NRE 501-040

STORMWATER ASSESSMENT DESIGN& MANAGEMENT PROJECT 2014

at West Eisenhower Area

Team 2

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NRE 501-040: Urban Stormwater: Science, Design, and Management

CONTENT

INTRODUCTION

The West Eisenhower Site Assessment examines the current condition of the southwestern portion of Malletts Creek watershed. Based on observations, assessments, and proposed changes, this assessment presents a myriad of potential solutions to improve the water quality and reduce flooding in this region of the creek and downstream.

Location

The West Eisenhower site is located in the southwest portion of the City of Ann Arbor, Michigan, near Interstate 94. The site is limited to north of Eisenhower Parkway, south of West Oakbrook Drive, east of Ann Arbor-Saline Road, and west of South Main Street. The site is approximately 79 acres. Along the southern border of our site, a tributary of Malletts Creek can be found.

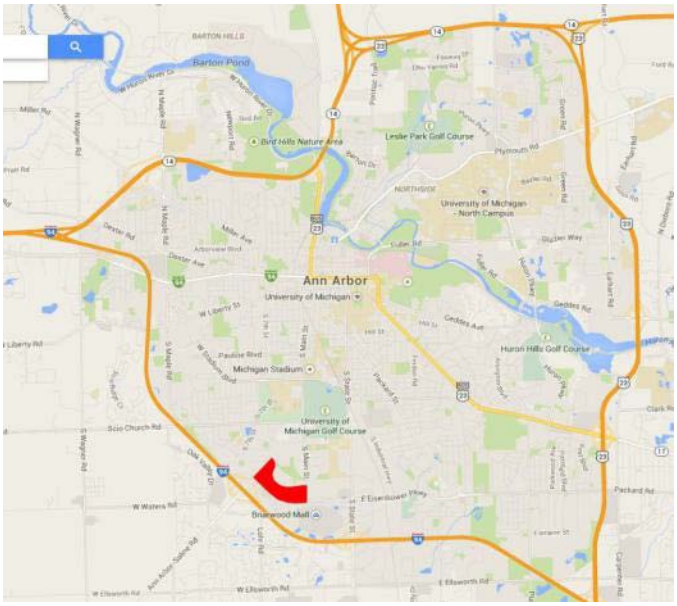

Figure 1: West Eisenhower SiteIn Ann Arbor

Present Land Use

Malletts Creek is part of an urban landscape with significant impervious land surface. The watershed as a whole is approximately 40 percent impervious surfaces, of which 85 percent are categorized as residential or urban. The Malletts Creek watershed is approximately eleven square miles and includes five municipalities: the City of Ann Arbor, Ann Arbor Township, Lodi Township, Pittsfield Township, and Scio Township, as seen in the figure below.

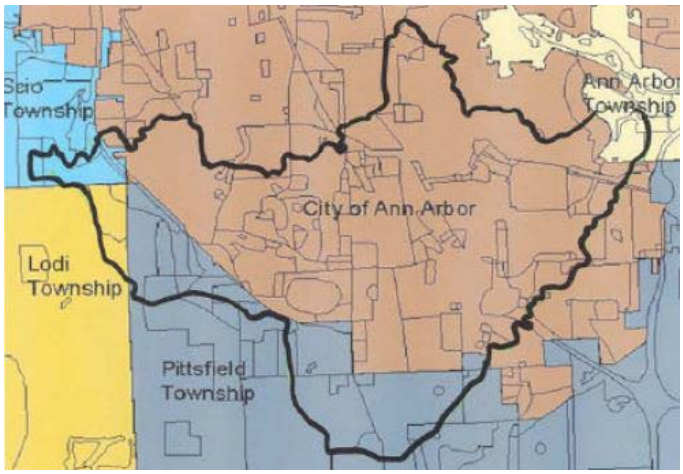

Figure 2: Municipalities In The Malletts Creek Watershed

Much of the West Eisenhower site is devoted to commercial and office properties, which include large impervious parking lots. With 61% of our site impervious, the remaining 39% pervious is primarily turfgrass (see Figure 5). Nearly half of the site includes the Cranbrook Village Shopping Center, anchored by stores like Whole Foods and REI. There are also multi-family residential properties within the site. The majority of parcels appear to be privately owned. Additionally, Eisenhower Parkway runs through the property, leading to large amounts of vehicle-related contaminants in the run-off along this busy street. The stream is open in portions but contained within a pipe where the stream crosses a road.[1]

The area is currently served by the municipal sewer system and does not need to rely on septic disposal. There are not currently any areas of significant open space, nor are there any parks within the site. Mowed lawns along the roads may contribute fertilizers, pesticides, and/or insecticides to the creek running along Eisenhower Parkway. Furthermore, the creek within the site is partially open and partially channeled underground. Accordingly, the water quality of Malletts Creek in this area is poor.

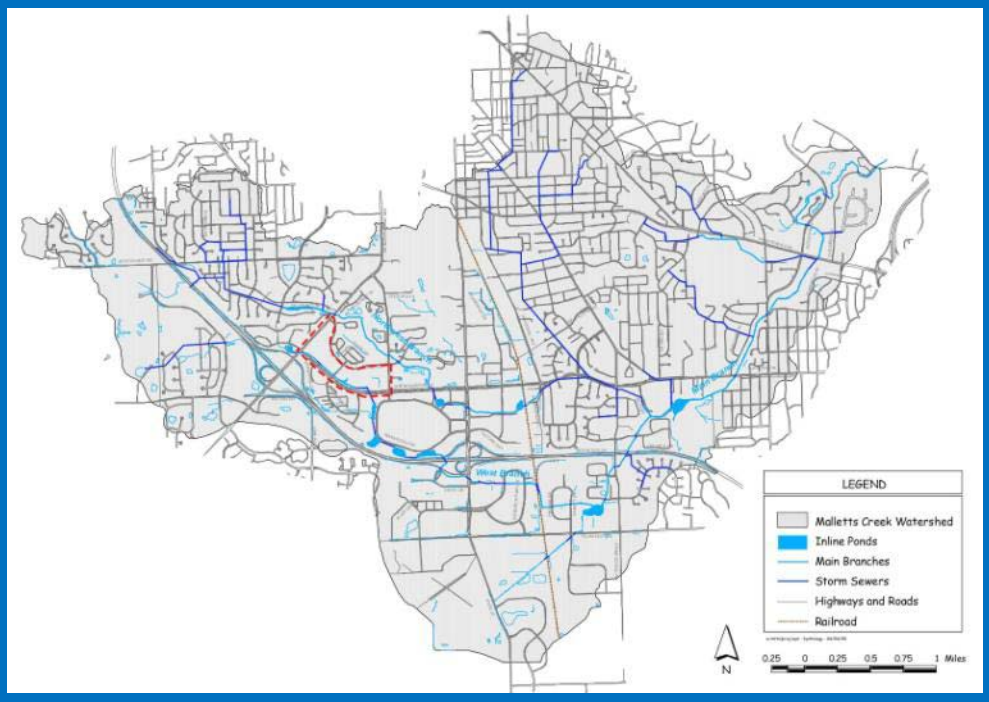

Figure 3: The Site Location, In Red, Within The Malletts Creek Watershed

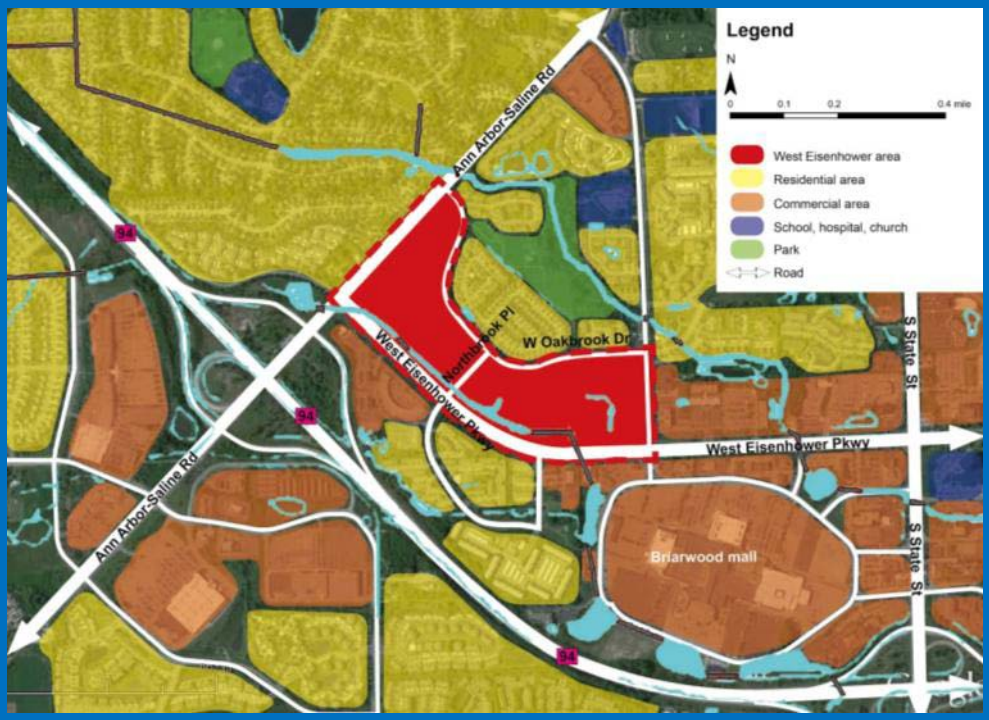

Figure 4: Land Use Surrounding West Eisenhower Site, In Red

I. SITE CHARACTERISTICS

Located near the headwaters, the West Eisenhower site is within an upslope portion of the Malletts Creek watershed. Inputs into our site stem from a wetlands to the northwest and stormwater runoff from impervious surfaces. Surrounding the site, the majority of land is used for residential or commercial purposes, see Figure 4. Water flows primarily south towards our site and then east out of our site so land to the north has the most influence over stormwater quality on our site.

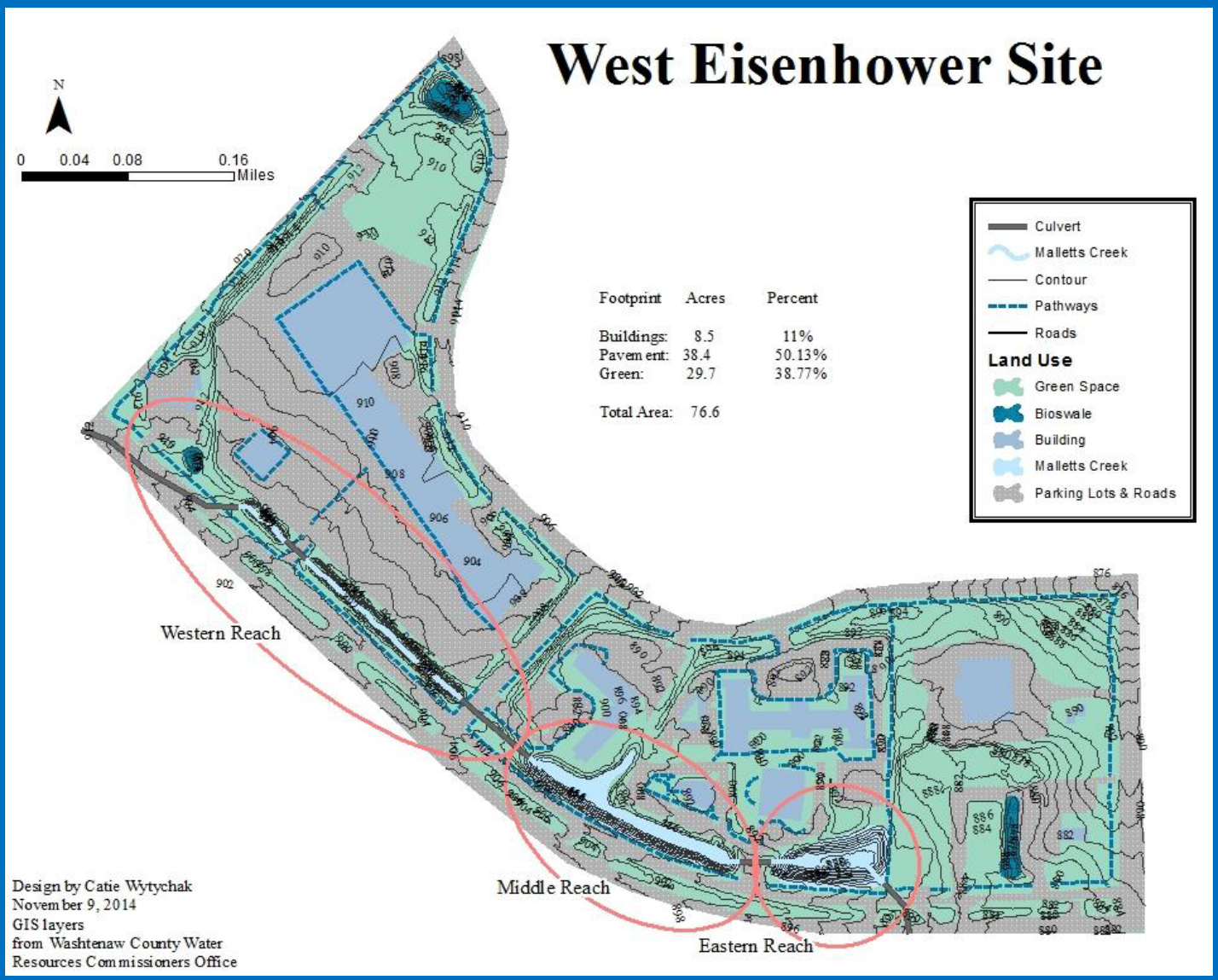

Figure 5: Current Land Cover On Site And Designated Reaches
Total impervious is 61% and pervious is 39% of total cover.

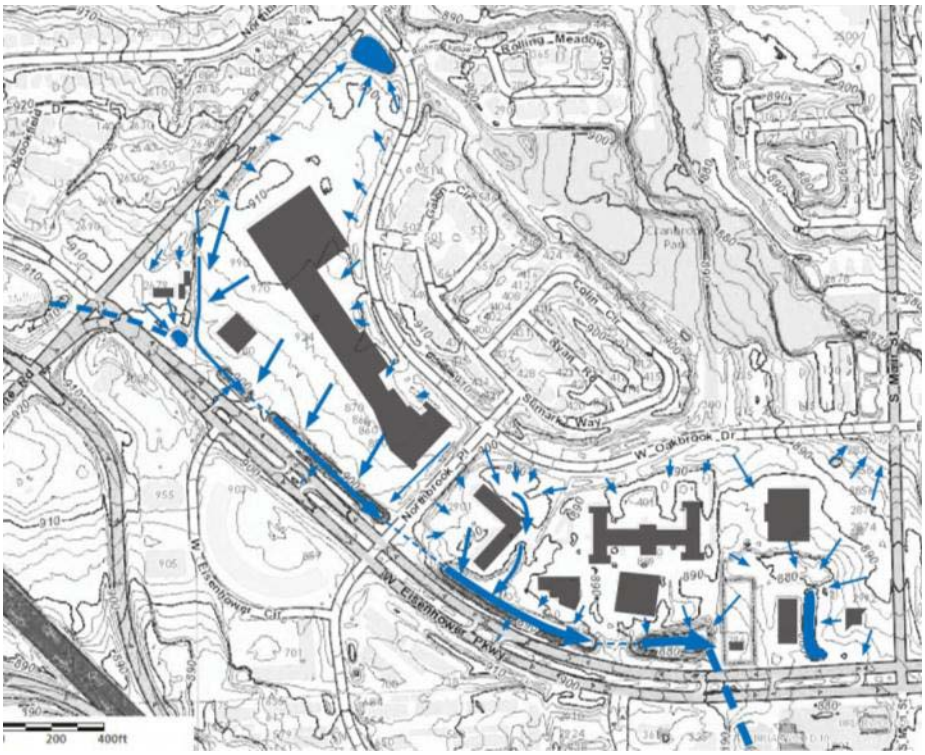

Figure 6: Topography Map Showing Stormwater Flow

Landscape architect and urban designer, Kristina Hill would consider this a network site with potential for infiltration.[2] Since the majority of soils throughout the site are morley loam, detention and infiltration strategies are pursued during this plan to reduce stream velocities and improve downstream water quality.[3] During a stream walk assessment, two aspects of the current stormwater design were noted; 1) contribution to on site or downstream flooding and 2) contribution to water quality.

1.1 Contribution to Onsite or Downslope Flooding

Since 61% of our site is impervious, the segment of Malletts Creek within our site likely contributes to onsite or downstream flooding (see Figure 5). If stormwater is unable to infiltrate on site into the groundwater table because of impermeable surfaces, the chances of flooding are increased.[4]Through a qualitative analysis, a straight stream with steep banks was noted. These characteristics likely indicate channelization from high velocity flows. No to minor amounts of erosion exist along the stream banks but the slope is estimated at 1:3 and at a total height of nine feet in areas. Baseline stream conditions are documented in the Malletts Creek report as having a peak flow of 118 cfs, a peak velocity of 3.6 ft/sec and a peak depth of 2.04ft. As compared to reference conditions, these numbers indicate that the West Eisenhower site is experiencing unnaturally high peak velocities, depths and flows.[5]

High peak velocities, depths and flows are estimated to result in insufficient capacity to contain a 100 year storm event. Models show this could result in the flooding of surrounding office buildings, likely the Concord Center Shops.[5]

The restoration activities of Malletts Creek may not solve the high peak velocities significantly. Activities in this area include removal of log jams and increasing streambank planting. The capacity problem of a 10-year flood was remedied, but the capacity to detain a 100-year flooding problem has not been implemented.

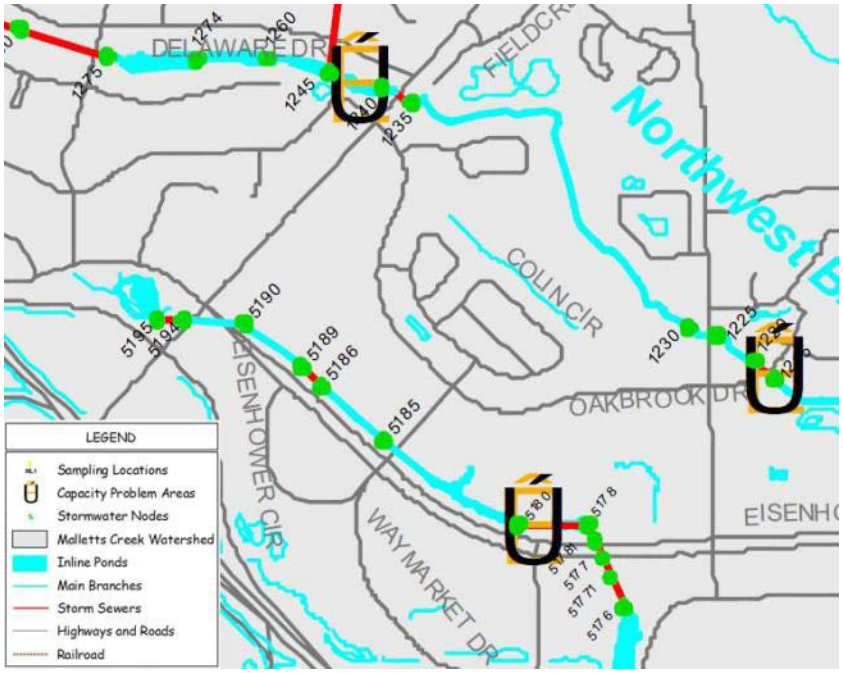

Figure 7: Capacity Problem Areas Outlined In Black

1.2 Flooding: Recent Changes and Future Threats

Since the Malletts Creek report was written, total stormwater inputs have likely been elevated due to increased impervious surface upstream. Future urban development will likely continue so slowing the peak velocities and flows of this upstream portion of Malletts Creek is a priority for our site's stormwater management plan.[6]

Additionally, climate change models predict an increase of precipitation by 10 inches annually for southern Michigan by the end of the century.[7]Increased precipitation and more frequent extreme events will only exasperate the high velocity and stream channelization occurring at West Eisenhower. These increases in precipitation will affect Malletts Creek on our site and downslope.

1.3 Contribution to Onsite or Downstream Water Quality

In addition to physical alterations to Malletts Creek, the chemical and biological characteristics at the West Eisenhower site have been affected by upslope residential lawn care practices, small mammal waste and contamination from cars.[8]The primary water quality focus in the Malletts Creek report is high levels of phosphorous.

High levels of phosphorous are often from failed septic systems and overuse of lawn fertilizers.[9] Since Southeast Michigan's natural soils have high levels of phosphorous, homeowners who apply multi-purpose lawn fertilizers will over-apply phosphorous. Over saturated amounts of phosphorus in fertilizers will not bind with soils and instead enter the stormwater system during rain events.[10]

Phosphorous effects water quality by increasing the net primary productivity within the water, which creates anaerobic conditions. Anaerobic conditions reduce the availability of oxygen for fish and other organisms. Algal blooms can occur under certain conditions and can become toxic. Toxic conditions can affect the ecology by decreasing biotic organism populations, and economically by reducing opportunities for fishing and recreation.[10] As a network site, it is important to contain contaminated stormwater. Since Malletts Creek is documented as discharging amounts of phosphorous in levels higher than the Total Maximum Daily Load allowable, design projects detailed in this plan aim to reduce the total phosphorous.[11]

High levels of E-coli in Malletts Creek is caused from small mammals like raccoons, possums and household pets whose waste runs into the stormwater system. Contaminants from cars that enter the stormwater system include tire particles, copper from brake pads, oil and gas. These contaminants can cause immediate and long term effects depending on climate conditions.[12]

The restoration activities related to improving water quality, in particular phosphorous levels, detailed in the Malletts Creek Restoration Plan include: retrofitting of existing detention basins, promoting land owner participation in creek-safe lawn maintenance, illicit discharge elimination program, increasing frequency of street sweeping in residential and commercial area and increasing the frequency of catch basin cleaning.[11]

1.4 Water Quality: Recent Changes and Future Threats

Since the Malletts Creek report was published in 1999, water quality issues have likely changed. Through education and outreach, some residents are reported to be using fewer fertilizers and pesticides, which can have a significant decrease in overall phosphorus loading into this upslope portion of Malletts Creek. After the City of Ann Arbor passed a Phosphorous Fertilizer Ordinance, measurable reductions in phosphorus concentrations have been found.[13]

Populations in Ann Arbor are expected to rise and although there are alternatives to driving personal vehicles, an increase in people is likely to cause an increase in vehicle traffic.[14] Increased vehicular traffic on West Eisenhower and throughout the parking lots on our site is a future threat. This threat manifests from the vehicles' subsequent shedding of tire particles, copper from brake pads, and oil and gas that will translate to a reduction in water quality.[15]

II. FIELD SURVEY

2.1 Contributing Onsite and Upslope Factors

In early November, a qualitative field survey was conducted to assess the stream quality and factors affecting to water quality. Noted factors included upslope parking lots, gas station, uncontained dumpsters and restaurants. Contaminants and consequential impacts from each of these features was detailed in Table 2.1. Vegetated islands in the parking lot were raised and catch basins quickly delivered stormwater from the paved surface into the stormwater system. This water was warmed from running off the black pavement and entered Malletts Creek at a velocity that was higher than under natural conditions.

Table 2.1 Onsite and Upslope Contributing Factors[15]

Source	Contaminant
Parking lot	Cars: auto fluids, tire particles, Polycyclic Aromatic Hydrocarbons (PAHs), copper from brake pads
	Asphalt: breaks apart into particles over time and during time of application can runoff into water. Warms runoff before it enters the stream.
Gas Station	Car contaminants named above
Uncontained dumpsters	Plastic trash, debris and organic material uncontained
Restaurants	Fats, oils and greases
Small Mammals	Waste leads to high e-coli levels

2.2 Water Quality and Flooding

Our study site can be divided into three reaches of Malletts Creek, as shown in figure 7. The western reach extends from Ann Arbor Saline Road to Northbrook Place; the middle reach extends from Northbrook Place halfway to Main Street; and the eastern reach extends to Main Street. The western reach is characterized by steep slopes and little vegetation on either side of the stream and is about 1,950ft in length[3].

The middle reach of the creek is vegetated and has less steep of slopes but many invasive species like Common Buckthorn and Phragmites. The eastern reach of this section widens and hosts a variety of vegetation throughout the basin, such as Peachleaf willow and Smooth sumac. Farther downstream and east, a vegetative basin captures stormwater runoff. During a qualitative site analysis during October, the following characteristics were observed for each reach.

Table 2.2 Qualitative Observations by Reach

Characteristic	Eastern Reach	Middle Reach	Western Reach
Flow	No flow because stream turns to patchy pools	Low velocity	Medium to high velocity
Stream Habitat	Unconnected aquatic habitat	Murky appearance indicates high amounts of suspended sediment and contaminants. No riffles but large pools	Many stormwater inlets with algae covered base and malodor. Pools and riffles present. Trash present
Stream Clarity	Gray and cloudy	Gray and cloudy	Gray and cloudy in pools. Clear in riffles
Riparian Habitat	Varied species composition and structure of canopy	Vegetation but invasives present such as Common buckthorn and Phragmites	Turf grass surrounding stream. Steep slopes. No tall vegetation
Wildlife Observed	Robin	Ducks	None

III. GOALS

As an upslope site, it is important to detain and infiltrate stormwater runoff so that the soils can naturally clean the water as it filters into the groundwater. Slowing water in detention basins not only impacts water quality, it can diminish the chances of flooding downstream or in extreme weather events. The main goals for the stormwater plan on West Eisenhower are the following:

1) **Reduce flooding potential onsite and downstream**
2) **Improve water quality**

Since portions of our site are noted as not having detention capacity for a 100 year flood event and our site contributes to the higher than allowable Total Maximum Daily Load for phosphorous downstream, it is important to reduce velocities and improve water quality.[5] The following proposed changes aim to complete this goal.

IV. PROPOSED CHANGES

Prioritization of Phases

Our phases are in order of priority. Prioritization was assigned according to urgency, legal requirements and ease of implementation. Recommendations in Phase One are either 1) simple solutions, like dumpster enclosures, 2) required by law, like the bike parking, or 3) urgent, like installing a riser pipe in the eastern reach to reduce the steep slopes and encourage infiltration. All recommendations in Phase Two would be completed during redevelopment of the Cranbrook Shopping Village parking lot. Recommendations in Phase Three would be highly beneficial in managing stormwater runoff but are also expensive and would only be pursued if the necessary funding was secured.

4.1 Phase I

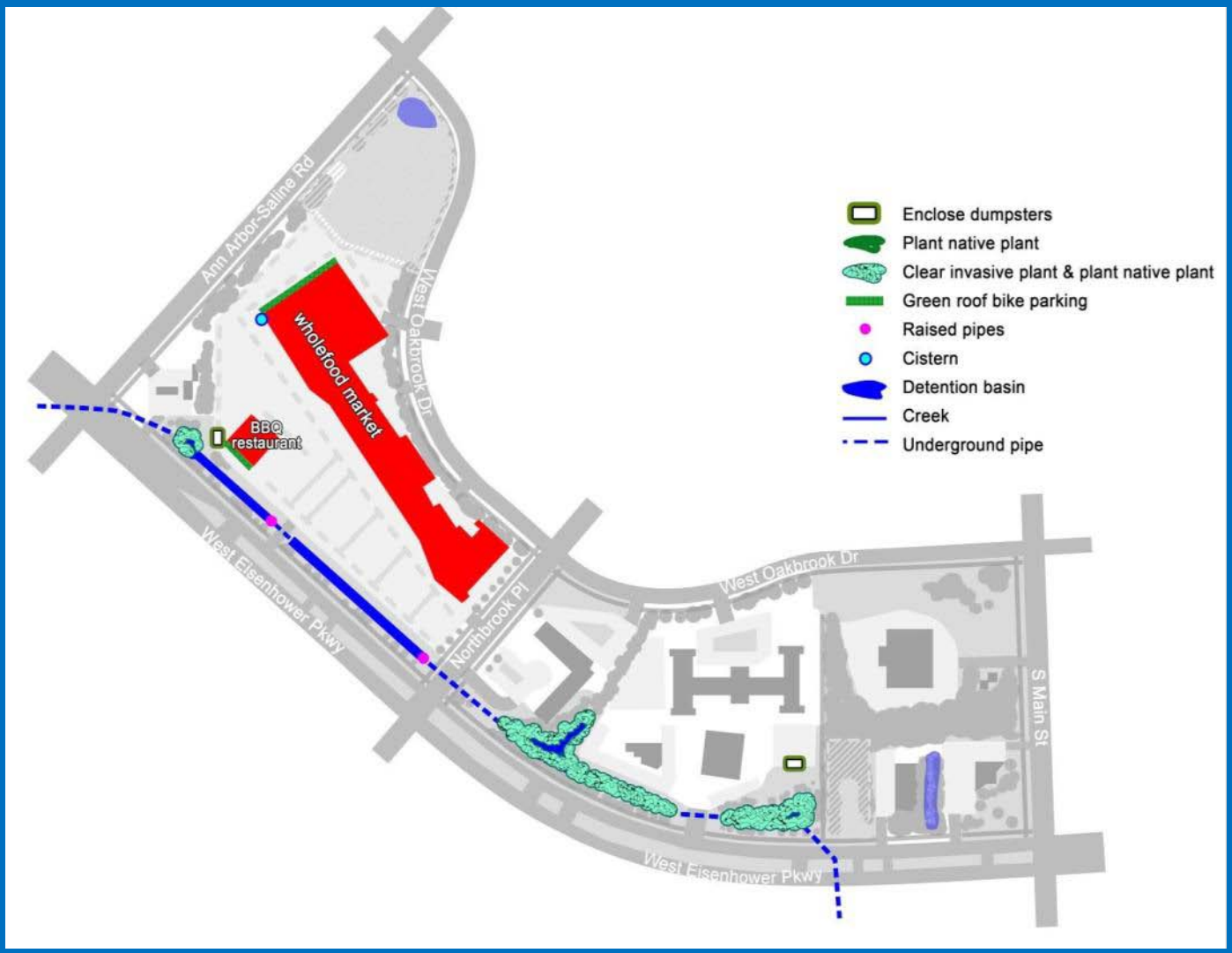

Figure 8: Plan of Phase I

Dumpster Enclosures

During the initial assessment, numerous dumpsters appeared to be directing litter into open stormwater and creek areas. Commercial dumpsters may be a major source of stormwater pollution if they are improperly maintained or operated.

Figure 9: Dumpster Enclosures

Benefit to Water Quality
Dumpster enclosures, which guard the sides and top of trash areas, will help to ensure that litter does not migrate into the creek area.

Bike Parking

One change suggested is the construction of a pilot green roof bike parking structure in the Cranbrook Village shopping center, which would bring the center up to code with respect to the required number of bike spaces. Ann Arbor Code of Ordinances, Title V, Chapter 59, 5:167 specifies that retail stores and centers with less than 300,000 square feet of floor area require one bike parking space per 3,000 square feet. Cranbrook Village should contain at least 61 bike parking spaces. During the initial assessment, far fewer than this number of bike parking spaces were noted. Therefore, this change has the added bonus of not only aiding compliance, but also encouraging alternative transportation for shoppers and employees, and increasing evapotranspiration through the planting on the roof element.

Figure 10: Bike Parking

Green roof plants will be a diverse mixture used to test the site specific success of different species. Species will include a variety of sedums, nodding onion and wild chive. Species that succeed will be noted and then used on the green roof proposed in Phase Three.

Benefits to Water Quality & Flooding Reduction
Bike parking will provide an alternative to driving. If fewer cars enter the site, there will be a subsequent decrease in the amount of contaminants, such as PAHs from car exhaust, tire particles, and copper from brake pads that enter the stormwater system. The green roof will decrease the amount of impervious surface on site, increase evapotranspiration and slow the amount of stormwater discharging into the stream. Additionally, green roofs can provide habitat for birds, butterflies and other biota.[16]

Native Planting

Remove invasive plants in the middle reach and detention basin. During the first phase of removal, three test plots should be created to test the success of invasive removal through 1) manual removal, 2) prescribed burn and 3) herbicide treatment. After assessing the site specific success of each methodology, the most successful technique should be applied throughout needed areas.

After removal of invasive species, immediate planting of aggressive native species is recommended. Aggressive native species that are adapted to survive in riparian or inundated zones are listed by preferred proximity to the stream in the following table.

Figure 11: Cross Section Of Floodplain Forest

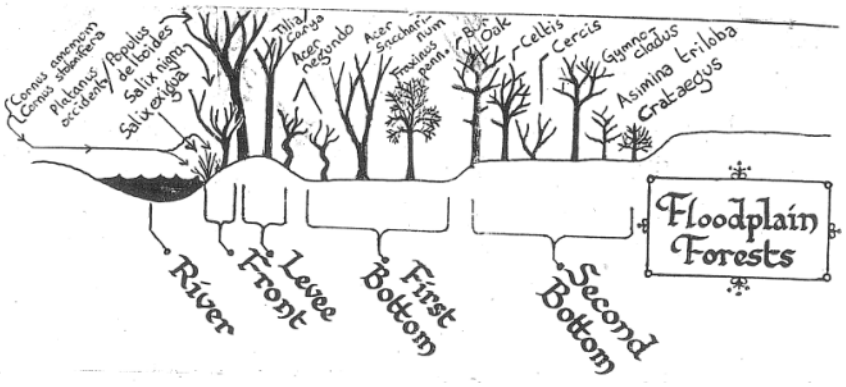

Table 4.1 Recommended Native Species

Location	Latin Name	Common Name
Directly beside stream	*Salix interior*	Sandbar willow
	Cornus amomum	Silky dogwood
	Cornus sericia	Red-osier dogwood
Stream bank	*Tilia americana*	American basswood
	Populus deltoides	Eastern cottonwood
	Platanus occidentalis	Sycamore
First Bottom	*Cercis canadensis*	Redbud
	Celtis occidentalis	Northern hackberry
Second Bottom	*Acer negundo*	Boxelder
	Acer saccharum	Sugar maple

Benefits to Water Quality & Flooding Reduction

Native species planted along Malletts Creek will act to stabilize the steep banks, slow stormwater runoff entering the creek and reduce the amount of water leaving our site through

evapotranspiration. Large trees like Sycamore and Eastern Cottonwood will shade Malletts Creek and act to reduce the warm stormwater runoff coming from the surrounding pavement.

Additionally, by encouraging biodiversity in vegetation, a more diverse habitat will be created. A diverse habitat will attract a variety of animals, which makes the area more enjoyable for those passing by and an important ecosystem in a fragmenting landscape.[16]

Install Riser Pipe in Creek

Raise pipe by installing a riser in the western reach to detain water longer and decrease slope. A raised pipe will allow water to remain in the stream channel for a longer amount of time, which encourages on site infiltration. With a higher water level, the overall slope will be decreased without reducing the detention capabilities onsite.

Plant native vegetation to create a riparian buffer strip in the eastern reach. Native plants are listed in Table 4.1. Trees and shrubs could be installed as live stakes for ease of implementation.

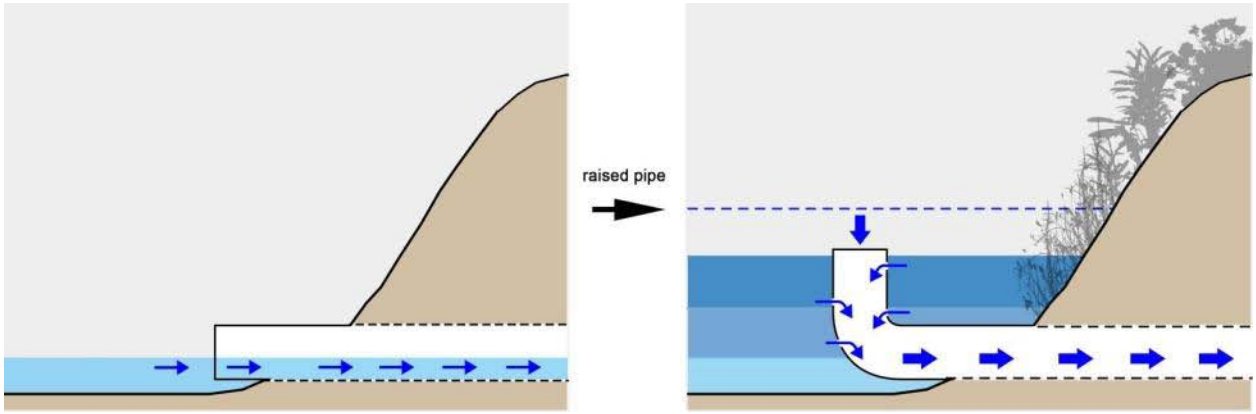

Figure 12: Raised Pipe And Subsequently Elevated Water Level

Benefits to Safety, Water Quality & Flooding

Detained water within the stream will infiltrate and reduce downstream flooding by reducing the total water flowing out of our site. A riparian buffer strip will reduce stormwater runoff velocity and soil erosion. Large trees will shade the channel and cool water, which is beneficial to the stream's living organisms.

Cistern

Install a 5,000 gallon cistern near the Whole Foods Market to collect roof water off of the shopping center for non-potable use in greywater toilets. The cistern will enable the shopping center to lower or eliminate flows from the rooftop, even if there is insufficient structural support for a green roof.

Figure13: Cistern Near Wholefood Market

Benefits to Flooding Reduction & Reducing Water Use

Cisterns can help to reduce stormwater runoff from the impervious roof surfaces. Additionally, the water harvested from the cistern can conserve potable water and reduce water charges for commercial tenants.

Urban Forest

Plant native trees in open spaces surrounding buildings to create an urban forest. The majority of those open spaces are currently covered by mown turf grass. According to general land surveys in the 1800s, our site is documented as having been an oak hickory forest prior to industrialization. To restore the permeable areas of our site back to their original land cover, we recommend planting oaks and hickories. Since the space for roots is much more limited now than it was before development, we recommend smaller oaks like the Shingle oak, *Quercus imbricaria* and Red oak, *Quercus rubra* which can be planted as dense as 1,000 trees per acre.[17] A variety of hickories; bitternut, pignut and shagbark, should be planted and then assessed to determine the necessary space for each species to survive.

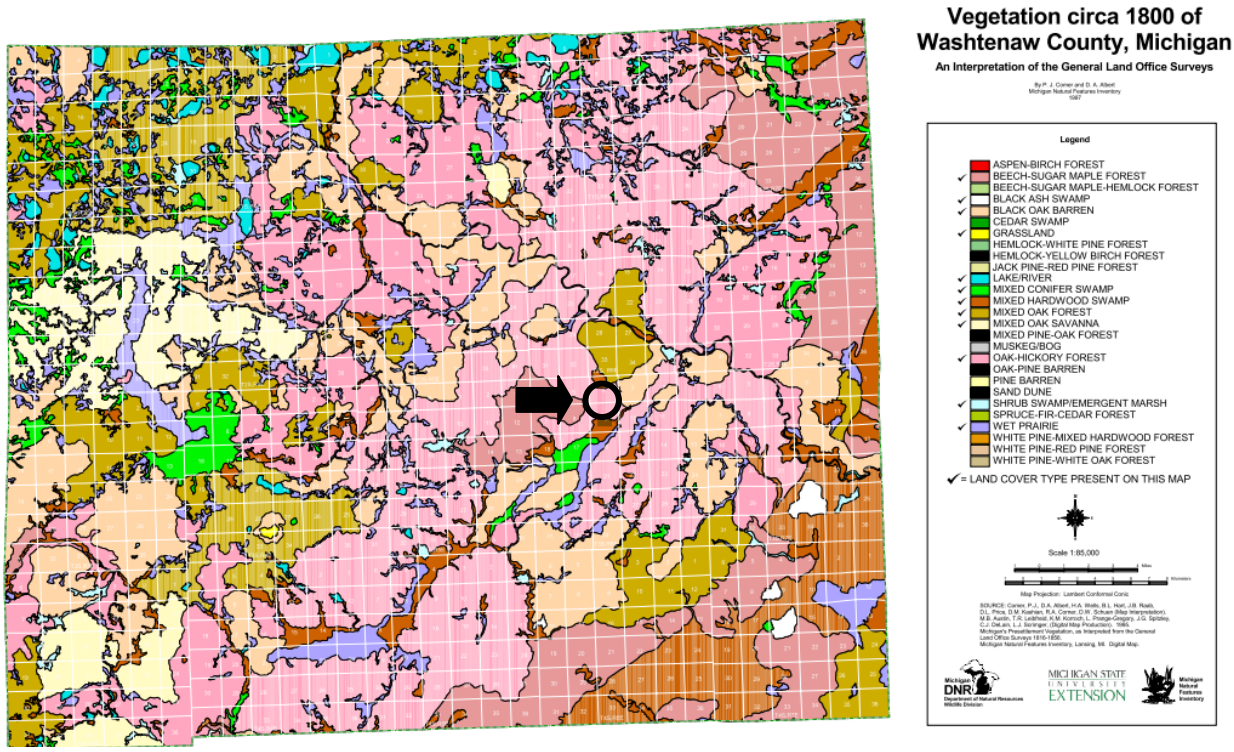

Figure 14: Vegetation map circa 1800s as interpreted from general land office surveys by Michigan State University.West Eisenhower was documented as an oak hickory forest.

Benefits to Water Quality

Replacing turf grass with trees upslope of the stream will encourage rainwater storage through root uptake and subsequent evapotranspiration. Additionally, a diverse habitat created near the riparian plantings will create a more resilient system. If riparian species are able to pollinate and reproduce with surrounding species, their populations will avoid genetic drift. Genetic drift occurs when populations are isolated and reproduce only within a small gene pool. Reproduction within a small gene pool leads to weakened genetics and less resilient populations.[18]Since southwest Ann Arbor has highly isolated forest fragments, it is important to diversify the gene pool for our planted native species to ensure their success.[16]

4.2 Phase II

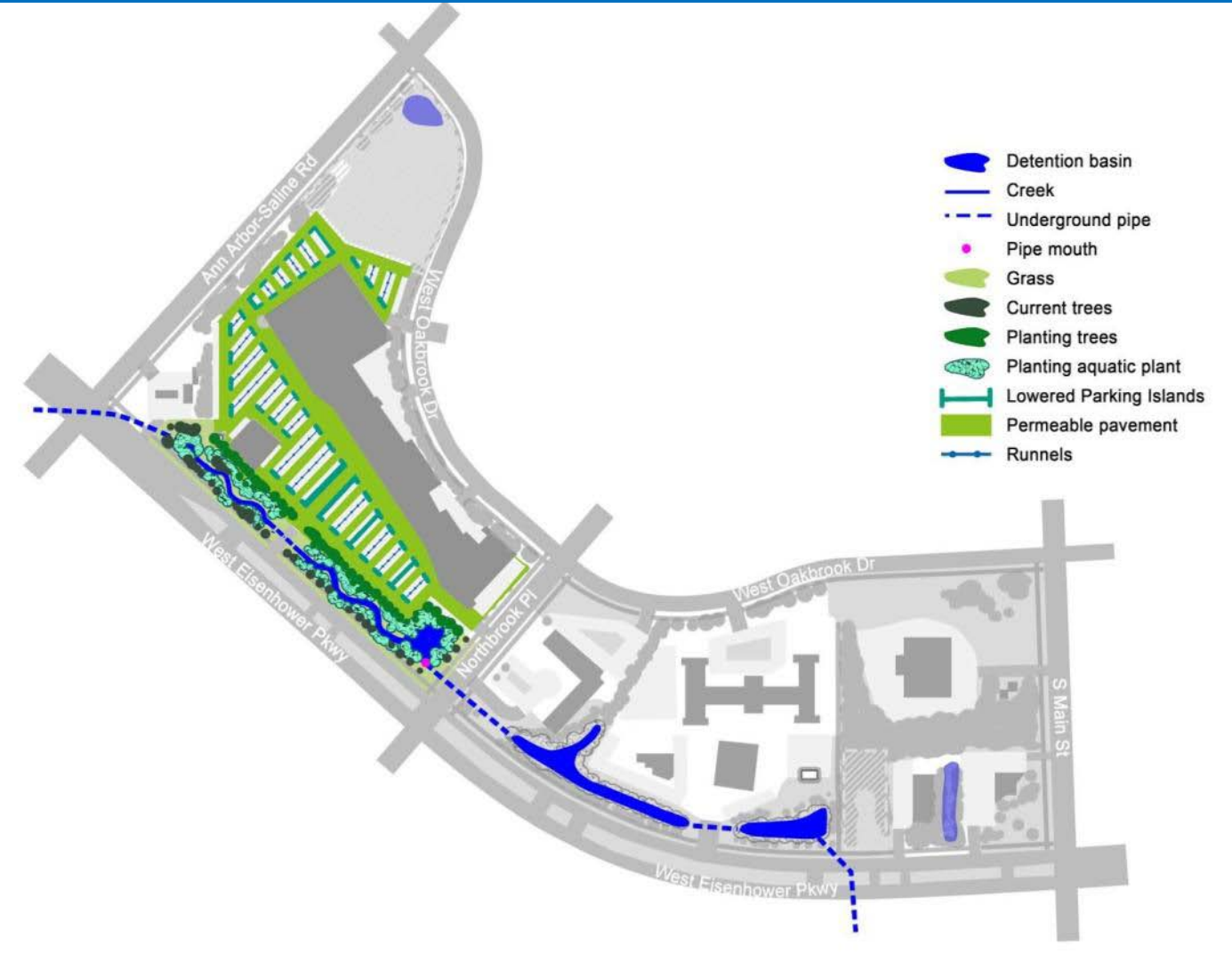

Figure 15: Plan of Phase II

Permeable Asphalt Parking Lot

Install permeable parking spots in the Cranbrook Village shopping center, with the potential to expandutilization of pervious paving materials to senior care facilities and other commercial buildings in the site.

Figure 16: Permeable Asphalt

Benefit to Flooding Reduction

Permeable asphalt will benefit the site by slowing the flow of runoff from formerly impervious areas. Stormwater will seep into the ground and infiltrate stormwater upslope.[16]

Runnels

To reduce the need for pervious pavement and increase the visibility of stormwater flow, we recommend using runnels. Common in Europe, runnels are thin impervious channels that stormwater drains into and flows within. Water flowing through the channels can irrigate trees or flowers along the way, as pictured. We recommend placing runnels with tree planters along the middle line of parking spaces, which will be impermeable asphalt. Tree planters should have large underground boxes where roots can expand. Trees planted along the runnel should be adapted to flooding and be highly resilient to urban pollutants, such as Sycamore *Plantanus occidentalis,* or Redbud *Cercis canadensis.* Signage should be included to educate the public about where their stormwater goes and the contaminants that can be carried along.

Figure 17: Runnel

Benefits to Water Quality

If runnels are designed to irrigate trees, the stormwater running through the channel will be shaded and cooled before it reaches the stream. Additionally, if people are made more aware of the impacts stormwater runoff can have on our water bodies, they may act to prevent pollution from entering the stormwater system.[19]

Lowered Parking Islands

Runnels channeling water down the center of the parking spaces will end in vegetated and lowered parking lot islands. To maximize water entering the islands, each will have curb cuts that drain water into a small sediment bay The infiltration zone will have large rocks to slow stormwater entering the system. Once water slows, it deposits sediments, which in this case are carrying contaminants.

Figure 18: Lowered Parking Island

The vegetated islands will be similar to rain gardens in their planting design. Recommended

native plants include Blue vervain, Blue lobelia, Switchgrass, Sensitive ferns, Rose mallow, Blazing star, Goldfinger potentilla, Red-osier dogwood and red maple. Red maple will grow into a large tree that can withstand flooding and contaminant inputs. Providing shade and relief against the large parking lot, trees are important for these parking lot island designs to be accepted.

Benefits to Water Quality & Flooding

Lowered and vegetated parking islands will separate harmful contaminants from runoff and allow stormwater to be retained and infiltrate. Water infiltrating upslope from Malletts Creek will be cooled, cleaned and slowed as it moves towards the groundwater table. Green spaces within the parking lot will make it a more desirable location because it is aesthetically pleasing. Native vegetation will increase evapotranspiration through their leaves and infiltration through their roots. Some native plants, like Blazing star, have roots that can reach up to 15 feet in depth.[16]

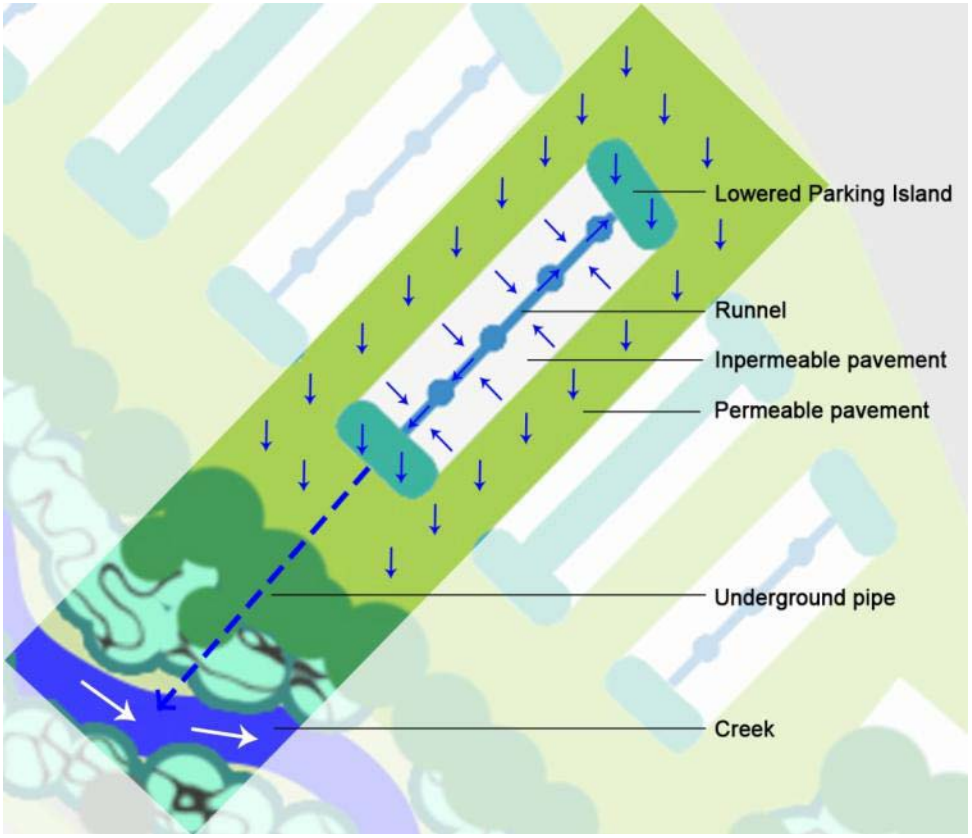

Figure 19: Water flow in the parking lot. Water flowing from the parking lot into runnels, then parking lot islands and finally overflowing into the creek

Construct Detention Basin

We recommend reducing the number of parking space at the southeast side of parking lot of Cranbrook Village shopping center and reconstruct it into a vegetated detention basin. Around the basin, we would then create a riparian buffer strip to increase infiltration capacity.

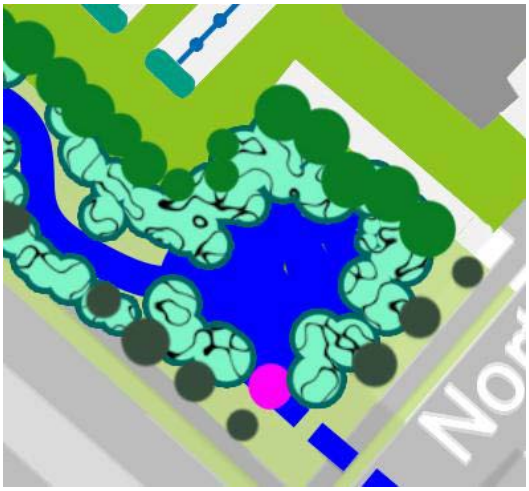

Figure 20: Detention basin design

Ann Arbor Code of Ordinances, Title V, Chapter 59, 5:167 specifies that retail stores and centers less than 300,000 square feet of floor area require one parking space per 310 feet of area (minimum) or one space per 265 square feet of area (maximum). Cranbrook Village would require between 595 to 696 vehicle parking spaces and 61 bike parking spaces. Because the current lot has about 300 more spots than required, the changes include taking out parking spaces near the creek to expand available land for infiltration and habitat.

Surrounding the detention basin, native plants mentioned in Table 4.1 should be planted to create a riparian buffer strip. Large trees should be favored because of the large area available.

Benefits to Water Quality & Flooding

By increasing the permeable space on site and regrading stream banks, we are able to create meanders to slow the stream and introduce a riparian zone. Meanders will slow the peak velocity and flow both on site and downstream which will diminish flooding possibilities. Since the proposed area for the detention basin has been noted as insufficient for a 100 year flood event, it is important to increase capacity to reduce the possibility of flooding.[16]

4.3 Phase III

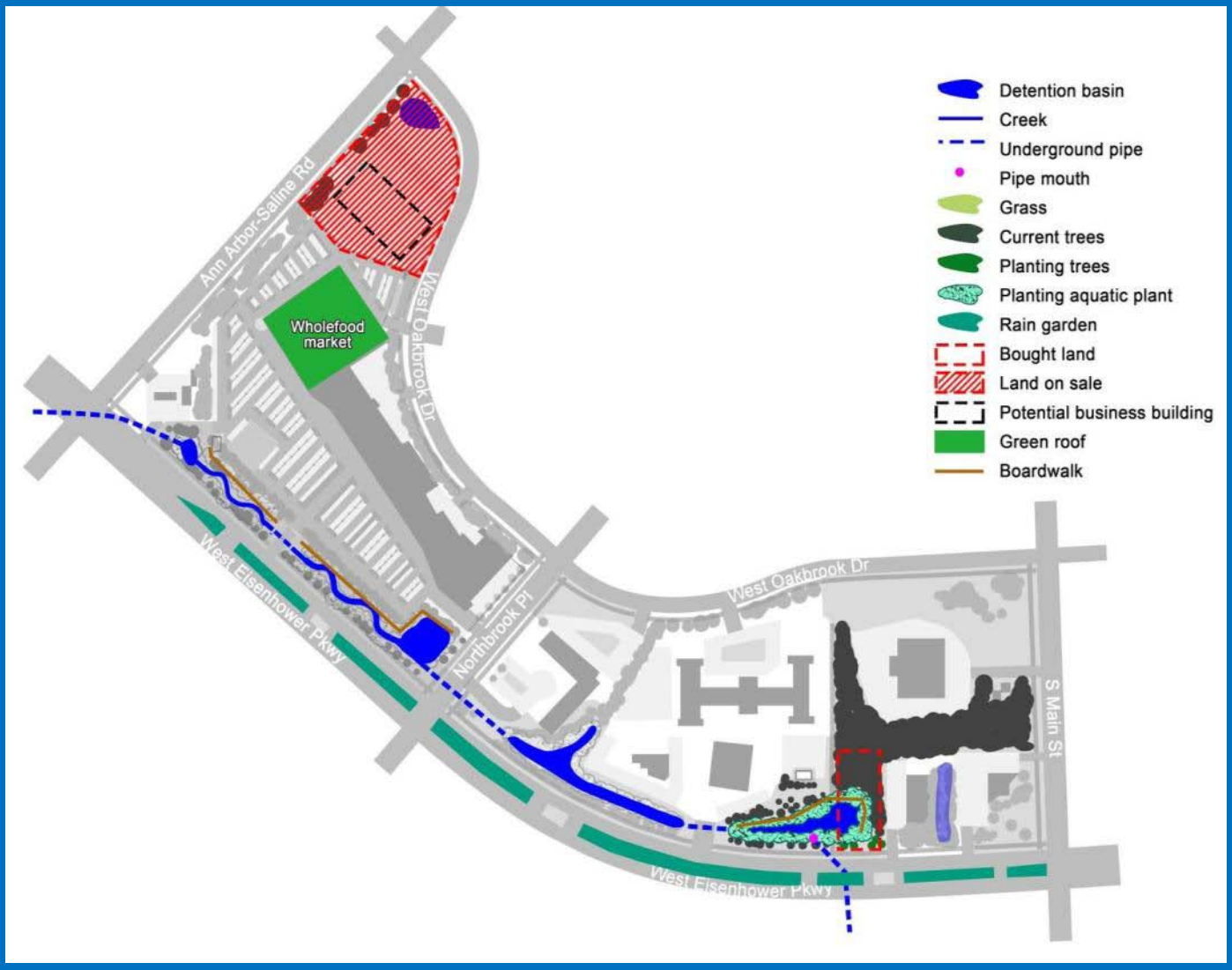

Figure 21: Plan of Phase III

Encourage Sustainable Development

Encourage development of the Northwest Zone as a LEED Platinum mixed-use building, utilizing stormwater best management practices (BMPs). The lot north of Whole Foods is currently available for sale and could be utilized in such a way as to demonstrate how well stormwater can be managed, including features such as parking on the first level, a blue roof, and pervious paving surrounding the building.[20] Although the project would be privately developed, the use of tax-increment financing could encourage stormwater-friendly development in a commercially valuable parcel. Any new development on site will have comply with new Washtenaw County stormwater rules that require 100% infiltration of the first flush in a rain event up to the 100 year storm event.[21]

Benefits to Water Quality and Flooding Reduction

By ensuring that the development of the Northwest Zone occurs in a sustainable manner that does not increase impervious area and stormwater runoff, this proposal aims to reduce flooding in other areas of the creek and parking lot. It will also slow the flow of contaminants into the creek, improving water quality. Since the majority of the northwest corner of our site flows northward, away from Malletts Creek, this project is of low importance, see figure6.

Green Roof

To reduce total impermeable surfaces, we recommend a green roof atop the Whole Foods within the Cranbrook Village shopping center. The green roof will be planted with the species most successful atop the bike parking structure. Although a variety would increase the habitat quality, for maintenance purposes, we don't recommend planting more than five species.

Benefits to Water Quality and Flooding Reduction

By altering an impermeable roof to a vegetated green roof, rates of evapotranspiration will increase and runoff rates will decrease. These two factors will have the combined effect of reducing the peak stormwater discharge. With percent impermeable cover increasing, the peak discharge has become higher and entering streams quicker than prior to industrialization, which negatively affects aquatic organisms. An additional benefit of green roofs is that the energy efficiency of the building is increased because the roof acts to retain heating or cooling efforts. High energy efficiency will lower heating and cooling costs in the long term.[16]

Enlarge Detention Basin Surrounded by Boardwalks

To enlarge the detention area in the southeast portion of the project site, the abandoned home should be purchased. This would be part of a proposal to create a larger detention pond and bioswale, complete with boardwalks and educational signage to simultaneously increase infiltration, storage capacity, and public awareness.

Vegetation should be planted to create a riparian buffer around the basin. Species mentioned in the lowered parking lot section and in Table 4.1 can be utilized.

Benefits to Water Quality & Flooding Reduction

By enlarging the detention basin in this region of the site, we are drastically increasing the amount of water held

Figure 22: intention image of detention basin

during a storm event and allowing the riparian zone to be expanded and regraded. The basin will help slow flows, remove suspended solids and limit downstream erosion. Since the proposed area for the detention basin has been noted as insufficient for a 100 year flood event, it is important to increase capacity to reduce the possibility of flooding.[16]

Rain Garden Median

Finally, rain gardens should be created at various locations along the Eisenhower Parkway median. Since the road is heavily traveled, particulates from brake pads and tires, as well as petroleum derivatives would likely find their way into the nearby creek during storm events. The median will slow this process, increasing infiltration and storage capacity so that polluted runoff does not immediately enter the creek.

A large sediment forebay should be included to slow water as it enters the rain garden from West Eisenhower through a curb cut. Since the velocity of water will be high and the concentration of contaminants large, it is best to slow the water and allow contaminants to settle out in this sediment forebay. Slowed water can then enter the rain garden where vegetation will act to infiltrate and evapotranspirate. Vegetation can be similar to species mentioned in the lowered parking lot island section described above. An overflow device such as a notch in the downslope berm, should be included to account for heavy rain events.

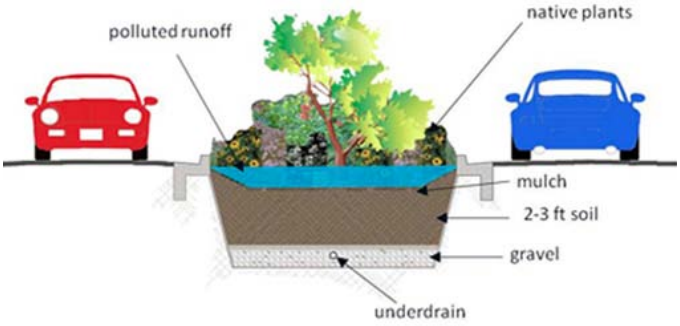

Figure 23: Section Of Of West Eisenhower Rain Garden Median

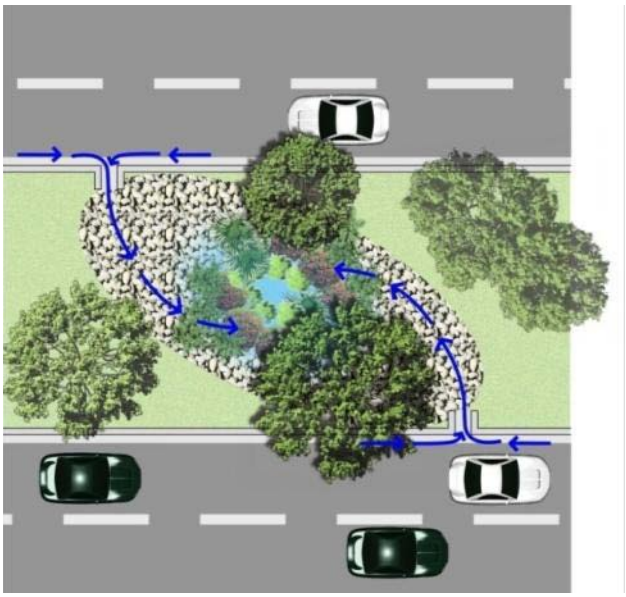

Figure24: Plan Of West Eisenhower Rain Garden Median

Benefits to Water Quality & Flooding Reduction

Roadside rain gardens are “landscaping features planted with vegetation that collect, infiltrate, evaporate, and evapotranspirate runoff.”[22]These lowered areas will allow for contaminants to separate from stormwater as it infiltrates. Although this project would be costly to do throughout the islands, strategically placing only a few rain gardens in this median area generates the benefits of these gardens at a more economical price-tag.

4.4 Maintenance and Monitoring

Proper maintenance and consistent monitoring are essential for the success of all proposed projects. Each project will need to be regularly inspected but the following areas should be prioritized.

Native Plantings

Native plantings must be maintained two to three times per year for the first three years. Maintenance should include removal of invasives, thinning if necessary and pruning as needed. This should occur in parking lot islands, detention basins, West Eisenhower rain gardens, and reforested areas. Volunteers from local high schools, gardening clubs, or individuals performing community service pursuant to a criminal conviction could be partnered with to perform the maintenance.

Rain Gardens, Parking Lot Islands, Runnels and Detention Pond

All rain gardens and parking lot islands should be checked regularly during the first two years to assess drainage. Overflow drainages should be checked after large rain events. Sediment forebays should be removed yearly. All sediment must be disposed of to a landfill because of the high concentration of contaminants. Signage in the parking lot islands could change yearly to maintain people's interests and environmental awareness. Runnels should be cleared of sediment or debris as needed.

Riser Pipe in Western Reach

After large rain events for the first two years, water levels should be monitored to ensure that the detention capabilities are sufficient. If flooding events occur and Phase Two hasn't been implemented, then there is an added incentive to reconstruct the parking lot to increase retention capabilities. If flooding occurs and Phase Two has been implemented, then the pipe may need to be lowered to original levels or more upslope infiltration should be pursued.

Pervious Pavement

It is not necessary to apply salt or plow pavement since snow will infiltrate through pervious pavement. Dry methods like street sweeping should be used if it is necessary to clean pavement.

4.5 Overall Benefits of Proposed Changes

Water Quality & Flooding Reduction

From a water quality perspective, the harmful chemical contaminants are infiltrated through lowed parking lot island, permeable pavement, detention ponds, green bike parking and rain gardens. Litter and organic debris are caught by dumpster enclosures, runnels and rain gardens. Soil erosion and sediment loading events are reduced by native plantings and the urban forest. Native plantings along the creek, detention ponds, runnels and rain gardens shade and cool down the water to reduce events where conditions exist for harmful bacteria to breed.[23]

From the perspective of flooding reduction, the green bike parking, green roof and native plantings in detention basins and rainwater gardens help to increase the evapotranspiration and/or infiltration of rainwater. The cistern harvests rainwater from the roof and reduces runoff. Permeable pavement in the parking lot, rainwater gardens and lower parking islands increase the rainwater infiltration and reduce runoff to the creek. The riser pipe detains rainwater, which alleviates downstream flooding. Adding meanders to the stream will reduce peak velocity and flows by slowing the water and allow infiltration. Additionally, slow water is less erosive and carries less sediments than fast moving waters.[23]

Improvements in Community Livability

Phase Three's detention basin will not only improve water quality and reducing flooding, it will also create a hospitable waterfront space along the creek. Boardwalks surrounding the detention basin and alongside the creek will allow people to walk their dogs, jog along the boardwalk, or sit down to enjoy the beautiful scenery of the creek. At the shopping center, due to better drainage, colorful plantings in islands and interesting runnel feature, people can enjoy a better parking lot environment. Even when there are heavy rains, the parking lot will drain quickly through infiltration. The developing in the northwest zone will not dramatically influence runoff at the shopping center if developed under new stormwater rules that require 100% infiltration.[21]

Creating meanders in the creek will be ecologically beneficial, but studies have also found that a curving streams is more aesthetically pleasing because it appeals to our sense of mystery.[24]Overall, the microclimate of the site will be enhanced with native plantings, added boardwalks for walking and improved water quality.

Promote Economic Development & Property Value

The creek will attract more people than before because it provides a beautiful waterfront space for people to relax, exercise and enjoy. With an increase in potential consumers, more merchants could rent shops at shopping centers or invest along this creek. The apartments and retirement community near the middle reach also have a reason to raise their rent due to the aesthetically pleasing environment and ecological design in their backyards.

The improvements in the waterfront environment will enhance the value of land. As more businesses are drawn to this shopping center, the property value will further be increased.[25]

V.PROJECTED IMPLEMENTATIONCOSTS/BENEFITS

5.1 Costs by Category

Table 5.1 Projected Costs of Improvement Elements

Phase	Activity	Units	Quantity	Unit Cost	O&M Activities	Total Cost
I	Dumpster Enclosure	Unit	2	$1,550 to $3,100[26]	Enclosure must be maintained periodically by businesses.	$6,000
I	Green Roof Bike Parking	Unit	1	$150,000[27]	Roof will need to be planted and maintained to ensure that species planted survive weather conditions.	$150,000
I	Removal of Invasive Plants	Acre	0.838	$438[28]	Continual weeding and invasive removal will be necessary, in case plants grow back.	$363
I	Plant native vegetation in the riparian strip	Acre	1.2508	$1,582 to $2,066[29]	Additional maintenance to ensure plant survive and periodically replant when individual plants die.	$1,979
I	Install a riser in the Western Reach	Unit	1	$12,000[30] $3,000 for installation	The riser will need to be periodically checked to ensure litter and debris is not clogging the caging.	$15,000
I	Whole Foods Cistern	Gallon	10,000	$0.5[31]	Additional costs include labor, site preparations, and plumbing retrofits.	$5,000
I	Plant Native Trees and Plants	Unit	1,000	$6.70[32]	Plant will need to be maintained throughout its lifespan.	$6,700
II	Lowered Parking Lot Islands	Sq Ft	72,113	$35 to $45[33]	Cleaning clogged underdrains, removing accumulated debris and plant material, weeding. ($3-$4/sqft/year)	$2,523,955
II	Permeable	Sq Ft	420,494	$0.5 to $1[34]	Regular street	$420,494

	Parking Lot				sweeping, vacuuming,	
II	Detention Pond I in Parking Lot	Cost/Acre	1	$41,600[36]	Annual maintenance costs can generally be estimated at 3% to 5% of the construction costs[35]	$41,600
III	Purchase House for Detention II Pond	Unit	1	$151,800[37]	Fair market value of $151,800 + fees and costs	$151,800
III	Create Detention II Pond	Acre	1	$41,600[39]	Annual maintenance costs can generally be estimated at 3% to 5% of the construction costs[38]	$41,600
III	Boardwalk in Detention II Area	Sq Ft	13,000	$100[40]		$1,300,000
III	Install Educational Signage Along Creek	Unit	1	$27,462[41]	Monitored periodically for graffiti and typical wear.	$27,462
III	Green Roofs	Sq Ft	72,000	$5 to $20[42]	Additional maintenance to weed, irrigate, replace plants, fertilize & test soil	$1,080,000
III	Rain Garden in Eisenhower Median	Sq Ft	2,047,500	$35 to $45[43]	Cleaning clogged underdrains, removing accumulated debris and plant material, weeding. ($3-$4/sqft/year)	$2,047,500
					Projected Total	**$7.8 million**

Table 5.2 Benefits of Proposed Green Infrastructure

Activity	Unit	Reduction in Stormwater Runoff (38" rainfall / year)	Annual Savings
Reforestation	1000 medium size trees (Red oak)	1,129,000 gallons	12,670
Green Roof	5,000 Sq Ft 72,000 Sq Ft	71,100 gallons 1,023,840 gallons	$708.75 $10,206.00
Detention Basin	2,000 Sq Ft	113,760 gallons	

	43,560 Sq Ft	2,477,692.8 gallons	
Permeable Pavement	5,000 Sq Ft 420,494 Sq Ft	94,800 gallons 7,972,566.24 gallons	$175,573/acre[44] or $1,694,843.73
	Known site specific annual totals:	12,603,099.04 gallons reduced	$1,717,719.73 saved

With annual savings over $1.7 million per year, our plan will pay off its $7.8 million total within eight years and continue saving investors' money by capturing stormwater runoff, infiltrating rainwater and slowing Malletts Creek to reduce water quality impairments and flooding downstream.

5.2 Potential Funding Sources

State Grants

Michigan's Stormwater, Asset Management and Wastewater program "provides grants for the development of plans to identify and manage stormwater or wastewater assets, stormwater treatment management plans, planning and design of sewage, stormwater, or nonpoint source pollution reduction projects, and the testing and demonstration of innovative water quality improvement projects."[45] The fund also makes low interest loans available for projects in an asset management program or those included in an approved stormwater plan. The maximum available grant is $2 million per municipality. Furthermore, the Strategic Water Quality Initiatives Fund makes low-interest loans available to municipalities for removal of groundwater or storm water from sewer systems.[46] Ten to twenty million dollars are available for loans through this fund are available annually.

Tax Increment Financing

To help facilitate the development of the vacant parcel northwest of Whole Foods with a sustainable mixed-use development, the municipality could offer tax-increment financing (TIF). TIF allows the government to harness the power of private investment and increasing tax bases to eventually pay off public investment. Although initially the government secures bonds to share the cost of developing the property, this investment system has been popularized as a way to revitalize areas so that redevelopment is not only done by the rich, for the rich.[47]In the proposal mentioned in this assessment, the government's investment could be conditional on the development utilizing stormwater best management practices to ensure that the site is developed responsibly.

Tax Incentives

In order to convince businesses to independently finance certain elements of this proposal, the municipality could offer tax incentives for things such as green roof installations. For example, property owners in New York City are eligible to receive a one-year tax credit of up to $100,000 for green roofs that cover more than half of the building's surface area.[48]The incentive is meant to offset a quarter of the cost for green roof installations, helping to encourage property owners to look past the initial cost of construction.

Public/Private Partnerships

Additionally, the municipality can work with businesses and parcel owners to get these private parties to make investments in green infrastructure without public funding. For instance, for proposals that will reduce energy or water bills within a business, it may be a financially sound

investment for the business to install changes on their own. Government agencies can provide private parties with educational information as to the benefits of green infrastructure and how installing sustainable stormwater management techniques may help to: increase rents and property values, increase retail sales, save energy, reduce infrastructure costs, reduce costs associated with flooding, reduce water bills, and increase mental health and worker productivity.[25]Since the West Eisenhower site has so many socially and environmentally conscious businesses located within it (e.g., Whole Foods, REI), there may also be an appeal to the customer base that could increase sales within stores that invest in green infrastructure.

CONCLUSION

In conclusion, this project aims to reduce water quality impairments and flooding incidents on site and downstream. The three phases are cost-effective in the long term and advantageous ecologically, aesthetically and economically. With increasing urban development causing faster, warmer and more contaminated stormwater runoff and with climate change predictions that precipitation rates will increase, it is becoming increasingly important to design stormwater structures that are resilient. Resilient stormwater structures not only can slow, clean and cool water, they must also provide habitat in a fragmented landscape and be socially accepted. Our inclusion of native plantings, meandering stream restoration, and a boardwalk aim to increase the multifunctionality and long term success of the West Eisenhower site.

FIGURES

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