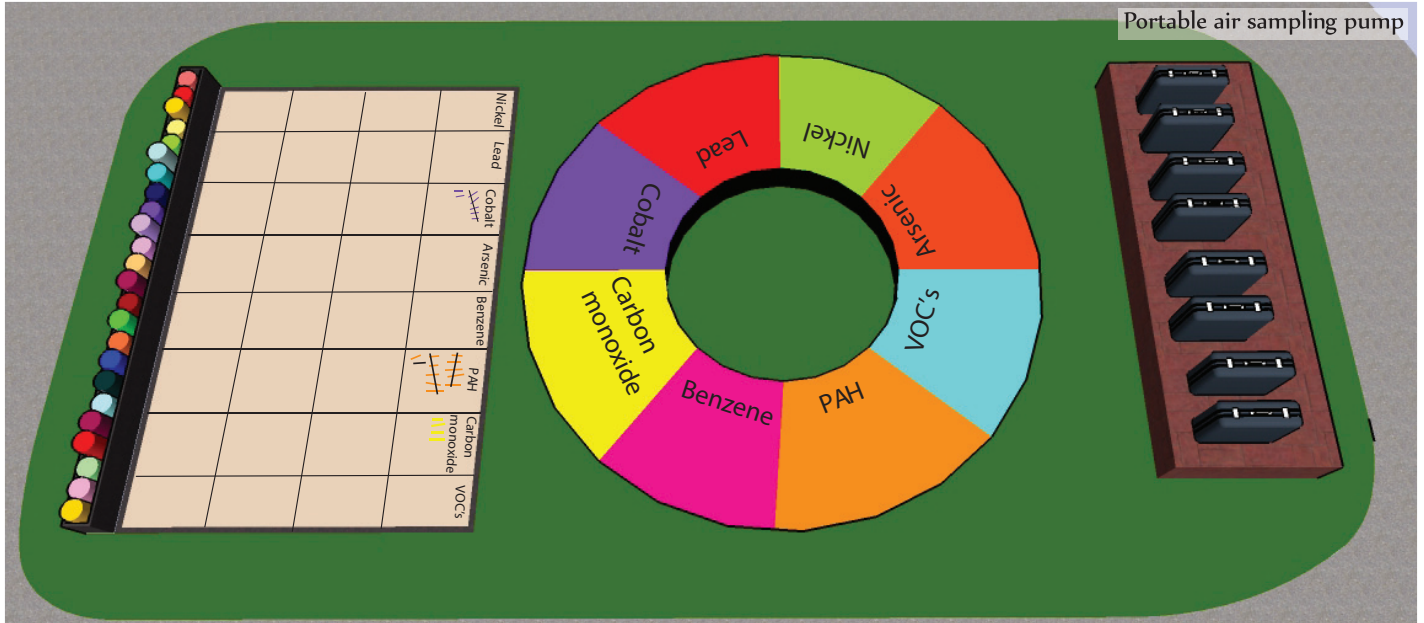
Plan View of Misting Station



Perspective View of Misting Station

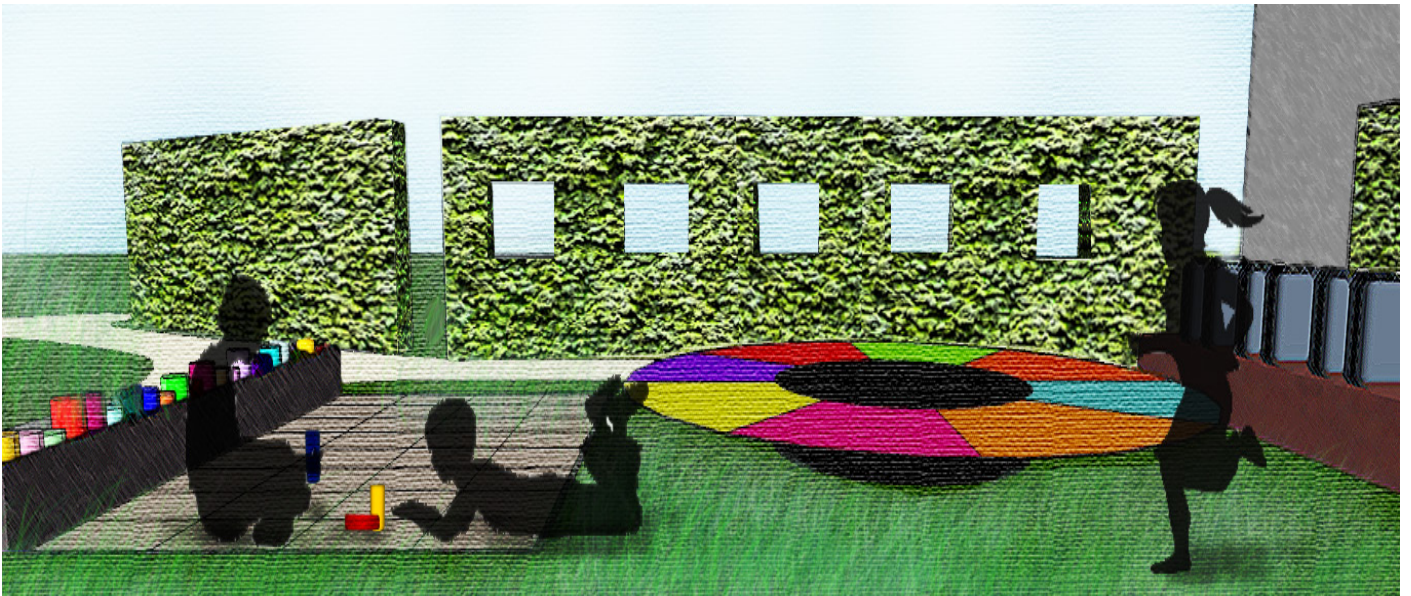


Plan View of Air Quality Testing Station

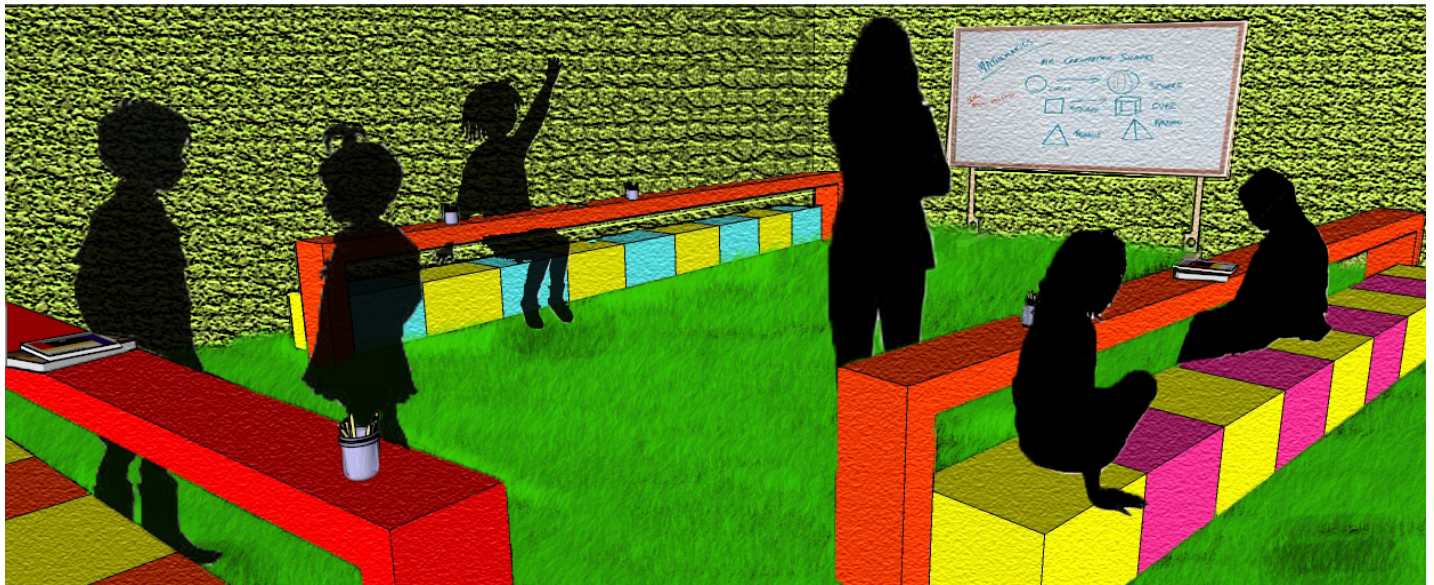


The colorful spinning wheel in the center of the air quality testing area spins when pushed by the school children. The children use the testing stations on the right to test the toxins in the air and they record each test result by the name of the toxin. In this process they learn the names of the toxins and how often the toxins appear in their own school environment. This is another example of a fun learning experience.

Perspective View of the Air Quality Testing Station



View of Outdoor Classroom



The design uses specific elements to respond to the exploration of phytoremediation. The design of the elements is appropriate for learners of the target age group to benefit interactively by seeing the connection between science and nature in an educational environment.

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Conservation is a state of harmony between men and land.

~Aldo Leopold