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Green Stormwater Infrastructure For the Town of Maynard, MA

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INTRODUCTION

Non-Point Sources of pollution from urban impervious surfaces and suburban lawns conveyed by stormwater and snowmelt are a big problem. Many state governments as well as the EPA believe that non-point sources (NPS) of pollution are actually the greatest contributor to the contamination of our waterways, and yet these are harder to regulate as they are not subject to the Federal CWA requirements because they are from runoff (Dorestant et al., 2017). The primary regulatory regime for mitigating NPS pollution—including runoff from urban/suburban lawns—is by the Clean Water Act's Municipal Separate Storm Sewer System (MS4) stormwater management program, which applies to urban areas whose (partially) separated stormwater and sewer infrastructure generates surface runoff that is not treated by the sewer system (Eanes & Zhou, 2020). Municipalities have gradually come to accept their role in water quality protection as they have been required to conform to the MS4 National Pollutant Discharge Elimination System (NPDES) permit requirements to discharge urban runoff.

However, many municipal governments may remain reluctant to actively enforce the volume of site-specific actions specified in the various states' General Permits (Cross & Duke, 2008). That kind of enforcement conflicts with the long-held view of these agencies as serving and protecting their constituents, not adding regulatory burdens for them. "Few or no programs specific to MS4 permit holders have had powerful influences in promoting compliance among industrial facility operators (Cross & Duke, 2008)." This is not surprising if MS4 permit holders typically decline or de-emphasize any role in promoting, enforcing, or supporting statewide permits (Cross & Duke, 2008). Nonetheless, the careful evaluation of tenable alternatives to monitoring and the benchmark comparison approach that comes along with it, seems even more crucial in light of the escalating consequences inherent in the proposed 2020 NPDES Multi-sector Stormwater General Permit (MSGP) changes. Therein, content has shifted from one that reinforces best stormwater practices at sites to more rigorous mandates and specified implementation measures yet to be finalized by the EPA (Kirschner, 2020). As NPS is hard to pinpoint at the source, satisfying permit requirements by testing water at the downstream end of the pipe provides yet another practical difficulty of monitoring and treating each outfall as needed. The municipalities operating MS4 networks often endeavor to meet downstream regulations by implementing upland urban land use policies that enable individual landowners to decrease the amount of contaminants being washed off their property (William et al., 2020).

From the perspective of a local government, municipal separate storm sewer systems (MS4s) are designed to cut down, to the 'maximum extent practicable' (MEP), sediment and contaminants with potential to enter a waterbody through a stormwater sewer system (Dorestant et al., 2017). In order for this overflow in the system's capacity to not occur, alternate methods--sometimes a combination or hybrid of green infrastructure and grey infrastructure-- are warranted to capture, store, and infiltrate stormwater runoff. As municipalities brace for today's increased federal regulatory pressures alongside climate change predictions indicating larger and more frequent storm surges mirrored with periods of drought, measures made towards flood defence and drought-risk mitigations through comprehensive Green Infrastructure (GI) planning and design could commence as a no-regrets strategy. The full array of GI benefits found within healthy vegetation, biodiversity, and habitat linkages are realized as they become established and mature, which simultaneously decreases the degrees of maintenance needed to ensure their effectiveness.

GI benefits not only address regulatory compliance measures related to stormwater runoff pollutant capture and flood mitigation on site, but also provide a myriad of other co-benefits that illustrate adaptive measures to bolster communities against climate change impacts. The suite of benefits will vary based on the GI practice and included flood risk reduction method used, so beyond reductions in stormwater volume and the total phosphorus and total suspended solids that comes along with that, air pollution reduction and an additional scenic amenity value alongside CO_2 storage capacity increases through Green Stormwater Infrastructure (GSI) (Nordman et al., 2018). Rain gardens are shown to provide the highest carbon sequestration potential which offsets its embodied carbon footprint. Carbon sequestration of bioretention basins, green roofs, vegetated swales and stormwater ponds can mitigate approximately 70%, 68%, 45% and 8% of their carbon footprint respectively (Kavehei et al., 2018).

GSI can be considered a purely public non-rival and non-exclusive good when implemented comprehensively through municipal ordinances and regulations as everyone can benefit from it without worry of its use triggering less availability to others or that the municipality would exclude anyone from enjoying its benefits. However, there is little incentive for private landowners to invest in stormwater management practices as these since the benefits of their actions would manifest to their downstream neighbors (a free-rider problem) (Nordman et al., 2018).

Inherent in its nature as a distributive public asset, Green Infrastructure is a socially equitable solution providing benefit to people throughout a community as opposed to a centralized approach that only provides accommodation to those in proximity to it. As a comprehensive planning strategy, GI design and implementation can help restore some of the historical inequities that were intentionally built to punctuate the disservice of marginalization and environmental injustices that have yet to be fully dismantled to this day.

GREEN INFRASTRUCTURE

Green Infrastructure (GI) refers to ecosystem service solutions that provide human benefit. This is arrived at through its inherent existence-value present in the conservation and protection of ecoregions (**Image 1**), or can be constructed for discrete solutions related to stormwater management in the form of bioswales, rain gardens, or green roofs (**Image 2**). In either manner of representation, the mature presentation is biodiverse in its optimal state. The origins of GI nomenclature was meant to serve as a tactic to elevate this concept to the same level as engineered or constructed infrastructure, and thus encourage the planning, design, and investment in GI to follow a built infrastructure approach (Benedict, 2006). In addition to ecoregion specification of wetland, forest, prairie, or critical habitat, the use of green infrastructure can also refer to an intention to create an interconnected network (**Image 1**) of these features to facilitate necessary linkages for people and wildlife (Munoz-Criado, 2016).

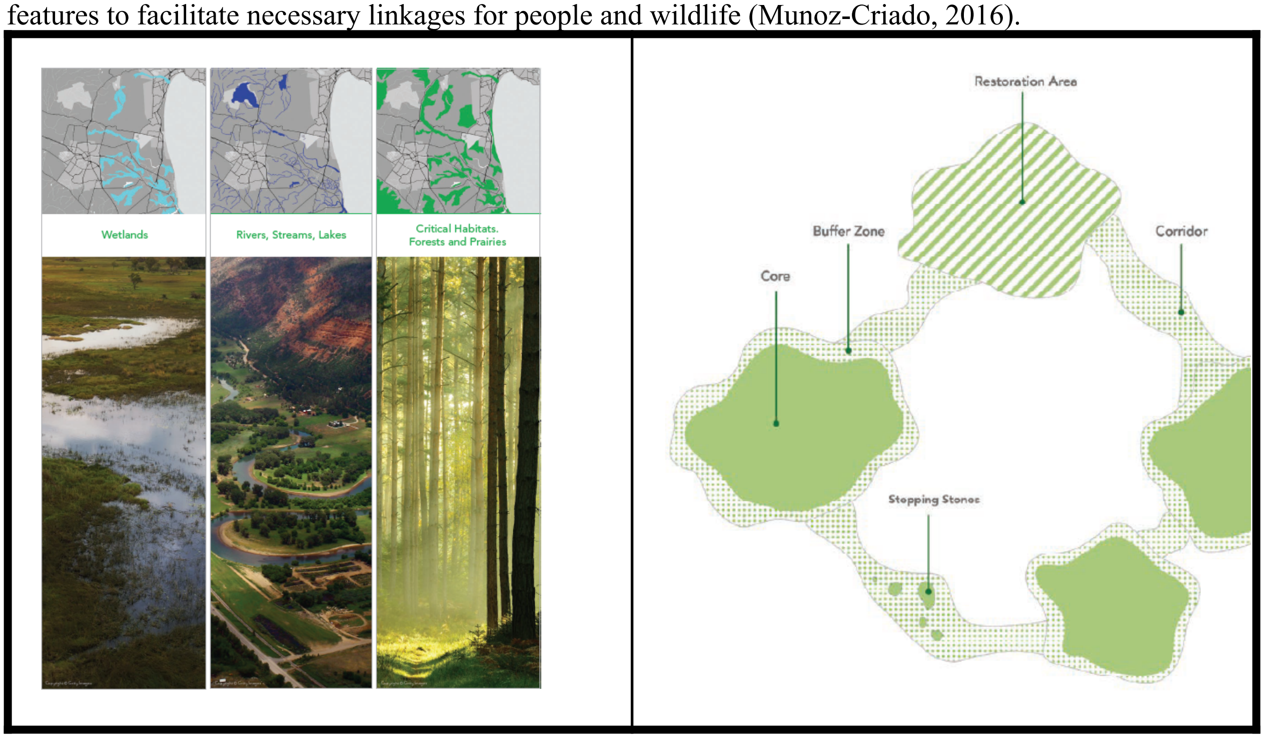


***Image 1**: (Munoz-Criado, 2016)*

Large-scale approach to the management of these ecosystem service solutions can allow for the multiplication of benefits to be captured. The benefit of public ownership of implementation sites with

green stormwater infrastructure is that it conveys continued maintenance through existing management programs which ensures protection of these public assets (Boyer & Kieser, 2012).

Stormwater Management

Even with the decades-long decrease in national industrial production alongside the CWA's regulation of pollution point sources water quality in rivers as improved, NPS pollution—chiefly stormwater conveyed pollutants from urban/suburban lawns—remains a driver of water quality impairments (Descher & Sinasac, n.d.). As is the case in municipalities located along rivers of old mill and textile-dependent towns and cities in the Northeast, the wake of industrial development from European settlement and the forced displacement of indigenous peoples, like the Wabanaki of Androscoggin County, Maine, USA, represent a cultural historical relic as well as an impervious surface continuum adjacent to rivers (Eanes & Zhou, 2020). When these areas are deemed historical and limitations are thus set on any additionalities to the site, restoration of native plantings and pre-industrial habitat configurations might also predate the industrial mills providing place for consideration as to what historical relic is meant to be served by preservation standards and inquiry into which meets the needs of today's changing ecosphere and our human biological support system?

Reduction of peak flow runoff volume generates an environmental and human benefit of improving water quality as those waters will be filtered and retained through vegetation if Green Stormwater Infrastructure (GSI) is implemented. This provides the social additionality of improved water quality with the increased green space and pleasurable aesthetics that come along with diversifying the hardscapes that tend to dominate human habitats and corridors (Panos et al., 2020). From the perspective of a local government, municipal separate storm sewer systems (MS4s) are designed to cut down, to the 'maximum extent practicable' (MEP), sediment and contaminants with potential to enter a waterbody through a stormwater sewer system (Dorestant et al., 2017). In order for this overflow in the system's capacity to not occur, alternate methods--sometimes a combination or hybrid of green infrastructure and grey infrastructure-- are warranted to capture, store, and infiltrate stormwater runoff. Healthy and well managed ecosystems can act as ecological infrastructure to buffer against these common hazards.

***Image 2**: Philadelphia Water Department. June 1, 2011. Green City Clean Waters Program Summary*

Stormwater management practices utilizing ecosystems and their vegetation to infiltrate and recharge groundwater reduce overflow on grey stormwater/sewer infrastructure by capturing runoff from

impervious surfaces before it goes into those systems. When stormwater and snowmelt are kept on site and directed to bioswales, rain gardens, or catchment basins lined with soil and vegetation, the pollutants from ground surfaces have an opportunity to be processed on site through bioretention and recharge the groundwater supply with higher quality water than if let to runoff untreated into water bodies.

GI performance and the ecological services for human benefit they provide would reduce municipal regulatory burdens once implemented as they require less continual monitoring once vegetation matures. State stormwater runoff management programs provide an avenue for control as pollutants from land area runoff of impervious surfaces released into the nearby waterways could be mitigated or remediated through Green Infrastructure (GI) regulations.

Design Strategies

No single GI practice will be appropriate in all situations. GI practice choice should be driven by the site and budget. Porous asphalt is an attractive GI practice given that parking lots are necessary and maintenance costs are comparable to those using conventional asphalt (**Image 5**). Rain gardens are low-cost and attractive options for small sites like homes and street corners. Infiltrating bioretention basins can be effective for treating larger areas of impervious surfaces. If scenic and recreational amenities are incorporated into the design, they may be even more cost-effective (Nordman et al., 2018). Developing partnerships with local stakeholders is key for facilitating collaboration toward common goals, interests, and likely implementational ease as in the Portage-Arcadia Watershed of Michigan. Western Michigan University (WMU) is a permitted Municipal Separate Storm Sewer System (MS4) along Arcadia Creek (**Image 3**) and the West Fork of Portage Creek in Kalamazoo, Michigan and as a part of their approved stormwater management plan they established partnerships with the City of Kalamazoo, the Michigan Department of Transportation (MDOT), Michigan Department of Environmental Quality (MDEQ), Kalamazoo River Watershed Council, and other local watershed stakeholders (Boyer & Kieser, 2012).

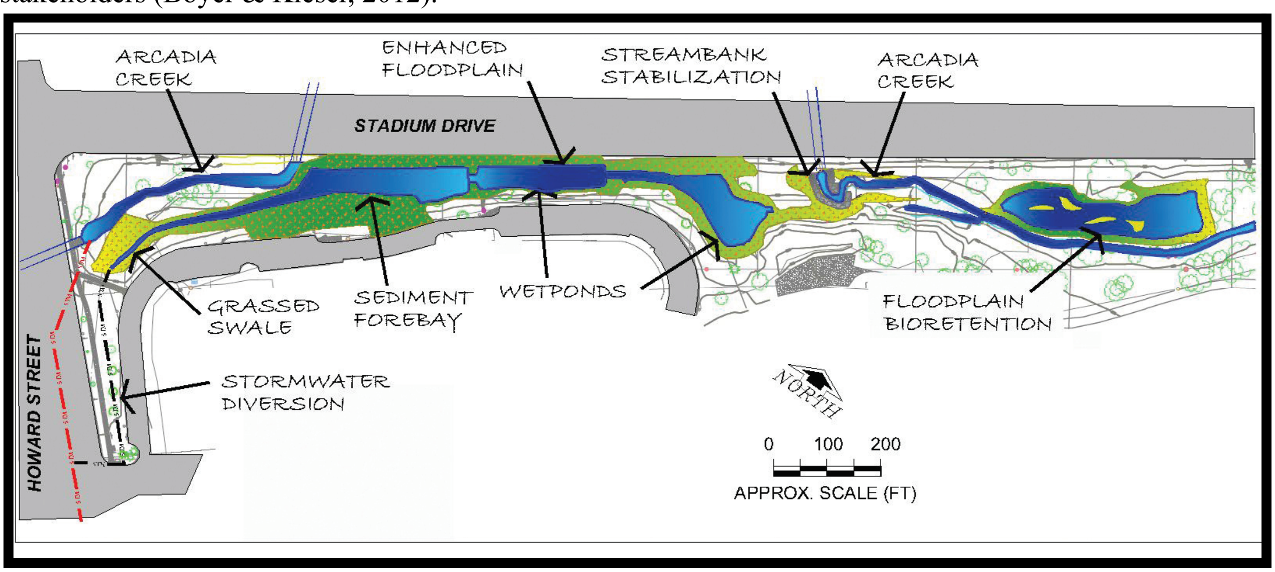


***Image 3**: Conceptual schematic of new WMU stormwater treatment areas along Stadium Drive, Kalamazoo, Michigan. (Arcadia Creek Project, Site #1.) (Boyer & Kieser, 2012)*

Other successful results of close collaboration took place within the Androscoggin Valley Stormwater Working Group (AVSWG) in central Maine, USA. The AVSWG is the multi-partner governance unit which manages the MS4 permit for four municipalities. The study done on this permit heavily focuses on what dictates individual-level behavior, and in doing so recognized the importance and influence that broader structural and sociopolitical factors like collaboration have to positively impact that (Eanes & Zhou, 2020). A broader transboundary collaboration can also help to support watershed-scale analysis and modeling for LID effectiveness over temporal and spatial scales. Hydrologic modeling is

becoming increasingly important to truly understand cumulative effects of LID at watershed scales. In order to inform regulations more appropriately, LID placement and treatment areas should be examined through watershed-scale modeling studies (Panos et al., 2020). LID placement for runoff reduction is greater than its storage capacity and sizing.

Low Impact Development (LID)

LID is a site design practice related to land use planning that employs environmentally friendly stormwater management approaches to maintain pre-development hydrology and drainage characteristics to reduce or eliminate stormwater runoff as an additionality to new or redevelopment. Effort is made to manage runoff at the site using smaller integrated stormwater management practices that often fall within the realm of Green Infrastructure. Examples of these solutions include porous paving systems, biofiltration, rainwater harvesting, green roofs, and bioswale infiltration systems to capture and convey the stormwater towards groundwater recharge. Effort is made during site design to minimize the amount of impervious cover created, while conserving crucial natural habitats, and retaining stormwater runoff on site. When converting pervious areas to LID, placement is more important for runoff reduction than storage capacity/sizing, and thus should remain an important consideration in LID modeling to achieve overall effectiveness of the implementation (Panos et al., 2020).

Implementation of Low Impact Development (LID) can be triggered through regulations for new and redeveloped residential and commercial locations with GI ordinances inside urban areas to ensure these benefits outweigh any disservices to traditional construction. To improve regulatory processes, revised regulations that aim to mitigate the effects of redevelopment should explicitly consider the design considerations of LID placement, area treated by LID, and outflow routing, in addition to LID sizing. Many states (e.g., Georgia, Kentucky, Mississippi, South Carolina, Tennessee, Indiana, Montana, North Dakota, Utah, and Nevada) base current redevelopment standards on capturing a certain size storm, or the first inch of rainfall (Panos et al., 2020).

A regional approach for larger network integration would help designate LID placement based on watershed assessment for implementing broad Green Infrastructure programs through the connection of watershed partners, conservation commissions, greenway initiatives and the like. This can be done alongside discrete efforts triggered by municipal regulations and landscape ordinances.

Management | Best Practice | Strategic Approach

GI is a no-regrets strategy with multiplication of benefits expressed at any time. "Green infrastructure management activities need to be directed toward one or more outcomes, such as protecting the water supply, increasing the number of migratory birds, restoring a specified area of wetland habitat, and so forth (Benedict & McMahon, 2006b)." This is true since there will always be co-benefits related to the implementation of GI. There may be one cardinal goal to a GI project objective and yet it will inevitably have other positive impacts. Making auxiliary benefits explicit will ensure a broader base of support is curated perhaps providing a pathway for additional management partners, while also validating comprehensive management plans that address the needs of all the outcomes.

Existing plans can also be the basis for elaboration towards GI. "For example, in the descriptive materials for plans, look at the key features largely ignored, overlooked, minimized or missing: (1) habitat, species diversity, and rare species; (2) environmental monitoring, management, and improvement; (3) hydrologic groundwater protection and habitat restoration;(4) habitat connectivity for regional wildlife movement; (5) ecological impact of traffic noise and pollutants; and (6) adaptive management for water conservation, stormwater runoff control, energy use, and water and air pollution. Existing communities have to address such issues by retrofitting. (Forman, 2014)" It is true that planners are not often having to start from scratch, and likely retrofitting will need to happen at both short and long-term scales.

There is a natural progression towards partnership in something as interconnected as Green Infrastructure. There can be partnership within bodies of a municipality and partnership across sectors and disciplines. To identify partnership potential first consider what the intended function of the GI is to be, and what the driver is that benefits from that function. For example, pollution could be a driver for a GI

implementation and environmental improvement would be the function of that GI. This benefit-function relationship can then be matched with a particular stakeholder or agency that intersects with the aim (Ibrahim et al., 2020). When engaging in multi-stakeholder partnerships it is important to clearly identify delineation of roles be it design, implementation, maintenance or funding (**Image 4**). These roles will present among state, private agencies, and community groups as internal factors. Learn from other municipalities, integrate with other city initiatives, continue to engage stakeholders and the public for compliance with MS4 permit (Dorestant et al., 2017). The external issues related to leadership, financial solvency, regulations and political context will all influence the speed and quality of implementation of GI (Ibrahim et al., 2020). Green governance is aimed to mediate between the internal and external without compromising the objective of sustainable management of water quality, flood mitigation and the ecology of a waterway (Ibrahim et al., 2020).

Image 4: *A. Ibrahim et al. / Journal of Cleaner Production 261 (2020) 121202. Fig. 1. Factors influencing the performance of Green Infrastructure*

It is important to make explicit the interests and concerns related to stormwater. For example, in the case of Western Michigan University, theirs included not only MS4 stormwater permit requirements, but also total phosphorus TMDL compliance requirements, campus flooding and infrastructure protection, and long-term sustainability toward Stormwater Neutral™ status for total phosphorus (i.e., "net-zero" phosphorus loading) (Boyer & Kieser, 2012).

Municipal regs should include fostering biodiversity and native plants and forgo limiting wood debris for aesthetics as it provides habitat. Concerning stormwater, landscape ordinance goals often state how sites should be developed and managed to prevent erosion and flooding or to retain water on properties as compared to other ecoregions where SW objectives focused on landscaping or water quality issues (Larson et al., 2020) Conserving natural areas, street trees, and rain gardens are all robust to cost benefit sensitivity analysis. Even under the worst case scenario (ten percent higher costs and lower benefits) these practices resulted in positive NPVs (Nordman et al., 2018). Similar to existing native or climate-adapted plant guides, guidelines for maintaining aesthetically appealing landscapes that offer wildlife or other environmental benefits could encourage more sustainable landscaping practices.

Outreach and educational materials as well as campaigns designed to influence lawn care behavior of individual urban/suburban residents may benefit from emphasizing not only the potentially

desirable outcomes of adopting stormwater-friendly BMPs (i.e., attitudinal dimensions), but also the ease and straightforwardness of doing so (i.e., PBC dimensions). Likewise, such efforts may benefit from activating individuals' response to local social norms (Eanes & Zhou, 2020). The flyers or demonstration events could highlight recognizable individuals in a given neighborhood that have committed to adopting stormwater friendly BMPs, and/or could highlight the proportion of residents in a neighborhood that have decided to forgo pesticides and fertilizers (including how this proportion has grown over time, if known) (Eanes & Zhou, 2020).

GREEN INFRASTRUCTURE FOR STORMWATER MANAGEMENT

Benefits of GI

Economic Benefits

Calculating the net economic benefits & costs of stormwater management using GI is possible. One example which came out of Grand Valley State University is the Rainwater Rewards calculator (http://www.RainwaterRewards.com). This accessible tool meant for citizens, landowners, and policy makers alike calculates ecosystem service values of green infrastructure within specific census blocks in Michigan. This model was developed alongside the INtegrated Valuation of Ecosystem Services Tool (INVEST) (http://www.gvsu.edu/wri/invest/) to educate community planners and landowners about the value of ecosystem services associated with non-urban land uses (Nordman et al., 2018).

Of the constructed Green Infrastructure practices, green roofs like the ones installed in Grand Rapids MI, were chosen to satisfy LEED certification, as on their own they are more cost than benefit. Studies have shown that LEED certified office buildings rent at a premium of 4-7 percent as compared to similar, non-certified buildings (Nordman et al., 2018). This may help to offset the additional $129/m3 WQv premium over a standard roof, of which only $82.06/m3 WQv has substantial present value benefits (**Image 5**) (Nordman et al., 2018).

Table 4
Net present value of six green infrastructure practices.

Infrastructure/GI type	GI size (for 84.95 m^3 WQv per 25.4 mm event)	PV benefits ($/$m^3$ WQv)	PV cost GI ($/$m^3$ WQv)	PV cost of gray ($/$m^3$ WQv)	Net Present Value ($/$m^3$ WQv)
Porous asphalt	3520.75 m^2	$38.08	$148.62	$131.83	$21.29
Green roof	3455.99 m^2	$82.06	$344.26	$215.02	($47.17)
Rain garden	199.28 m^2	$75.31	$38.44	–	$36.87
Infiltrating bioretention	283.26 m^2	$46.08	$49.83	–	($3.76)
Conserve natural area	3520.75 m^2	$181.19	$72.40	–	$108.79
Street tree (tree pit)	342 trees	$168.88	$122.94	–	$45.94

Table 5
Sensitivity analysis (10%) for best and worst case scenarios.

Infrastructure/GI type	Base case NPV ($/$m^3$ WQv)	Best case scenario NPV ($/$m^3$ WQv)	Worst case scenario NPV ($/$m^3$ WQv)
Porous asphalt	$21.29	$53.14	($10.56)
Green roof	($47.17)	$16.95	($111.31)
Rain garden	$36.87	$48.25	$25.50
Infiltrating bioretention	($3.76)	$5.84	($13.34)
Conserve natural area	$108.79	$134.15	$83.43
Street tree (tree pit)	$45.94	$75.12	$16.76

Image 5:*(Nordman et al., 2018)*

The American Forestry Association estimates that a fifty-year-old urban tree saves seventy-five dollars a year in air conditioning, seventy-five dollars a year in stormwater and soil erosion control, seventy-five dollars a year in wildlife shelter, and fifty dollars a year in air pollution control (Benedict & McMahon, 2006a). In the Delaware Valley, experts have quantified the benefits of the collection of trees within the area's urban forest. They remove 1.7 million pounds of air pollutants each year, a value

estimated at $3.9 million annually; they store an estimated 26.8 million tons of carbon; and sequester nearly 8,585 tons of carbon each year (Benedict & McMahon, 2006a). This is an important metric for city planners, conservationists, and economists who need to speak on behalf of the compounded benefit trees exchange to humans. Wetlands are also known to have the greatest carbon sink potential by soil type. Massachusetts' Blue Carbon Calculator (https://www.mass.gov/blue-carbon-calculator) is a tool for quantifying carbon sequestration for restored wetlands. Wetland restoration is an important objective seeing as how approximately 80 percent of the wetlands that existed in mid-century have been drained. This not only reduced their ability to act as a natural storage reservoir for flood waters it also enabled the water to run off more quickly (Benedict & McMahon, 2006a), and as we now know, decreased carbon sink capacity in doing so.

Not only do working lands, such as sustainably managed agroforestry, support many local economies, they also have been shown to cost communities less in service delivery. Studies show that farming and forestry generate more revenue than they require in public services (schools, road maintenance, water and wastewater, etc.), while residential development has the opposite effect: residential lands typically demand more in service costs (Benedict & McMahon, 2006a). This is an important insight into how tax dollars are spent. Too often we do not consider this impact as residents and imagine that more people living in an area means more tax revenue for the town, but this is a perfect example of how towns with working lands are an important distributional factor of tax dollars to public services and municipal revenues. Residents have a real stake in supporting their farms and local agroforestry product industries, not only through dedicated purchasing but protecting them from development as it benefits the local communities as a whole.

As the vegetation within a green infrastructure function matures it requires less maintenance, which in turn decreases the amount of dollars spent on maintenance, translating to a benefit value that increases over time. Grey Infrastructure, on the other hand, degrades over time requiring more dollars spent on continual maintenance or replacement as it ages. Not only does GI provide provisioning and resource revenue which when spent locally has a compounding positive impact for a community, it also increases property values and insights ecotourism to the area, especially when GSI is integrated into larger greenway linkages and urban centers.

Social Benefits

Human (Social | Public) Benefits & Disservices

GI facilitates social co-benefits to those of ecological importance through aesthetics and increased green space (Panos et al., 2020). Energy conservation is also achieved from the shading and cooling that street trees provide in warmer climates reducing energy bills and subsequently lowering carbon emission and hot spots (Larson et al., 2020). However social realm benefits are in the eye of the beholder. Neat and orderly landscapes tend to meet aesthetic preferences in private residential lots over naturalistic landscapes which appear messy or unkempt even though they provide ecological benefits. With the social norm emphasis on well-maintained and weed-free yards, the landscapes which provide vegetative structure to support local wildlife could be constrained by design (Larson et al., 2020). Since green infrastructure is inherently visible, social norms direct whether their presence negatively or advantageously affects the observed value of a home and neighborhood. The halo effect, where one is assumptive of positive attributes based on previous encounters, is particularly strong with regards to green infrastructure. Not only does the display of neighbors' yards have iconic impacts on individual preferences, but cues to care are also contagious (William et al., 2020).

Adopting stormwater Best Management Practices (BMPs) through GI presents more positive than negative benefits for people. It aids in keeping drinking water sources clean and thus protects the health of people, while it increases recreational opportunities and expands the sense of community pride (Eanes & Zhou, 2020).

With regard to social capital, studies have found that living in greener neighborhoods and using parks are affiliated with greater social cohesion, increased strength and extent of social networks, or both. (Frumkin, et. al, 2017). Parks and green neighborhoods certainly draw people out of their homes, likely

simultaneously when bookending a normal workday, and as such can facilitate incidental run-ins with neighbors or friends that build social cohesion. This sense of social connection leaves positive feedback, stimulating seeking out or routine behavior in this regard.

A Current Example of Green Stormwater Infrastructure at a Municipal Scale

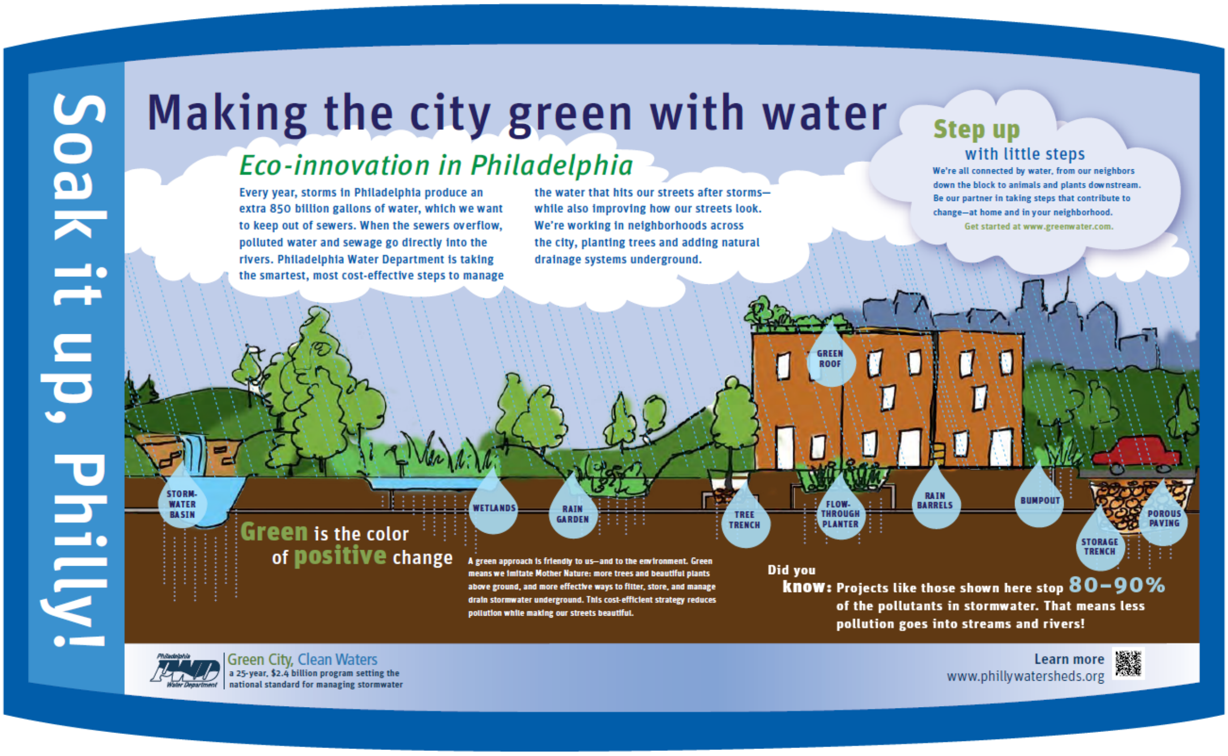


Image 6: *Image Source: Allison Rooney Communications (https://alisonrooney.com/2016/10/31/buy-in-for-a-green-citys-clean-waters/)*

Across the country municipal water utilities are and will continue to experience increasing pressure from today's complex environmental, demographic, and financial challenges. This will need to be reconciled in balance with increasing expectations from residents and businesses for a safe and affordable water supply. The City of Philadelphia is meeting these challenges in a revolutionary way. Typically, municipalities place significant investment in hard infrastructure to provide Combined Sewer Overflow (CSO) systems that channel residential wastewater and any stormwater collected in the sewer to a wastewater treatment plan. This methodology requires a cacophony of chemicals and miles of pipes, demanding energy to pump and distribute which draws on energy sources that often increase greenhouse gas emissions. Philadelphia is catalyzing a paradigm shift in their approach to urban water resources. Philadelphia's local government agencies are breaking out of their narrowly defined traditional roles with planners and politicians on board so they can better collaborate toward larger goals like the Green City Clean Waters Program. This initiative represents the City of Philadelphia's commitment towards meeting regulatory obligations while helping to revitalize their city.

Philadelphia's *Green City, Clean Waters* program will be the first in the country to utilize a green stormwater infrastructure (GSI) plan as their primary tool for regulatory compliance for stormwater management. Their water department is paying close attention to stormwater as well as flood protection to tie objectives for maintaining clean, attractive, fishable, swimmable rivers and streams together with those aims. By implementing vegetative pathways for infiltration, the city will be able to achieve elimination of mass pollutants system-wide that otherwise would be removed by the capture or overflowed into streams, to the degree of 85% by volume during precipitation events every year (Philadelphia Water Department,

2011). In addition to increasing the Philadelphia Water Department's capacity to implement green stormwater infrastructure throughout the City, a neighborhood outreach and planning protocol is being developed with intention to replicate resident-scale interventions throughout the City. The first step is to educate even more residents about the Green City, Clean Waters vision. When successful communication is reached, residents will be informed of challenges and opportunities that exist when planning for green stormwater infrastructure. The aim is to engage residents in identifying their own best opportunities for green infrastructure within the neighborhood where they live.

More than $360 Million has already been committed to the Green City, Clean Waters program from private sector development plans, watershed management commitments, capital project planning, and educational and outreach programs (Philadelphia Water Department, 2011). The stakeholders involved in the implementation and promotion of this ambitious project is extensive. This includes the City of Philadelphia's Streets Department, the Mayor's Office of Sustainability, Philadelphia Parks & Recreation, the Planning Commission, the Office of Housing and Community Development, the Housing Authority, School District, Parking Authority, Redevelopment Authority, Licenses and Inspections, Zoning Commission, Commerce Department, Philadelphia Industrial, Development Corporation, Health Department(Philadelphia Water Department, 2011).

The Philadelphia Water Department's (PWD's) Green City, Clean Waters program integrates the management of the city's watersheds into a larger context. It is designed to provide many benefits beyond the reduction of CSO use, so that every dollar represents maximum return of benefits to the public and the environment. PWD is framing the Green City, Clean Waters program through a social, economic, and environmental triple bottom line lens.

An important performance goal used as a metric of achievement is a 'Greened Acre.' Each Greened Acre represents an acre of impervious cover within the combined sewer service area that has at least the first inch of runoff managed by stormwater infrastructure (Philadelphia Water Department, 2011). This includes the area of the stormwater management feature as well as the area where it drains to. One acre receives one million gallons of rainfall each year. Unfortunately, if the land is impervious, it all runs off into the sewer and becomes polluted. A Greened Acre will stop 80–90% of this pollution from occurring. Similarly, this percentage is representative of the overall goal to reduce the load of the CSO by 85% volume, which can be done through this approach.

Currently, forty-eight percent of the City of Philadelphia, or about 64 square miles, is within the combined sewer system drainage areas. Four watersheds, generally comprising the older areas of the City of Philadelphia, receive CSO discharges. The City of Philadelphia has one of the first sewer systems in the country, with segments dating to the mid 19th century (Philadelphia Water Department, 2011). Much of that original infrastructure is still operational today. PWD's has an ardent and significant commitment to continuously inspect and maintain the 3,000 mile system in order to sustain the use by City residents for years to come. This project is not meant to fully replace their current CSO system but rather to deal

appropriately with the overflow that can be disruptive to the natural waterways during storm surges that push untreated sewage and pollutants from runoff into water bodies. *Image 7 Source: Allison Rooney Communications (https://alisonrooney.com/2016/10/31/buy-in-for-a-green-citys-clean-waters/)*

The origin of this initiative can be traced back to negotiations with the Pennsylvania Department of Environmental Protection (PA DEP) in September, 2009 when the city submitted its CSO Long Term Control Plan Update (LTCPU). Therein was an explanation of how this vision matured from Philadelphia's history of extensive watershed analysis and planning, along with local and national policy trend influences. In 2011, Philadelphia began implementing Green City, Clean Waters. Projected as a 25-year plan, the Green City, Clean Waters project is meant to meet regulations related to combined sewer overflows. Unique in its scale and innovation, the City of Philadelphia's investment is estimated to be anywhere from $1.2 billion to $3 billion over the lifespan of the program (Philadelphia Water Department, 2011).

Especially foundational to this program is the backing of the Mayor, Michael Nutter, who has spoken openly about making Philadelphia "The Greenest City in America," with commitments to reduce the City's exposure to increased energy prices, to expanding environmental footprint, and economic development towards the emerging green economy. Having strong leadership commitment creates ease in partnership building and momentum. His creation of the cabinet level Office of Sustainability and a Sustainability Advisory Board sanctions the commitment. It represents public, private, and nonprofit interests which are crucial for narrative development and buy-in across sectors for relatability and representation in the plan.

Methods & Analysis

There are many areas positively impacted through the implementation of green infrastructure for stormwater management in the City of Philadelphia's plan. They include social equity components, economic benefits, as well as environmental health which impacts and benefits the health and wellbeing of the communities. In terms of equity, because Green Stormwater Infrastructure (GSI) is dispersed and distributed throughout the city, that means it will be in every neighborhood as opposed to concentrated to discrete areas. Of the public projects led by PWD, 85 projects have created new or improved public open spaces such as parks, playgrounds, and schoolyards in low- to moderate-income communities, predominantly communities of color ("Green Stormwater Infrastructure," 2020).

Another positive benefit represented through the social sphere is the reduction of the heat island effect. GSI will reduce this heating by providing the cooling of tree shading as well as any other green roofing techniques which can provide direct cooling benefits to the buildings on which these are installed. Green walls can similarly function as not only a stormwater processing agent and a thirsty receptor for vegetative growth, but the healthy plantings will provide shading in the summer reducing cooling needs as well as insular qualities in the cooler months which brings economic benefit to homeowner's utility bills. Comprehensive public and private investments will equitably advance public health and safety through this method. Decreased energy consumption subsequently reduces air pollution and greenhouse gas emissions further compounding the health benefit from GSI in neighborhoods. Finally, this is all linked to the health and wellbeing of the residents. Research consistently shows that access to parks and green spaces for recreation reduces chronic disease and stress rates while also improving mental health and function ("Green Stormwater Infrastructure," 2020). It is easy to consider connecting green infrastructure with walking and biking pathways so residents feel socially connected to their community while being provided with safe and attractive pathways to access the services of their town.

This greening pathway continues to carry a local economic benefit, not only for bringing residents to town for local services, but also because GSI projects involve activities (like planning, design, construction, supply, etc) that provide significant local opportunities for implementation. The use of GSI then becomes a tool from which to rebuild the economy equitably and with climate resilience at the fulcrum. The GSI Partners is a signature initiative of the Sustainable Business Network of Greater Philadelphia (SBN). SBN is a network of local triple bottom line businesses that are within and can

support the green stormwater infrastructure industry. Through this initiative, SBN is working to grow the local GSI industry and advance innovation ("Green Stormwater Infrastructure," 2020). Recognizing this feature as essential for partnership coordination with SBN as a crucial facilitator provides a model to follow. This could take the form of a volunteer committee, or become a program initiative out of an already established community organization whose mission and vision aligns with the concept. In rebuilding our economy, the government must prioritize green stormwater infrastructure because it's a tool that fosters job growth, public health, community well-being, and resiliency.

Environmental health is likely the main objective and realized through the utilization of GSI for stormwater management. The ecological benefits of linking networks of habitat and supporting migratory patterns as well as beneficial native plants all the while making the most of nature's capacity to filter pollutants while feeding itself is paramount. It is the basis from which all other human aspects can thrive. The actualizing of Philadelphia's plan will represent a model of possibility for many other urban areas as this will be our country's first and only plan to use green stormwater infrastructure (GSI) as the primary tool for regulatory compliance. If a city as densely populated as Philadelphia can do it, it must surely be achievable by smaller town municipalities.

Results & Recommendations

Philadelphia has a vast partnership network to make this plan come true. What is most compelling is the need to connect the Green Stormwater Infrastructure initiatives to economic development. The community of Maynard has been described as sustainably-mined. There may be an opportunity to harness the interest for forming a sustainability committee from volunteer residents to support the city. Perhaps developing, promoting, and launching a GSI initiative could be an actionable project to support a Green Recovery post-Covid while also meeting some of the stormwater remediation needs of the town.

This could be done through developing partnerships with area landscape architects, conservation commission, and contractors to co-create objectives around the equitable incorporation of GI for stormwater management into the construction or renovation projects within the town business district. This could take the form of structuring an advisory committee that reports to the building department of the town and town council representing feedback from various stakeholders involved in the process. Those could include residents, tourists, shoppers, business owners, local contractors and developers, local banks, area industries, recreational departments, conservation commission, DPW, and the planning board.

Another model example from Philadelphia's project is the important partnership that developed as a result of their program between PWD, Philadelphia Industrial Development Corporation (PIDC), the Department of Commerce, and the Special Service Districts like their Center City District. These industrial, economic, and municipal partnerships helped to transform commercial corridors and the business parks within Philadelphia. With the addition of stormwater management codified into development, redevelopment, and beautification projects overall maintenance costs will be reduced while facilitating restored corridors. These greener, safer corridors will draw new customers as well as interested retailers, creating additional local and potentially green jobs in the City. Should this model be incorporated into Maynard, an alliance between planning, economic development, and DPW will be essential.

One challenge to the Green City, Clean Waters program is to infiltrate the initiative's needs and objectives into the design, construction, operation, and maintenance of all their City systems (transit, streets, universities, schools). This is a major undertaking yet essential to the growth and nurturing of the area's natural systems (parks, rivers, streams, wetlands) as well as to the protection of public health systems (Philadelphia Water Department, 2011). Communication across city departments is crucial to adopting this plan thoroughly and comprehensively across all city sectors.

The program is comprehensive and extensive. It is challenging to locate areas of weakness in the policy beyond what was already stated as challenges the City will face in the implementation of this plan. Perhaps the biggest will be the cultural paradigm shift. Even though the city received thousands of signatures of support and petition for green infrastructure in neighborhoods, there is often strong political will in the hands of a few who might have economic leverage to influence outcomes. It will continue to require explicit strong leadership from the Governor as well as from the heads of departments within the

partnering groups. Institutionalization of this program within the Philadelphia Water Department will ensure that it will be carried forward, even with a change in leadership. However, the consistency that steady commitment brings in the form of trust within the community will determine the viability of a culture shift that embraces this methodology and expresses the transformation.

Conclusion

Philadelphia's plan is guided and influenced by the numerous federal and state mandates aimed at improving urban streams. The regulatory guidelines of the Clean Water Act (CWA), and specifically The Clean Water Act Section 303 Total Maximum Daily Load (TMDL) Process, NPDES Municipal Separate Storm Sewer Systems (MS4) Stormwater Regulations, PA Act 167 Stormwater Management Planning, The Safe Drinking Water Act of 1974, and the Combined Sewer Overflow (CSO) Control Policy, all greatly influence and dictate their watershed planning objectives (*City of Philadelphia: Green City, Clean Waters*, n.d.). This provides a guiding framework for any municipality, including Maynard, to harvest principles from regulations specific to their state and region to identify how Green Stormwater Infrastructure solutions can satisfy mandates. The concept of their green acre goal helps to view progress on an achievable scale that is neighborhood or community-block specific. Robust partnerships and integration across sectors, as well as within municipal entities, will provide the necessary network to keep this program front of mind for all projects. Be it maintenance, renovation, or new construction, the indicator or trigger to include aspects of GSI to these frequently occuring activities will translate to continual progress for program implementation.

SITE BACKGROUND: MAYNARD, MASSACHUSETTS

According to the Town of Maynard's 2020 Master Plan, "the Town of Maynard is a small, urbanized community in Middlesex County surrounded by the Towns of Acton to the north, Concord to the northeast, Stow to the west, and Sudbury to the east and south. It is a former mill town, developed around the Assabet River, that is now comprised of a mix of suburban and commercial uses with an established downtown of mixed restaurant, retail, and business services. With a population of 10,526 persons, according to the 2012-2016 American Community Survey 5-Year Estimates, and an area of 5.24 square miles, the Town has significant residential density – particularly as compared to some of its more suburban-oriented neighbors. The Assabet River National Wildlife Refuge, which overlaps into the adjacent Towns of Stow and Sudbury, comprises approximately 20 percent of the Town's total land area. These factors combined have resulted in the Town being largely "built-out" and *in need of a guiding framework to balance residential and commercial redevelopment* in a manner that allows the Town to retain its small-town character and associated quality of life, while factoring in market demands, economic realities, and geographical limitations."

This unique and potent representation as a small community nestled within the corridor of a National Wildlife Refuge, provides a clear opportunity and obligation to cultivate linkages for crucial habitat throughout the rest of the four square miles of town outside of this National designation. Exploration into the potential partnership possibilities from the National Wildlife Refuge with the town's Conservation Commission and regionally through the Metropolitan Area Planning Council (MPAC) could prove advantageous for GI implementation support.

Maynard's Resiliency Building Workshop Summary of Findings 2020

"Appendix B (page 8): Potential Impacts from Projected Climate Change Conditions: Impacts from changing precipitation conditions." With more inflow requires more capacity to receive it, and in the context of stormwater this translates to increasing green infrastructure and infiltration methods. Even though Maynard has generous open green space they should seek to achieve 'green acres' (as from Philadelphia's Green City, Clean Waters plan) in the zones that include impervious surfaces.

Maynard's Open Space & Recreation Plan 2004

"Create new and improved municipal bylaws and regulations to address, among other things, stormwater, infiltration, land use, and downtown character." Can GSI satisfy all these objectives? Certainly educational outreach and subsequent briefing for city council or select board members with ample time to review and ask questions promote better acceptance to binding GSI bylaws. It would be

advantageous to align GSI priority outcomes to the town's values, of which Open Space and Recreation seems prominent.

Maynard's Master Plan 2020

"It is worth noting that topographic or site condition constraints may not always be a deterrent in terms of land developability. What is deemed undevelopable today may become developable in the future. Only permanently protected lands should be considered as undevelopable, such as wellhead protection zones, riverfront buffers, wetlands, lands deeded with restrictions, and Article 97 protections." Knowing that site conditions and topography are not a factor for land developability now or under future pressures, ensuring adequate Green Infrastructure programming to buffer the most vulnerable of areas will be paramount. Best Practice with GI takes into account topography and landform as a way to appropriately plan green infrastructure and deprioritize other development. If the term 'undevelopable' is not to be reexamined or redefined to match today's understanding of the protective services of certain topographies, consider GI ordinances to hold the role of risk reduction from developmental impacts.

Land-use planning objectives for Maynard align with Green Infrastructure practices and benefits. These are just a few of the land-use objectives that could be satisfied through GI ordinances. Aligning the outcomes of objectives with GI features will help make the intended planning explicit as well as ensure proper assessment is conducted for maintenance.

"LU1-1 Continue encouraging best practices in sustainable land development, such as open space/cluster development, low impact development, mixed use development, etc."

"LU2-1 Seek permanent control over water supply protection areas via zoning changes, land acquisition, or by establishing conservation easements."

"LU2-4 Increase Maynard's percentage of tree canopy coverage through protection of existing forested areas,implementation of an annual planting program, focusing new development on reuse of previously built properties, and more robust landscape requirements for developments Maynard's Draft Stormwater Regulations"

Draft Stormwater Regulations: Maynard

The objectives of these regulations are:...To promote infiltration and groundwater recharge;...."This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook."

Groundwater recharge is mentioned as an objective, however it was not directly referenced as an opportunity or goal for these regulations. The concept of keeping water protected from contaminants and limiting unintended use of the MS4 system is mostly discussed in the current version. Infiltration and groundwater recharge as an outcome is crucial and beneficial for sustaining against future periods of drought. Having regulations and permitting explicitly calling for designs to infiltrate stormwater to meet this goal would be a powerful alignment.

PROPOSED STRATEGY

Connect with the abutting townships to Maynard, especially focusing on the regions which have MS4 permit requirements to satisfy, as a means to ignite a region-wide Green Infrastructure program for ongoing maintenance and for the procurement of adequate and diverse funding models. Ensuring there is a trained workforce available to implement the management may require regional workforce training and/or the generation of internalized job openings.

There is a prevalence of golf courses in the area surrounding Maynard, specifically upstream from Maynard, that may have an impact on the Assabet and groundwater. The concept of constructed wetlands is a method worth considering for stormwater management from the runoff of pesticides from turf management be it from golf courses or residential lawns.

Utilizing federal policy as a means for institutionalizing the commitment to GSI and formalizing the interrelation of stormwater and urban forestry management. This mechanism could be foundational to budgetary coherence and reduce perceptions that GI only exists for preservation efforts. Identify potential sources of funding, like The Conservation Fund's Green Bonds and their Working Forest Fund. Consider

reviewing the Green Infrastructure Vision for Cameron County, Texas (a part of the CF's program) as an example.

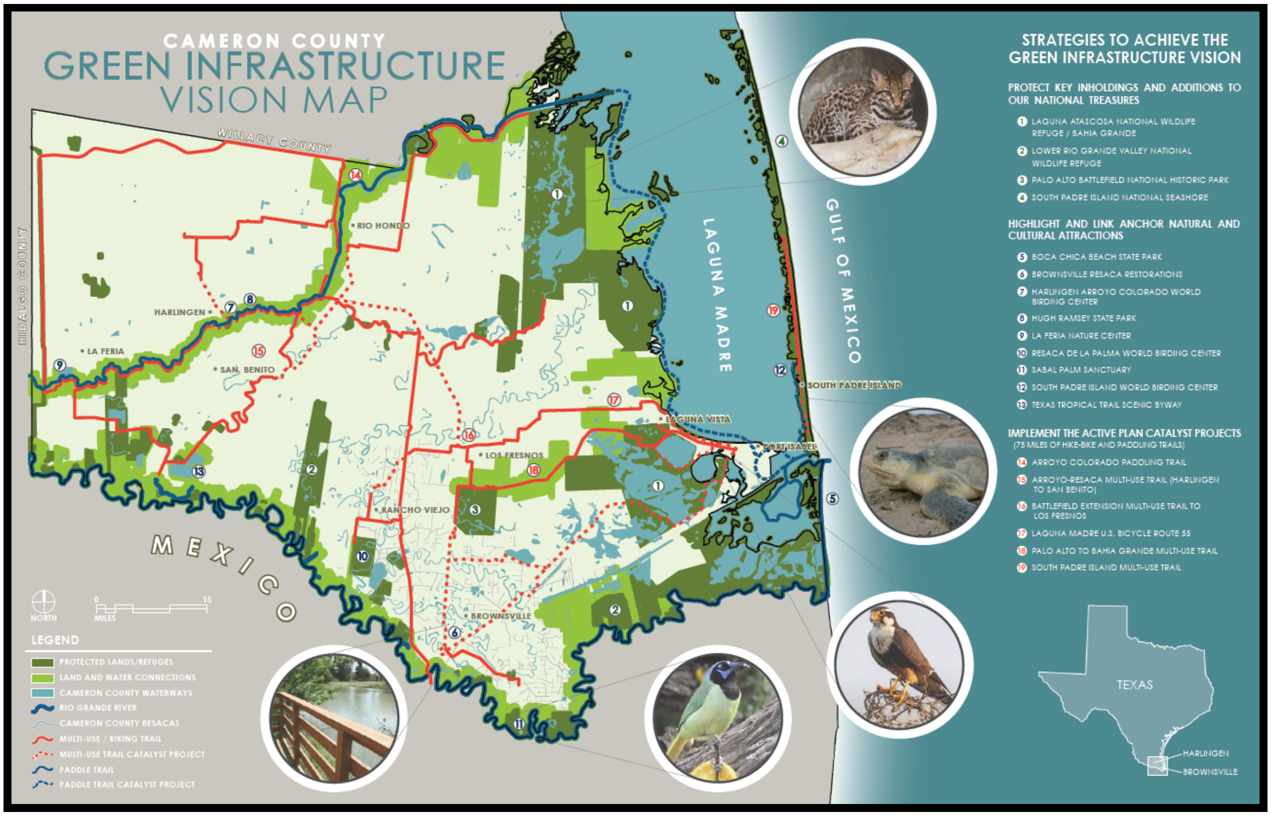
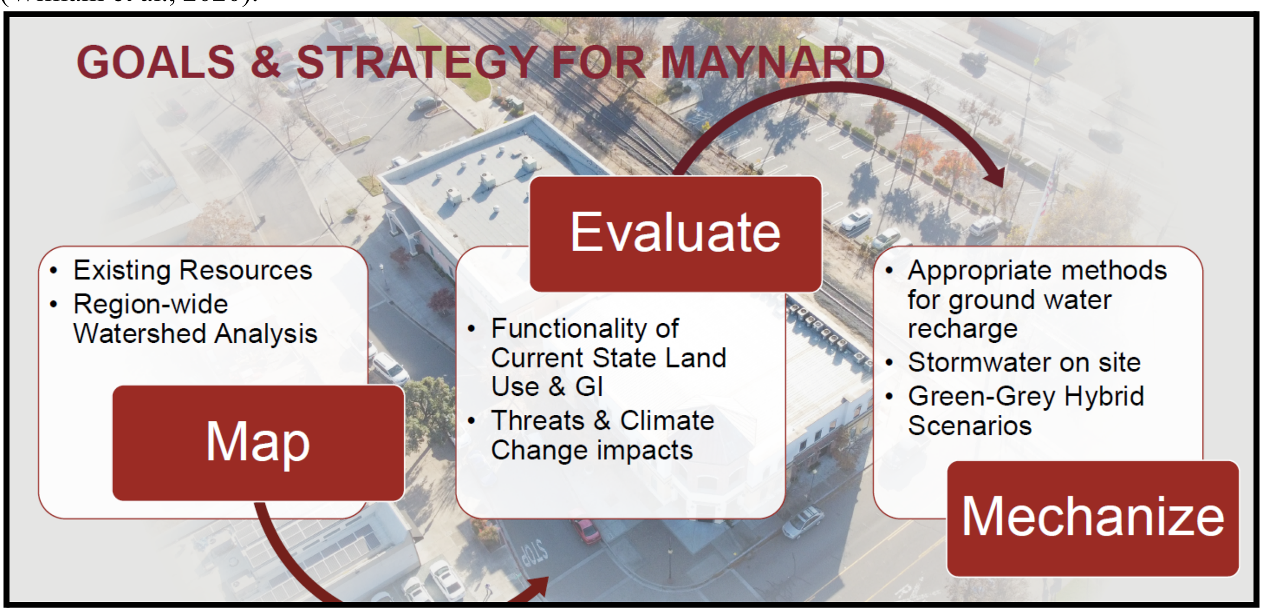


Image 8 *Image Source: The Conservation Fund Projects (https://www.conservationfund.org/projects/green-infrastructure-vision-for-cameron-county-texas)*

Local residents of Maynard who have indicated their Willingness to Pay (WTP) for conservation efforts are another viable option for congruent funding alongside budgetary allocation. In reference to the 2004 Open Space and Recreation Plan for Maynard, One question attempted to quantify how much citizens would be willing to pay annually to acquire land for open space. Of the total respondents, only 7% would not be willing to pay any additional amount for open space, whereas *93% were willing to help finance the costs of acquiring open space*. More specifically, 25% of respondents would pay $1 to $50 annually for additional open space; 33% would pay $51 to $100; 26% would pay $101 to $300, and another 9% would pay more than $301 annually for open space. It is clear that the values of residents are to maintain and increase open space. This provides important and valid fiscal pressure to budgetary allocations, and as described in the plan, an opportunity to generate additional revenue sources in doing so. This effort could be compounded through an optional annual appeal expanded to residents of surrounding towns (Stow, Acton, Sudbury) to support a coordinated regional effort.

As highlighted in Philadelphia's Green Cities Clean Waters Program, having Mayor Nutter's leadership on sustainability and the development of Greenworks Philadelphia proved beneficial to their programs successful foundation and expansion. Other research on urban forestry-based GI success stories also validated sound agency-level commitment alongside sanctioned and diverse funding structures as the most effective factors (Young, 2011). As seems to be the case for any bold long-term initiative outside of the budgetary normative, Green Infrastructure and GSI specifically as a program will require institutionalization across town departments as a necessary part of the strategy. GI can be seen as a public service and as such the planning and management funded through the municipal budget since the benefits are experienced through other public services for example, stormwater management, groundwater protection, and conservation. These also provide benefits to the local economy and aesthetic.

However, budgetary approval and any additional ordinance, mandate, or tax increase will need to come to fruition through community buy-in. Not only is involving the residents an inclusive effort in modern planning and a perceived best practice, it is psychologically the best approach as well to prevent rebuke. The Self-Determination Theory creates a model of human motivation conditional to three factors: autonomy, relatedness, and competence. Autonomy as the urge to be a causal agent in one's own life. In other words, the desire for self-direction. Relatedness as the need to feel connected to other people . Mastery or competence as the feeling of accomplishment from overcoming challenges, or gaining a new skill (William et al., 2020). The opposite of autonomy is reactance—the resistance to social influence from others as a defence from a sense of loss or threat to one's personal freedom. The most obvious of these threats are from laws and regulations (William et al., 2020). Therefore, community-created and co-created rules and initiatives are much more likely to be adhered to. When constructed in a group the factor of relatedness, which is another key driver of human motivation, also becomes present. The impact of social norms, in the form of positive role models, also have a powerful effect on behavior outcomes (William et al., 2020).



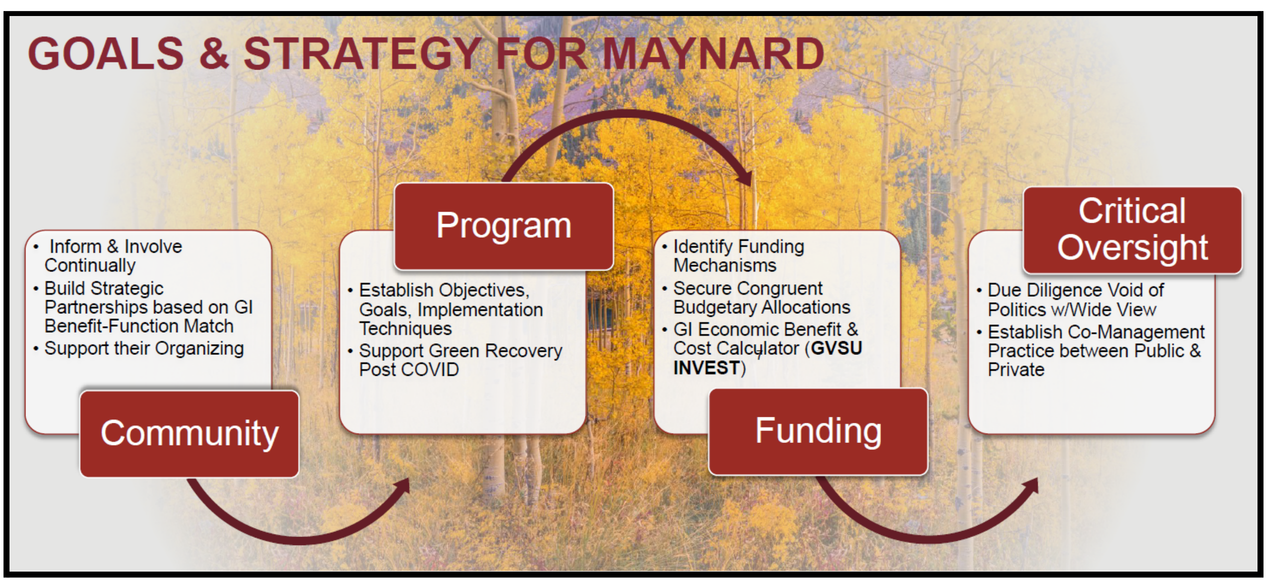


Image 9 *Image Source: Presentation for the Town of Maynard, Angie Gregory*

PROPOSED REGULATIONS

Creating regulations that are not only triggered by new development, surface grading, or redevelopment projects but that also are an embedded part of a larger land use planning and conservation effort will answer the call for green infrastructure stormwater management for the town. It can do so while also increasing habitat, biodiversity, green space, economic benefit, increased human aesthetic, recreational, and wellbeing needs. This multiplication of co-benefits should be made explicit so that appropriate management practices encompass all components of GSI. The town should work with residents, and ideally the region, to develop a strategy similar to the Green Acre from Philadelphia's program to identify contiguous acreage of impervious surface that could be augmented to receive, infiltrate, and recharge the groundwater supply while diverting runoff from the MS4 system and providing onsite pollutant remediation.

Reducing the strain on sewer systems and the obligatory regulation that comes along with it is possible through GSI management. Doing so could also potentially prolong the life of the current grey infrastructure as it decreases maximization events. A regulatory framework with the strategy of multi-stakeholder engagement and regional buy-in will be necessary to achieve this scale of influence. Analysis of the watershed can inform directionality of larger coalition planning and implementation, while localized ordinances can mitigate impacts of new development, the public right of way, or projects that disturb the soil surface to include GI for stormwater capture, infiltration, and retention.

Herein are examples of proposed language meant to serve as an illuminative guide to structurally support the community-informed and municipality-specific regulation characteristics of Maynard. The draft language is adopted from the City of Los Angeles and their 2014 Green Sustainable Street's Initiative. As their city noticed street related infrastructure repair needs, their city council directed the sanitation department, street services, engineering, water and energy departments to incorporate GI for stormwater management with the impending Public Right of Way projects. This created an opportunity to reap additional environmental benefits while maximizing the public's return on investment during city repair and improvement of the public ROW (Susilo, 2016). In anticipation of their ordinance, the City developed flow charts (**Image 9 & 10**) to assist public project designers meet the Ordinance and Handbook requirements. Flow Chart 1, describes the City processing procedures. Flow Chart 2 includes provisions to assess the overall drainage area for flooding risks, the infiltration/capture capability of the project site, and then a quantification of the benefits provided by each project. The town of Maynard should consider incorporating similar flow charts for designers and contractors who will be implementing any construction projects that would trigger a GSI ordinance.

MOTION AND ORDINANCE

The proposed Ordinance would add Sections to the Maynard Stormwater Regulations and would require public street construction and reconstruction projects as well as new development and redevelopment projects to implement post-construction stormwater management through BMP implementation for Green Stormwater Infrastructure.

Ordinance Objective:

The objective of the ordinance is to manage, through the use of stormwater LID techniques, urban runoff from the street or public right-of-way as well as runoff from the adjacent drainage, and from any development or redevelopment that results in soil disturbance. The purpose of this management is to acquire multiple benefits including stormwater pollution abatement, flood control, reduced burden on the town's MS4 system, groundwater recharge, open space development, cooling and reduced energy consumption, aesthetic and economic acceleration, recreational services, and carbon sequestration.

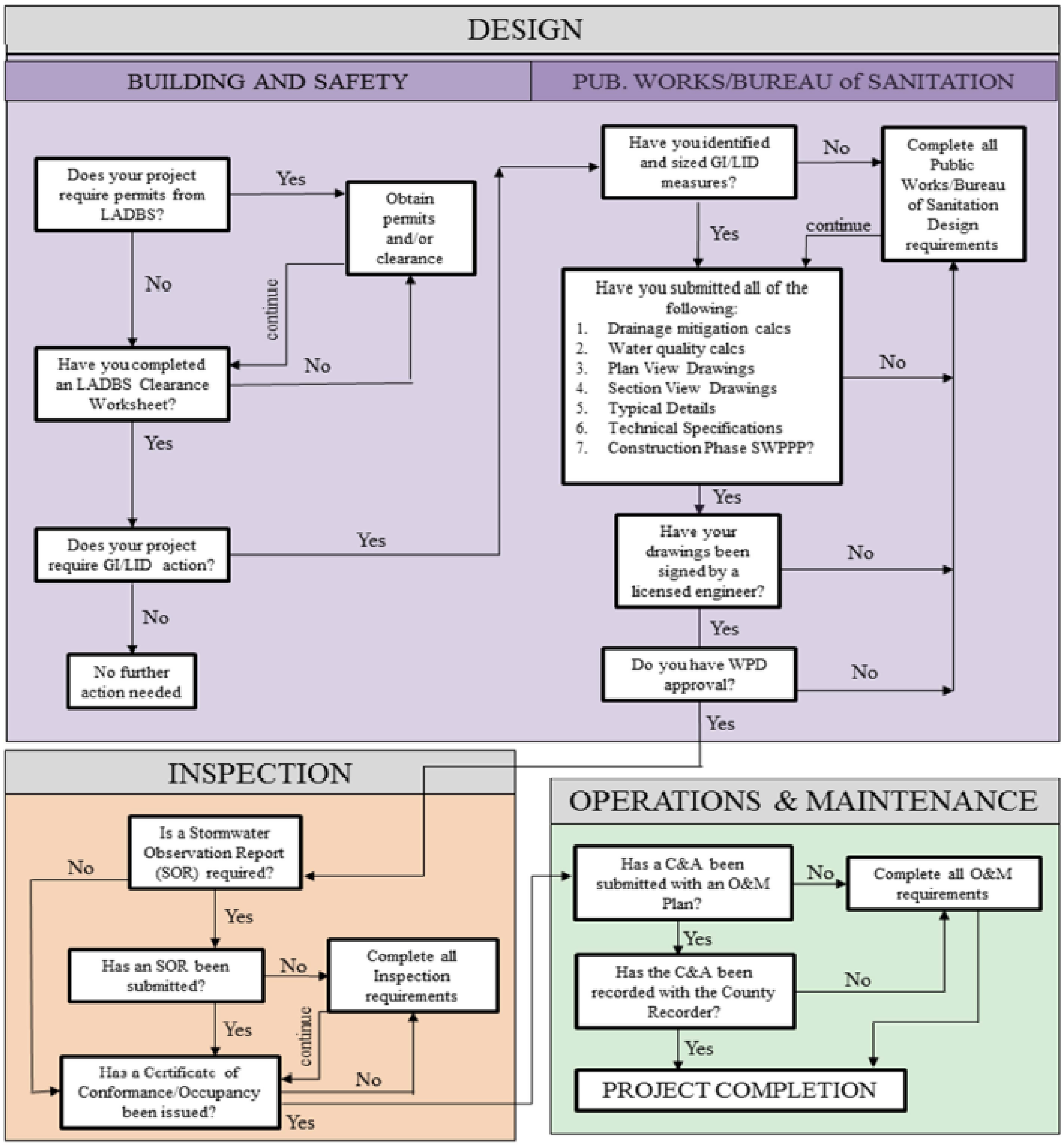
Ordinance Scope:

The provisions of this section contain requirements for all street construction and reconstruction projects as well as development and redevelopment projects that generate an acre or more of impervious surface to integrate post-construction stormwater management practices in accordance with the Massachusetts Stormwater Management Handbook.

Activities Covered under this Ordinance:

All street or right-of way construction, reconstruction, and resurfacing performed as part of private and public projects are covered under this ordinance. These activities include but not limited to utility installation, maintenance resurfacing and emergency projects, and projects involving planned right-of-way dedication. Projects required to comply with this Ordinance are streets or public ROW projects that include "clearing, grading, or excavating that result in soil disturbance" and would not typically be captured by existing LID policies.

FLOW CHART 1: PROCESSING



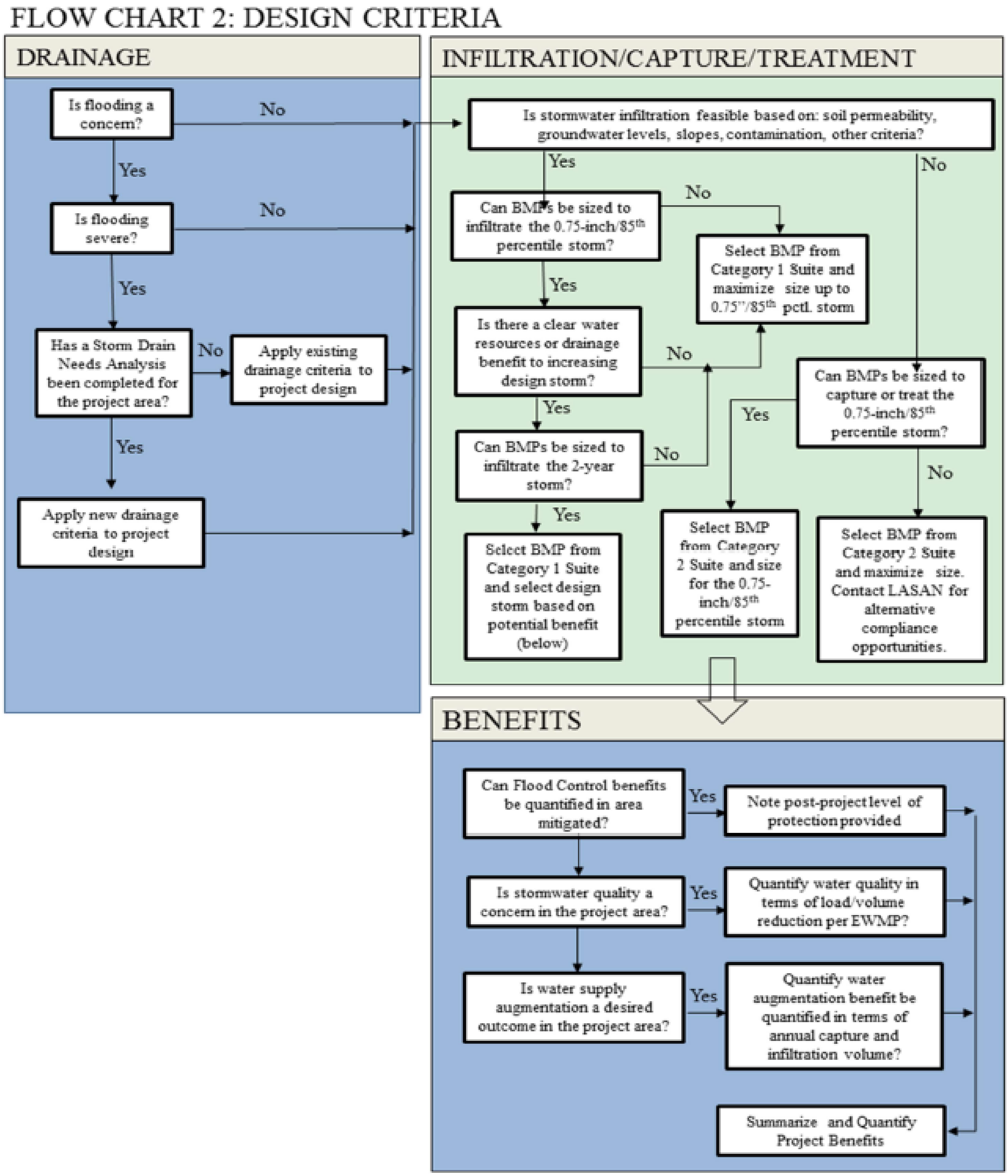


Image 9 & 10 *Image Source: Adopted from the Greater Los Angeles County Integrated Regional Water Management Plan (Susilo, 2016)*

Streets and ROW LID Requirements:
In accordance with the Ordinance, all project requirements would conform to the following requirements:

1. Projects that are subject to permit requirements by Department of Public Works (DPW), Department of City Planning (City Planning), and the Massachusetts Department of Environmental Protection (MASSDEP) Stormwater Handbook.
2. The runoff from each project site would be designed to manage stormwater runoff on site through the use of infiltration, capture, and/or biofiltration/biotreatment, in order of preference. Green Infrastructure techniques such as bioswales, rain gardens, constructed wetlands, and porous pavement can achieve this.
3. Onsite stormwater management techniques must be properly sized based on a design volume of water produced by the quality design storm event that results from a 1.00 inch storm event or from the 85th percentile, 24-hour runoff event as determined from the annual US Climate Data reports for Maynard, whichever is greater.
5. When, as determined by the Town Engineer, Department of Public Works Director, and the Water/Sewer Division, the onsite management requirements are technically infeasible, partially or fully, as defined in the Handbook, the infeasibility shall be demonstrated in the submitted runoff management plan. The technical infeasibility may result from conditions that may include, but are not limited to, locations where incorporations of stormwater BMPs will result in geotechnical hazards; and other site or implementation constraints. (Susilo, 2016)

CONCLUSION

As municipalities across the country face the risk of increasing regulatory pressures from stormwater runoff pushing untreated surface pollutants into our waterways at a moment in time when Climate Change is increasing the frequency and severity of storm surges, ardent planning and implementation of GSI can provide a no-regrets strategy for reducing the reliance on an aging grey stormwater infrastructure system. As systems are at risk of failure from stormwater capacity maximization, stormwater should be treated at the site through infiltration methods or a hybrid matrix of grey and green infrastructure functions. Climate Change mitigation is also possible through GI efforts in their ability to sequester carbon, provide cooling and in turn reducing energy demands, while supporting ecological integrity which is the basis of all life. Bioswales and Bioretention basins, increasing tree canopy, pervious parking lots, increased conservation, rain gardens, street trees are all viable options subject only to budgetary and site constraints.

Protection of water and natural habitat is more important than ever as surface temperatures increase and development may be pressured by climate migration to areas that have more open space. Green Infrastructure should take place in conservation areas and as a means to create linkages between these habitats, locations with contiguous acreage of impervious surfaces, in residential areas, along rivers and waterways, in town commercial districts, and on public/city property. For the short term relevancy, whenever there are soil surface disturbances through development, grading, or other redevelopment of land, ordinances can ensure mitigation efforts are met through implementation of GSI through LID ordinances. Long term relevance can be achieved when broad scale regional initiatives informed by hydrological studies guide watershed management and analysis for LID siting outside of any redevelopment or new development triggers. LID placement and sizing should be informed by large scale watershed analysis as a best practice. Auxiliary regulations should include biodiversity conservation, native plant propagation, and habitat considerations within the GSI performance standard.

Institutionalizing a program is essential alongside legislative and executive leadership, and coalitions of residents alongside local organizations. This can be achieved through GSI program integration with complimentary city initiatives, engagement with stakeholders and progression into a multi-stakeholder partnership between town departments (DPW, Water Dep, Planning Dep, Conservation, Recreation), community and economic development, economic agencies, the private sector, residential and community groups, and just as importantly, through regional alliances.

As this program launches, strongly consider green governance for facilitation of ongoing implementation and management. Clear delineation of roles, diverse financial mechanisms for continual management and implementation capacity, community culture adoption, business and economic

integration and affiliation, and BMP for stormwater management through LID strategies adopted through bylaws and made public through engagement are all included in the comprehensive management of a GI program. The public needs to be involved in every step of the way as continual stakeholders and proponents of change at the residential level. They are municipalities' strongest assets. As stated by the Metropolitan Area Planning Council (MAPC) the growth in the region should be guided by informed, inclusive, and proactive planning. Sustained public engagement helps to yield more effective and durable planning solutions. Planning mechanisms should create continuity of participation and priorities through time (from planning to development) and across jurisdictions (from state to regional to local).

The importance of Green Infrastructure as a method and means for beginning to resolve environmental injustices can not be understated. Through its inherent distributive, non-exclusive, and non-rival nature, this publicly owned infrastructure will continue to provide restoration and health to the exchange of humans and their biophysical support system for years to come. The enjoyment of its benefits does not reduce its supply. Providing intergenerational equity, climate change adaptation, and strength in social capital built through social-local connectivity, Green Infrastructure implementation also generates capacity for community resilience.

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