EcoDistricts

LIVING INFRASTRUCTURE GUIDE

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1. INTRODUCTION + FRAMEWORK

Purpose

The purpose of this Guide is to present the breadth of strategies that create a living infrastructure at the district and neighborhood scale and to guide users through selecting the strategies best suited to their local conditions.
The people interested in revitalizing their districts and neighborhoods have a wide variety of backgrounds and frames of reference. Accordingly, this guide will:

1. Establish a concrete, common understanding of the attributes of a district with a vibrant living infrastructure and the strategies that support each attribute, and
2. Present a framework that leads project teams through the steps of enhancing the living infrastructure of a district.

The audience for this Guide is groups who are working to select, prioritize, and implement an infrastructure that supports ecosystem services. This could include municipalities, developers, property owners, businesses, residents, utilities, and community-based organizations.

Because district-scale projects are highly variable, specific design and implementation guidance is beyond the scope of this Guide, though some examples are presented in Appendix II. It is not possible to provide detailed guidance for a district's specific targets and priority strategies in a document such as this one, which is generalized to all district-scale projects. Instead, the Guide introduces a framework for things common among them. Although many of the practices described provide ecosystem services, the economic valuation of ecosystem services is also outside the scope of this document. Finally, although this Guide addresses aspects of hydrology throughout, this is not a technical Green Infrastructure (GI) Guide in the sense of the GI Guides that provide precise instruction to municipalities for managing the volume and quality of stormwater.

Attributes of a Living Infrastructure

The living infrastructure of a district or neighborhood refers to the network of natural systems and engineered systems, such as storm and wastewater practices, that affect ecological processes including the hydrological and nutrient cycles. This network can reestablish ecological function through a pattern of living nodes, connectors, and buffers that work together at a variety of scales. Creating a robust living infrastructure strengthens the district's resilience to climate change.

This Guide assumes that the Attributes are nearly synonymous with benefits, that is, that a robust living infrastructure supports the previously stated goals of the district. Therefore, this Guide does not provide information to justify and defend the virtue of these Attributes, it simple focuses on how to achieve them.

In this document, we have chosen to use the term living infrastructure to describe the features of an urban system that provide ecosystem services and support all life. The four attributes of a Living Infrastructure correspond closely to the four types of Ecosystem Services: Supporting, Provisioning, Cultural, and Regulating, which includes standard GI best management practices. For further discussion of terminology, see Appendix 1.

A district with a robust living infrastructure fulfils the following conditions:

1. Harbors and supports indigenous flora, fauna, migratory species and pollinators
2. Conserves and replenishes fresh water, protects and restores fertile soils, and regenerates food and fiber
3. Connects people to nature
4. Employs strategies to eliminate or regulate impacts to climate, hydrologic cycles, nutrient flows, natural hazards, and pests

Function and Scale

This guide takes a functional approach, which is a specific way of looking at the ecological components of a place. For example, some of the functions of a site such as a stream might be to support a food web or process organic matter. Strategies to support and enhance those functions must help maintain long-term survival of native ecosystems at a large geographical scale, a systems scale that encompasses the area necessary to support the function.

In contrast, a structural approach focuses more on discrete components such as individual species. In practice, experienced practitioners should be able to develop successful strategies using either a functional or structural approach, but the functional approach helps people extend their thinking to the entire system. In addition, the landscape of urban systems is often so altered that little of its structure can be restored or replaced.
Flood storage, nutrient retention, wildlife diversity, and active recreation are examples of functional lenses that could be used to evaluate a district. However, the scale of the systems that support these functions will rarely coincide with the district boundaries. It is not possible to determine whether the flood storage of a district is adequate unless the evaluation includes hydrology from outside the site, whereas it may be possible to evaluate nutrient retention on the scale of the drainage shed of a bioswale. Large-bodied species of wildlife may have ranges that reach beyond the boundaries of the district, whereas opportunities for active recreation might be evaluated at a much smaller scale according to the needs of the population. Overall, achieving and measuring functional success depends on understanding current and potential conditions for a specific location and a range of processes.

In many places, urban centers have arisen on what was once a vibrant and complex landscape. Using a functional approach to the Living Infrastructure of an urban site helps uncover and renew some of the underlying systems that incorporate the human world into the natural one. That is part of the reason that scale is so important in planning: we are thinking about how to bring back a web of foundational vibrancy that can be defined in a single space with a complex history.

There is no set scale for the creation of district-scale projects, but they are often created on political or cultural boundaries. Living infrastructure is best planned on a scale that is determined by the underlying natural form, most commonly a watershed. Regardless of the type of planning unit used to define the district, the functional approach requires an examination of the way water, living creatures, nutrients and other ecological elements move onto and off of the site.

FROM GREENFIELDS TO RETROFITS

It is important to note that the teams of organizations and individuals who are planning district-scale redevelopment projects are working in a wide range of initial conditions in terms of development and redevelopment. Obviously, planning the development of a green field site is a completely different process than an urban renewal retrofit project.

In planning a community from scratch, the Living Infrastructure focus is on maintaining the existing natural functions of the landscape. In an urban landscape, the intent is usually to recover some of the ecosystem functions that have been lost to conventional infrastructure, such as water management that uses underground pipes to transport nutrients and water out of the system and flush them downstream in concentrated flows.

This Guide has been written to support the multitude of development and redevelopment types that our cities are facilitating.

The EcoDistricts Protocol: This Guide in relation to other EcoDistricts Publications

This Living Infrastructure Guide is designed to be accessible to any group that is planning living infrastructure on a district or neighborhood scale. Some readers will be registered users of the EcoDistricts Protocol. For them, there are two ways to understand where this document fits: in terms of the overall EcoDistricts Protocol and in terms of the EcoDistricts Priority Areas.

The EcoDistricts Protocol, in particular the third commitment (Implementation Model) is composed of four phases: Formation, Roadmap, Action, and Stewardship.

This Guide is intended to support the Roadmap Phase of the Implementation Model, and the EcoDistricts District Assessment Toolkit which provides guidance for completing the necessary steps to verification for this Phase. This Guide also supports the Ecosystem Stewardship Priority Area associated with the second commitment in the Protocol.

This Guide addresses one of the six EcoDistrict Priority Areas, which are the result of an exhaustive consultation process with leaders in sustainable planning, led by the EcoDistricts Technical Advisory Committee. Each is associated with an overarching Goal, Objectives, and Metrics, as summarized in the EcoDistricts Protocol.

Section Two of this Living Infrastructure Guide is intended to develop a common understanding of what strategies support living infrastructure. Section Three describes the context of living infrastructure improvement efforts. Section Four gives specific guidance and examples of information necessary to understand the baseline condition of the district in terms of Ecosystem Stewardship. Section Five is generalized guidance for Setting Targets that improve Ecosystem Stewardship, and Section Six addresses selecting appropriate strategies with which to develop a roadmap.

THE PRIORITY AREAS:

Livability

Health + Wellness

Prosperity

Ecosystem Stewardship

Mobility + Connectivity

Climate Protection + Resource Efficiency

This Living Infrastructure Guide explores the planning opportunities for maximizing Ecosystem Stewardship, via maximizing its ecosystem services, developing GI, promoting living systems, and addressing stormwater at the district scale. Because Priority Areas are interconnected, the Guide also addresses some elements of each of the others, especially Climate Protection & Resource Efficiency and Mobility & Connectivity.

Strategy Groups of District-scale Living Infrastructure

LIVING INFRASTRUCTURE ATTRIBUTE	STRATEGY GROUP
Harbors and supports indigenous flora, fauna, migratory species and pollinators.	Protect Natural Features
	Create Habitat with Vegetation
	Build Connections in the Landscape
Conserves and replenishes fresh water, protects and restores fertile soils, and regenerates food and fiber.	Capture, Treat and Reuse Water On Site
	Support Healthy Soil
	Use Landscaping Space to Grow Food
Connects people to nature.	Integrate Natural Processes in Built Environment
	Increase Access to Nature
	Celebrate Nature
Employs strategies to eliminate or regulate impacts to climate, hydrologic cycles, nutrient flows, natural hazards, and pests.	Mitigate Urban Heat Islands
	Stabilize Soils
	Improve Air Quality
	Address Urban Pests
	Reduce Volume/ Improve Quality of Stormwater

2. CREATING LIVING INFRASTRUCTURE

This section will describe how urban planning and restoration can create districts and neighborhoods with the four attributes of a living infrastructure. This section provides a brief but thorough menu of creative ideas to develop these attributes and touches on some of the most important considerations and challenges in their implementation. A few examples of documents that provide more detailed guidance are listed in Appendix 2.

Attribute 1. The district harbors and supports indigenous flora, fauna, migratory species and pollinators.

HABITATS AT SCALE

Every species has space requirements, both for its own survival and to sustain a viable population of the species without running the risks of inbreeding or local extinction. Because space is limited in urban environments, it may not be possible to restore habitat structure. Survival depends on habitat integrity that is assessed based on landscape context, size, and condition. District-scale projects offer the chance to map a network of connected design elements at significant scale. The challenge is to create connectivity that functions for a range of animal groups from small insects to mammal species.

Landscapes can be viewed as islands of suitable habitat hubs embedded in a matrix of unsuitable habitat. For the benefit of most species, the suitable habitat within a district should be interconnected to the greatest possible extent. That means that from the point of view of habitat function, a park is more valuable if it is closer to or connected to other parks (e.g. via a greenway). Riparian corridors are a particular focus because they often form a network of connected habitat in developed settings. The matrix or surrounding unsuitable habitat can also sometimes be made more welcoming so that wildlife can more easily move between habitat hubs.

In addition to habitat connectivity, the overall coverage and condition of valuable habitat at scale, especially of the larger patches, is important to habitat function. While a narrow urban greenway will not support species of the interior forest or reclaim the full complexity of their original ecosystems, district-scale projects can start to repair the oversimplified urban settings by increasing the size, structure, and composition of interconnected native plant communities. All of these considerations point towards a hub and corridor framework for planning habitat at scale. Some district habitat strategies will be contained within a certain site, e.g. plants that provide abundant nectar may be selected for planting, but to maximize the habitat potential, planning must incorporate the scale and connectivity of the entire potential habitat.

There are three general approaches to ensuring that a district supports biodiversity, or a wide range of native plants and animal communities: 1) protect natural features, 2) create habitat with vegetation, and 3) build connections in the landscape. Urban design practices to realize these three aspects of habitat are described below.

PROTECT NATURAL FEATURES

Protected Sites

The first principle of strengthening habitat and supporting biodiversity on a district scale is to preserve the habitat that is currently available, which often means setting priorities. One of the first steps in collecting baseline data on habitat (Section Three) will be to catalogue the existing habitat resources of the district. Efforts can then be made to prioritize sites for conservation. This often takes the form of tracing the riparian backbone of the local area and focusing on protecting or improving its integrity. Based on the geographic location, a wide range of other ecosystem types such as upland forest or scrub, may be included.

Functional Riparian + Wetland Buffers

Riparian and wetland buffer zones deserve special attention because of their relevance to other ecosystem functions such as flood prevention, food chain support, and nutrient cycling. The wider the buffer, the more functions the habitat will provide, such as reducing the volume and nutrient load in runoff. Broad riparian and wetland buffers also support biodiversity by providing the best habitat for native and desirable wildlife in developed areas.

Restored Ecological Systems

The opportunities and needs for restoration vary from district to district, but many urban areas will contain green space in which function can be improved. Reducing stormwater flow, erosion and/or flood risk is a common motivation for restoration. Buried, piped streams can be lifted to the surface (daylighted). Restoring channels that have been incised can reduce sediment loading and reconnect the channel with its floodplain. A wide floodplain helps slow down storm water and provides area for infiltration.

Invasive + Non-native Species Control

Controlling the introduction and/or spread of invasive species is important to ensuring native vegetation can thrive and provide functional value. Non-native and invasive species can rapidly degrade habitat, and urban and disturbed areas are particularly vulnerable to invasions. Early detection of invaders and a thoughtful management plan for invasives in the district are the best strategies for avoiding such problems. Invasives are often a persistent problem, and where they are impossible to remove, managers can direct the evolving structure of the vegetation to be more resilient to invasion and require less maintenance.

Habitat for Desirable Species

Managing areas to attract or benefit certain species of wildlife can provide a set of concrete functions that are easily measurable, providing biodiversity and habitat goals. Some management efforts focus on umbrella or indicator species whose conservation and management provide benefits to other desirable species or require multi-faceted functionality of an ecosystem. This approach is one that divides practitioners, some of whom argue that focusing on one species lets one lose sight of the forest for the trees, while other champion the use of focal species because they provide a concrete rallying point to build support and clear management directives and metrics.

CREATE HABITAT WITH VEGETATION

Abundant Native Plants

One of the first considerations in enhancing urban habitat is simply to maximize the number and area of the right species of plants. Native species have multiple habitat advantages, including nutrient and watering needs that align with the natural hydrology and supportive relationships with native fauna. Ensuring an abundance of native plants means making a concerted effort to maximize the amount of native planting at every opportunity, whether selecting species for street trees or enhancing the vegetation at the forest edge in an open space.

Diverse Vegetation

Everywhere there are plants in a district, there is an opportunity to improve the ability of that vegetation to serve as habitat by emphasizing diversity and structure. Most vegetation hosts other organisms and affects soils microbe communities. Vegetation that is diverse in both species composition and vertical structure can generally support a larger and richer community of species.

Pollinator Plants

Pollinators such as hummingbirds, butterflies, and bees are a valuable part of local ecological function, and attracting them may merit special efforts to plant species that can attract and support the most pollinators. Thus pollinator plants may be one group that falls outside the basic prescription of cultivating diverse vegetative structure and native plants. Pollinator gardens have the advantage of providing a public amenity and cultural resource when flocks of butterflies are visiting them in the spring. Pollinator plants can be placed in open spaces and residents can be encouraged to plant them in public demonstration gardens or outreach to private property owners.

BUILD CONNECTIONS IN THE LANDSCAPE

Landscape-scale Planning

As mentioned above, habitat quality is fundamentally a question of connectivity, and each district must consider the habitat it provides in the context of the local and regional landscape. Because ecological systems do not end at the borders of the district, landscape-scale connectivity must be taken into account as the green and open spaces of a district are planned or selected, and in built forms, as they are prioritized for restoration or revegetation.

Connected Greenspace

In addition to explicit consideration of the geographic orientation of green or open space outside the borders of the site, planning for connectivity means maximizing the ability of wildlife to move throughout the local area as opposed to being confined to small patches of habitat. This includes consideration of the built forms as well as the open space. Where development is planned, green building strategies and practices such as planting native plants in pedestrian corridors can lessen the disruption to some species while serving cultural functions for humans.

Attribute 2. The district conserves and replenishes fresh water, protects and restores fertile soils, and provides food.

FOOD AND WATER AT SCALE

Water should be viewed as a resource at any scale; however, building water infrastructure that conveys, treats, and beneficially uses or reuses water will be more economical at the district scale than on a parcel-by-parcel basis. The district scale can maximize the use of onsite resources and employ decentralized systems that do not require supplemental water or nutrient sources. Planning over larger areas mean the district can aspire to balance water and nutrient flows and improve the ability of the community to provide consumable resources such as food and water.

Three approaches to support Attribute 2 are to 1) capture, treat and reuse water onsite, 2) support healthy soil, and 3) use landscape areas for the production of food. Practices to address these three areas are described below.

CAPTURE, TREAT AND REUSE WATER ONSITE

Water Conservation

To reduce the required size of the infrastructure that delivers and treats water, a project should always first seek to encourage water conservation through use of high efficiency plumbing fixtures, as well as develop a public/user education practices to help inform and inspire water-conscious behavior.

Cisterns

Where permitted by local health regulations, roofs can be designed to optimize rain collection for small-scale irrigation needs in rain barrels and into cisterns for more significant non-potable water demands. Of these strategies, cisterns are more useful at the district scale. Rain barrels are very popular but in practice they are rarely used as intended and easily become mosquito breeding sites.

Onsite Potable Water Harvest

At scale it is possible to produce potable water from harvested rainwater. Although technically feasible with appropriate design, the regulatory requirements remain barriers in many areas. Project owners must often become certified as a water utility to provide this public water supply; with this designation comes the responsibility and liability to ensure ongoing operations are satisfactory.

Functional Landscapes

Where rainwater is not harvested, it can be directed towards landscape zones where soils and vegetation can beneficially use and process the flows through functions such as: evapotranspiration; nutrient assimilation; and shallow groundwater recharge. Directing rainwater to landscape areas also slows rates of water running off to better protect downstream ecosystems.

Onsite Wastewater Treatment

Instead of getting immediately piped offsite, blackwater and greywater can be reused to both supply a portion of the non-potable demands of the district and sometimes recharge groundwater. Appropriate technologies to treat black and/or greywater from buildings vary by ecoregion, site constraints, water quality reuse goals and architecture. Stormwater treatment is further discussed under Attribute 4, below.

Recycled Water Piping and Infrastructure for Water Reuse

The district scale affords an opportunity to plan a distribution network of recycled water piping ("purple pipes") and storage facilities that supply the project with recycled water for toilet flushing, clothes washing, irrigation, and industrial applications. Recycled water may also be used in cooling towers, however, it will require additional polishing treatment.

Nutrient Recovery from Wastewater

Wastewater is a rich source of nutrients. For example, treatment processes can be tailored to extract phosphorus in a crystallized form, ready to be used as fertilizer.

Dashboards for Water Conservation

Meters that track water use for individual buildings are an engaging way to strengthen community awareness and efforts in water conservation and reuse.

Minimal Irrigation

Landscape guidelines at the district scale can eliminate the use of plant materials that require intensive irrigation. Often the optimal plants are native species, as discussed above.

SUPPORT HEALTHY SOIL

Soil Management

Landscape maintenance guidelines can focus on improving soil fertility through best management practices that are appropriate to the region, such as minimizing compaction, preventing erosion, and reducing the need for chemicals.

Municipal Composting

Municipal composting programs can collect yard waste and food scraps from households, restaurants, and other buildings.

Organic Fertilizers

Organic fertilizers provide a more sustainable alternative to ones that are petroleum based, and their lower in nutrient concentrations more closely match plant absorption capacity, which means fewer nutrients are carried away by storm water runoff to pollute local waterways.

Biological Digesters

Biological digesters, such as anaerobic digesters, can be used to breakdown organic waste. While digesters are primarily used to produce energy, they also produce a by-product that can be used as a soil amendment.

Soil Remediation

Depending on the history of the site, soils may be contaminated and require remediation. Practices for site remediation may include excavation and removal or allow for in situ remediation. Remediation techniques vary depending on the contaminant(s) and specific site conditions.

Community and Private Gardens

Community gardens can provide herbs, fruits and vegetables. Restaurants located in the district may opt to grow food on site, using landscape space for gardening or having a rooftop garden. Siting of gardens will require considerations such as legacy contaminants, solar exposure and access to water.

Example for onsite wastewater treatment (Attribute 2: Capture, Treat and Reuse Water)

This DC high school treats its wastewater onsite in a series of wetland that are a popular campus attraction. Photo credit: Biohabitats, Inc.

Attribute 3. Connects people to nature.

Urban ecologists share the conviction that planning should enhance ways for people to interact with nature. This attribute is an opportunity to embrace nature and the human delight it can cultivate. These relationships vary through time, both on the human scale, ranging from children in natural playgrounds to seniors with the opportunity to see birds approach their homes, and on the annual scale, as the seasonality of our physical environment changes what we expect and enjoy from our interactions.

Biophilic Design describes designs that respond to the inherent human attraction to all things that are alive and vital. Biophilic principles of design apply as much inside as outside: they may be embodied in buildings constructed of natural materials or buildings that beckon to the living systems outside of the built envelope.
Three central approaches are to 1) integrate natural processes into the built environment, 2) increase access to nature across the district, and 3) celebrate nature.

THE SCALE OF HUMAN CONNECTIONS

An important consideration in planning for the cultural benefits of a living infrastructure is equality in accessibility. Nationwide, affluent urban neighborhoods have more and better opportunities to interact with the natural world. At the district scale, access to natural systems can be at the forefront of efforts to connect people to nature, among other things, this means that the district should be walkable.

Transport is largely covered by the "Mobility and Connectivity" priority area, but it has specific implications for living infrastructure. Greenways and parks are important elements of a walkable district, and they can be integrated into development to provide respite and social places that are connected by greenways and pedestrian-friendly streets. A landscape ecology hierarchy of hubs and corridors translates well to the human routes through a district, where strategic natural hubs providing resting and gathering space are connected by a network of corridors that are designed for pedestrians or for multi-modal transportation. Planning for this type of connectivity will mirror the hub and corridor connectivity in Attribute 1. Finally, project teams have the opportunity to challenge their creativity and build a district that celebrates nature and natural forms throughout.

Practices to address these issues are described on the following page.

INTEGRATE NATURAL PROCESSES WITHIN THE BUILT ENVIRONMENT

Exposed Water

Our cities are typically built on a buried network of streams that persist in pipes and engineered conveyances for water. Open water allows people to see and hear this traditionally hidden system. Examples of design elements are constructed wetlands for wastewater and/or stormwater treatment, daylighting streams and replacing culverts with open channels, and using regenerative stormwater conveyance. Practices that mimic natural hydrological cycles, such as Regenerative Stormwater Conveyance, are discussed in further detail under Attribute 4.

Greenroofs and Rooftop Gardens

Roofs supporting vegetation that acts in water filtration and nutrient cycling can also expose people to nature in their daily settings. Greenroofs and rooftop gardens are popular, though there are challenges associated with maintaining visitor safety and creating the structural integrity to support the weight of the roof. It is usually easier to incorporate their design into new buildings. Even small terraces can become living infrastructure amenities if small container gardens or potted plants are integrated into the design of the space. Greenwalls can afford additional opportunities to interact with nature.

Functional Landscaping

Vegetation in an urban landscape can provide shade, air quality benefits, and structural forms such as living buffers between pedestrians and busy streets. Often stormwater management is an added benefit. Street trees and other creative planting opportunities can be used across the district to create habitats with vertical structure that can support a wide array of life.

INCREASE ACCESS TO NATURE

Accessibility in Design

Natural interactions should be accessible to residential, commercial, and industrial users and designed in compliance with the Americans with Disabilities Act. Ensuring that all user groups are accounted for is an important part of planning. One useful approach is to track people's movement through the district, from opportunities in buildings to interactions with nature throughout their daily lives. These could include everything from bus stops to schoolyards, parking areas, walkways and buildings.

Varied Park Types

Parks and green spaces provide opportunity for community gathering, active recreation, and spiritual reckoning. In addition to larger habitat hubs described above in Attribute 1, the district, working with Parks and Recreation authorities and other partners, can seize a wider variety of opportunities for interaction with nature in the form of pocket parks, nature play areas, and consider multicultural landscapes that begin to tell the story of the district. A holistic approach to park design can integrate natural areas with stormwater management, repurposing vacant lands, and open space and parkland designed for users.

Multimodal Pathways and Trails

The pathways and trails traveled by pedestrians, bikes, and even cars provide residents and visitors with various experiences of and interactions with nature – walking, hiking, biking, running – in a safe environment. Trails can be designed alongside and within parks and natural systems, though they must be planned in a manner that minimizes the fragmentation of important habitat patches or corridors. These elements increase the health and wellbeing of residents and provide areas for both passive and active recreation. Local trails can also be temporary, making use of undeveloped or vacant lands before they are transitioned to a new use.

CELEBRATE NATURE

Biophilic Buildings and Infrastructure

Buildings, bridges, and other architecture in a district are opportunities to incorporate biophilic design principles. Office buildings, schools, and residential dwellings can integrate plants and living walls to help with indoor air quality. There are many ways designers can use biophilia: placing operable windows that provide natural sunlight and ventilation; designing for views and viewsheds of natural areas; using natural materials in a way that celebrates sustainable production and consumption; or including signage explaining the material selection and telling the story of built infrastructure.

Environmental Awareness and Identity

Underlying ecological zones and historical systems can become powerful parts of how people think of the places where they live and work. Efforts to enhance this awareness can include signage that engages visitors with the natural history of a place, integrating local ecology and stewardship into curricula, and creating citizen science or outreach elements in local parks. Planning activities and festivals around birding, migrations, and other seasonal cycles can embed celebrations of nature into the district's identity.

Stewardship and EcoAction

Groups that are organized around specific efforts to improve the living infrastructure of a district can be powerful assets. Programs to adopt a stream, help plant native plants, control invasive species, and clean and maintain rain gardens are great ways to engage residents as stewards of their natural resources. Citizen science programs such as the Christmas Bird Count are also effective ways to engage interested citizens in stewardship.

EcoArt

Art installations can celebrate human interactions with and perception of the natural world. Local artists, environmental scientists and educators, government agencies, and community members can use pieces to interpret nature and inspire the community to engage in conversations about the natural environment. The use of local materials can reinforce the idea of closed-loop systems.

Example of Education and natural connection (Attribute 3: Celebrate Nature)

This serries of markers in Denver's Poudre River mark the fluctuation of the annual flow and historical highwater marks. Photo credit: Biohabitats, Inc.

Attribute 4. Employs strategies to eliminate or regulate impacts to climate, hydrologic cycles, nutrient flows, natural hazards, and pests.

If the first three Attributes are achieved in the planning and design of a district, the regulation of ecosystem cycles should follow naturally from their implementation. Nevertheless, it is useful to separate some of these technical areas because the metrics and targets associated with improving hydrological and nutrient cycles put a different lens on the strategies and introduce another set of metrics that can be used in target setting (Section 5). Also, there is a rich body of work devoted to providing guidance on Stormwater GI, and it is important to think about how those approaches nest inside the more comprehensive approach to living infrastructure presented in this Guide.

This guide does not address plans for sequestering carbon at the district scale. While carbon is taken from the atmosphere and converted to biomass as plants grow, it is important to recognize that the scale of an urban district affords extremely limited potential to sequester carbon. Furthermore, methods for doing so are not well established. In order to avoid confusion about the potential effectiveness of carbon sequestration on the scale of urban neighborhoods, it is not mentioned below.

PLANNING WITH ECOLOGICAL CYCLES AT SCALE

Scale becomes a critical factor when considering the ability of a district to regulate nutrient, hydrologic, and biological flows. For example, an individual street tree has no real ability to mitigate heat island effects, but a district or neighborhood with green roofs and 30-40% canopy cover can dramatically reduce heat islands. Similarly, nutrient processing, diseases, pest resistance, and water regulation are all enhanced at the district scale because they can improve interconnected systems.

MITIGATE URBAN HEAT ISLANDS

Tree Canopy

Landscaping plants can play a large role in mitigating heat islands, particularly where a dense tree canopy is regionally appropriate. Waterbodies, parks and other open spaces can also reduce the local impacts of urban heat islands.

Alternative Pavements

Hardscape surfaces that minimize heat absorption such as lighter colored pavement reduce urban heat. Permeable pavements have the added potential to minimize runoff, recharge groundwater, and treat hydrocarbons and other contaminants in the biofilms that form there.

REDUCE VOLUME AND IMPROVE THE QUALITY OF STORMWATER

Rooftop Vegetation

In addition to providing an opportunity to connect with nature and potentially cooling through evapotranspiration, greenroofs may also be used to absorb rainwater, slowly releasing water after a rain event and reducing the stress on the storm sewer infrastructure.

Underground Storage

There are many proprietary products that can be located below ground surface, designed to hold storm water and released slowly after the rain event. Some of these products are designed specifically to provide irrigation to street trees.

Treatment Outfalls

Stormwater outfalls can be designed to minimize erosion and impacts to receiving waterways. Strategies such as Regenerative Storm Conveyance (RSC) employs a series of step-pool sequences to convey water while slowing the water down and infiltrating runoff. RSC can be used restore existing channels, reconnecting the channel with the floodplain. RSC can also be effectively used at outfalls to minimize erosion and impacts to the receiving stream.

Urban Biofiltration and Bioretention

There are numerous types of biofiltration that can be incorporated into private and public spaces. Bioswales, rain gardens, storm water planters, and green streets are just a few examples.

Green Parks and Public Spaces

Parks and plazas can be utilized as places to capture and treat stormwater, while providing a public amenity.

STABILIZE SOILS

Erosion and Sediment Control

Stabilizing soils during and after construction activities can play an important role in keeping soils from contributing sediments to the air and waterways.

IMPROVE AIR QUALITY

Maximize Canopy Vegetation

Vegetation planted for many other reasons, listed above, has an added benefit of trapping pollutants on leaves, releasing oxygen and stabilizing soil to minimize dust.

Support Walking and Biking

Modes of transportation that do not rely on combustible engines (walking, biking) can be encouraged through design of bike paths, trails and sidewalks.

Minimize Industrial Emissions

Urban industries adhere to regulations that govern their emissions, but local areas can also provide incentives for industries to exceed the permit limits on their emissions.

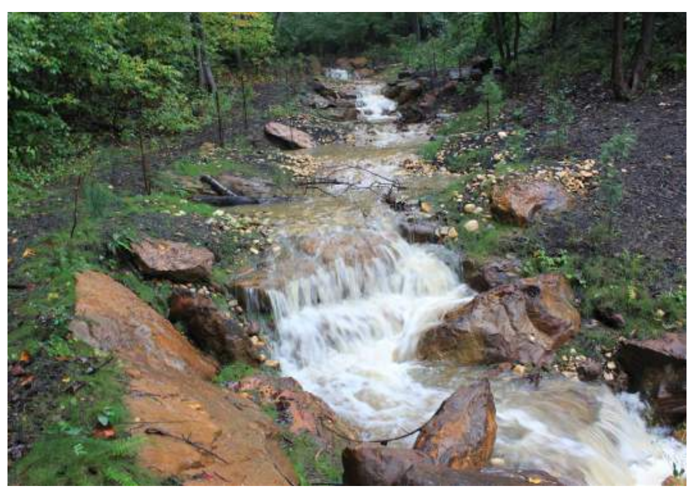
ADDRESS URBAN PESTS

Support Biodiversity

Pests thrive in disturbed urban sites where they face little competition and no predation. Therefore supporting biodiversity is a strategy to combat their populations. Avoid planting large areas of a single species, and instead rely on a diverse native plant palette. Where gardening precludes the use of native plants (food crops), plant a variety of species with similar water/sun/nutrient requirements together.

Integrated Pest Management (IPM)

IPM strategies can be used to address pests from plants to diseases and problematic insects throughout the district. Strategies will vary, depending on landscape use (parks versus private gardens) and regional location.

Example for treatment outfalls (Attribute 4: RSC)

Carriage hill Before Gully and During Hurricane: Severely eroded outfalls such as this stream near Annapolis can be stabilized with Regenerative Storm Conveyances. Photo credit: Biohabitats, Inc.

3. CONTEXT SETTING

As described in the EcoDistrict Protocol, the first step in the Roadmap Phase is developing a context, or getting to know the district. This includes understanding the drivers, existing and planned investments, identifying and engaging with the stakeholders, and listing the key community assets. Developing living infrastructure brings together many of the same stakeholders as the other Priority Areas, and identifying existing investments is a similar process of investing time in research and conversations. This section briefly identifies a few key non-negotiables and partners who are especially relevant to living infrastructure within a district or neighborhood.

DRIVERS

It is common that people usually make larger, district-scale infrastructure investments because of an actual or perceived need. This document does not make the case for supporting a robust living infrastructure, instead it assumes that to be a goal of district-scale projects. Nevertheless, making the case is an important part of ensuring the success of the project, and identifying the drivers behind potential improvements is a key step in doing so.

For example, the drivers in selecting water infrastructure include the need to provide water affordably over the long term, the need to increase human density while holding the water footprint down, the need to meet stringent stormwater mandates, the need to treat wastewater in sites that are not connected to the municipal sewer, or the need to reduce water flows to accommodate outdated infrastructure such as combined sewers or undersized pipes. Understanding what will motivate investment is the most important part of establishing context. Drivers for other elements of living infrastructure include the demand for recreation, the need to attract residents interested in healthy lifestyles, the desire to increase property values, and the desire to “do the right thing” to add meaning and support sense of place.

Some stakeholders are motivated to approach natural resources sustainably because they know it is the right thing, though this effort may be colored by wanting to do something distinctive, create an amenity, or demonstrate a concern towards sustainability. Their initiatives can be made more powerful and less likely to be removed by value-engineering if the underlying need is identified. It can then be linked to the economic, social and ecological case for the multiple benefits of a set of strategies.

REGULATORY CONSTRAINTS

It is always important to be familiar with existing regulations, as they can be constraints to effective and integrated district development. Some regulations can be easily met and are complementary to reaching targets (e.g., stormwater management requirements); while other regulations might be impediments unless a plan is in place to modify or update them (e.g., rainwater harvesting is limited in certain arid locales).

One consideration that often constrains living infrastructure is regulation of the use of water. For instance, decentralized water collection and treatment systems may be governed by a slew of regulations that make them difficult to build. The rules are typically designed by Health departments to protect the quality of our drinking water, but codes may not be designed for local or on-site water systems. For example, county-level public health codes often prohibit or limit the use of clean, filtered rainwater for anything, even flushing a toilet. Mapping out relevant regulatory constraints and opportunities to building a robust living infrastructure within the district is an important context-setting task.

PARTNERS

Identifying the partners that can be engaged in living infrastructure strategies underscores the breadth of their benefits. For example, the local workforce can be engaged in creating and maintaining strategies such as stormwater best management practices. This amplifies the multiple benefits of having a living infrastructure strategy for the district, as economic, social equity, and environmental outcoes can be leveraged.

Living infrastructure planning will also bring in interested parties such as local GI (stormwater) contractors. These groups are relatively easy to identify, but the methods of partnering with them could involve some creativity. For instance, Philadelphia's Water Department has found that their model of partnership with local landowners hinges entirely on setting up a system so that contractors are part of the application process.

Civic-led organizations that affiliate interested members of the public around specific themes can be helpful for developing aspects of a living infrastructure. Some are focused on specific taxonomic groups and may not have been aware of the EcoDistricts Protocol. For example, the American Bird Conservancy, National Audubon Society, Native Plant Societies and the Xerces Society for Invertebrate Conservation usually provide guidance for aspects of creating living infrastructure as it pertains to their mission. If there are local actors who have not already been engaged, they should be identified as part of the Living Infrastructure context.

Upon completing an evaluation of the general context, project teams should focus on the specific technical information that will inform their targets by collecting Baseline data.

4. TARGET SETTING: BASELINE DATA

This section will present brief, science-driven ecological and environmental assessments for each of the four attributes to give a sense of the type and level of information required to parameterize their target-setting.

The Role of Data Collection

There are two times when data gathering is the focus of the EcoDistricts Protocol. The first is in the Roadmap phase, aimed at understanding the site well enough to set targets. For example, understanding the soils types and basic hydrology of the district is a strong start on understanding the habitat types that a district can provide.

The second effort in data collection is in the Action phase, when data are needed to set specific parameters for project implementation. For example, a site with vacant land may have potential for a project converting those acres into stormwater treatment practices. In the Action Phase, the project team might look at the specific storage and drainage capacity of each site in detail, using soil borings and information on the permeability of the bedrock to select sites.

This section is designed to help project teams address the first phase of data-gathering, and it is therefore a consideration of the district from an overarching perspective rather than the more precise level of information required to guide project design. As these sets of questions are tailored to a district, team members should ensure that each question contributes directly to understanding a constraint or opportunity afforded by the site. In the age of readily-accessible GIS data, it is easy to accumulate large bodies of information that may not bear directly on the tasks at hand.

Historical Ecological Types and Conditions

The first step in an assessment is understanding the ecological history of the site. Some of the basic features, such as bedrock materials, change little with time. Others may be altered beyond recognition. To understand the natural hydrology, native flora and fauna, and productivity of the site, the assessment should begin with a basic description of the pre-built or underlying ecology, as can best be established before the district was originally developed, along with a description of how the site evolved over time to its current state. The ecological context of any site is variable, and no static description can do it justice, but it is useful to understand the range of variation of the basic natural characters of a district.

This description should include general plant and wildlife community zones, if known, and basic hydrology and soil properties. This historical information also has the potential to become part of the cultural identity of a district or neighborhood. One of the best sources for a quick assessment of the region is the dataset provided by NatureServe: http://explorer.natureserve.org.

The task at hand in district planning is often to revitalize and find the energy in a heavily urban environment, so an understanding of the living systems beneath the built form is critical. But knowing that the structure of the historical setting is not likely to be able to be replicated, the focus should rather be on the past functional attributes, which might be replicated.

This section presents a suite of questions to guide the baseline data collection for each Attribute. It bears repeating that the questions posed and answered at this step of Target Setting should reveal opportunities or identify constraints that will bear directly on the district's Targets.

Attribute 1: Existing Habitat Conditions

The National Wildlife Federation uses the basic elements of food, water, cover and space to define wildlife habitat. The questions below are designed to assess the ability of the district to provide the essential elements to native species.

Habitat Type and Condition

1. Which of the historical ecological communities (identified in the historical context) persist?
2. What percentage of the district is preserved as open space?
3. How diverse are the habitat types compared to reference sites?

Habitat Size and Shape

GIS affords a wealth of simple metrics to describe habitat patches and their connectivity. The results depend heavily on the spatial resolution of the data, but it should be possible to find reasonable comparisons for values determined by patch analyst, fragstats, or other connectivity packages. . Examples of these questions include:

1. 1Patch Metrics
   - What is the median patch size of greenspace within the district?
   - What is the mean perimeter: area ratio of a patch?
   - What is the patch cohesion value?
2. What is the % coverage by target land cover (e.g. forest, field, ephemeral wetland)?)
3. What barriers need to be removed or modified to improve connectivity to surrounding native ecosystems?

STRAIGHT.COM

Habitat Size and Shape

1. Which species historically found in the district persist there today?
2. Are the wildlife populations constrained by the availability or quality of foraging opportunities or water?

Focal Wildlife

1. Are there rare, threatened or endangered species on the site?
2. What are the focal species of concern for the area? Are they year round residents or transient?
3. How do species move across the district?
4. Are their major corridors (e.g. between wetlands for amphibians) that can be protected?
5. Are there local, minor features that need to be enhanced or connected? Are there species such as migratory birds or fish that use parts of the district during their annual lifecycle?

Habitat Threats

1. What are the critical threats affecting habitat viability? Which of these can be improved at the district scale? (See Drivers, in Context, above)
2. Are there emerging diseases present or near the site?
3. Are invasive and non-native species present? What degree of threat do they pose to native systems?

Attribute 2: Existing Food and Water Conditions

Increasing the resiliency and water sovereignty of a district often requires a combination of water-centric strategies that seek to reduce reliance on importing potable water and exporting polluted wastewater and excess nutrients. By identifying and modeling synergies between the different water supplies and demands on the site, informed decisions can be made to select which infrastructure improvements to pursue, and at what scale.

Hydrology

1. Where does rainfall run on and off the property? How do surface flowpaths connect to offsite hydrology?
2. How does infiltration support natural processes such as groundwater recharge/discharge and/or stream base flow?
3. How do surface water patterns support types, locations, and productivity of native plant communities?

Rain Capture

1. Determine the amount of water needed for meeting the non-potable demands throughout the district on an annual and monthly basis. Non-potable demands could include irrigation, toilet flushing, laundry, cooling or other permitted uses.
    - Consider different types of landscaping throughout the district that have varying water requirements.
    - Gather climate data to understand landscaping water loss (evapotranspiration)
    - Create estimates of non-potable demand based upon a low to high range of water consumption values for occupants/project users.

2. Quantify the amount of water that may be available for reuse. Determine the annual and monthly rainfall based on the total building roof area that will be used to collect rainwater. Examine both dry and wet periods, as well as outcomes from different storm frequencies (i.e. the 2 year, 5 year and 25 year events).
3. Is rainfall seasonal or year-round?
    - If seasonal, are appropriately sized cisterns or other storage features feasible?
    - A monthly (or daily) balance calculation performed around the cisterns can be used to determine the ideal volumes.
4. What kinds of uses are appropriate for rain capture water? Irrigation, industrial application?
    - The planned use will impact the need for additional treatment (filtration, etc.).

Wastewater Treatment and Recycled Water

1. Determine the amount of wastewater that will be produced onsite, on a daily basis in both average and peak conditions.
    - Consider separate uses such as office/work space wastewater production and residential wastewater production.
    - Calculate the portion of the daily wastewater flow that makes up toilet flushing (or other targeted non-potable reuse application). This amount can be used to determine the remaining effluent that must be managed or discharged after reuse.
    - Determine flow diagram for ultimate fate of wastewater – will some exit the site treated or untreated through connection to the municipal system, or will it all be reused or infiltrated on site? This flow diagram is a useful tool for discussing the feasibility with the regulatory community, who will have a large impact on the implementation of these strategies.
2. Is this new construction?
    - New construction is the most feasible for installing dual plumbing into buildings, allowing them to use recycled water for toilet flushing. Similarly new construction may be easier to design for capture of effluent or separation of graywater.

Healthy Soils

1. Are there contaminated soils onsite?
2. Is there an existing composting program that can serve the district?

Community and/or Private Gardens

1. Is space available for community gardens?
    - Are there available locations that can be accessed by the public?
    - If available space is located on private property, are there opportunities to set aside an easement for a community garden?
2. Are site conditions suitable for a garden?
    - Are soils contaminated? Is the site a brownfield? Will soils need to be imported?
    - Does garden space have adequate solar access?
    - Is water available, or can it be made available, at the proposed garden locations?

Attribute 3: Existing Cultural Conditions

Integration of Natural Processes

1. What are the historic landforms and hydrological forms that can be commemorated in structures and landscape designs?
2. What local species (plant or animal) could provide inspiration for biomimetic design efforts, forms or processes?
3. What are the locally available natural materials to be used in buildings?
4. What local native plants and planting palettes can be considered for gardens, green roofs, street trees, and other open space and vegetated areas?
5. What local ecosystems can act as a reference for the design of the site?

Access to Nature

1. How many acres of vacant land are in the district and what are their current uses?
2. What % of residents have access to parks within a 15 minute walk?
3. How does access to nature vary across the district?
4. What are the primary constraints and barriers to such interactions, both physical and political?
5. Are there connections with trails, greenways or open spaces the immediate vicinity of the district?
6. Are there any groups with particular needs for natural benefits? Prisons, schools, hospitals, retirement homes?

Celebration of Nature

1. What natural features can be preserved and celebrated in the district?
2. How do people in the district think about the existing living infrastructure?
3. Are there any concerns about street trees or dense vegetation?
4. Is there a cultural legacy of natural interactions among the people in the district?

Example for water conservation (Attribute 2: Capture and Treat Water)

Domenici before and after: The entrance to the Domenici Courthouse used 750,000 gallons/month for irrigation before it was redesigned with appropriate arid zone plants. Photo credit: Biohabitats, Inc.

Attribute 4: Existing Regulating Conditions

Climate

1. What are the annual rainfall patterns and amounts?
   - Does rainfall occur steadily throughout the year or are there periods of drought?
2. What are the annual weather patterns on site?
3. Does the area receive longer periods of cloud cover and rain or is the area more prone to sunshine with little rain?
   - How are the values above predicted to alter under climate change?

Hydrology and Stormwater Infrastructure

1. Are there existing streams on site? (See habitat section)
   - Are they incised, have eroding banks or otherwise degraded?
   - Are there existing wetlands and/or wetland buffer within the site?
   - Is the site within the floodplain of a nearby stream?
2. Are/were there streams on site that have been buried or piped?
3. Do properties adjacent to the district discharge storm water onsite?
4. Is there other stormwater infrastructure located near the site?
   - Is this infrastructure functional and treating stormwater correctly?
5. Is there a large amount of impervious area within the site?
   - Is the impervious cover in good condition or does it need to be replaced?
   - Can the impervious cover be converted?

Soils

1. What types of soils are found on site?
2. Are they native soils or has the site been filled?
3. What are the infiltration capacities of onsite soils?
4. Are the onsite soils contaminated?
5. Are the onsite soils highly eroded or erodible?

Air Quality

1. Are there existing air quality concerns at the site?
   - Is there a major highway adjacent to the site?
   - Are there industrial emissions adjacent to the site?

Pests

1. Are there invasive plant species at the existing site?
2. Are there invasive animals on or adjacent to the site?
3. Will proposed living infrastructure increase any pest population that is already a current issue within the area?

Qualitative Assessments

The Baseline data collection for the EcoDistricts Roadmap Phase includes community engagement, which is inherent to the EcoDistrict Protocol for all Priority Areas. Nevertheless, it bears repeating here that a Baseline Assessment is not complete without a qualitative element. Whether developed through workshops, open-ended surveys, or semi-formal conversations, the qualitative side of the Baseline provides an opportunity to capture information and background that may not be self-explanatory in the data.
It also might provide the opportunity to engage people who are important in the community but not formally engaged in this work. Examples could include faith-based groups, schools, and large adjacent land owners.

A complete baseline, one that includes each attribute and qualitative assessments, is the foundation for the next step, constructing a meaningful set of targets.

5. TARGET SETTING: DISTRICT TARGETS

Target Setting for the district should begin with a comprehensive knowledge of the existing initiatives at the district, Municipal, and City scales. These are pieces of information that should be gathered as part of the Context step in district planning, but this is a good point at which to double check that all of the relevant ongoing efforts are familiar to the team.

The EcoDistricts Target Setting Template provides specific guidance for the process of setting targets. Below are a few key considerations that will be relevant to almost every situation.

Don't Plan in Silos

As it moves across a district, water might go by a dozen names: rain, fish habitat, stream, stormwater, grey water, irrigation water, wastewater, etc. But the resource must be treated as a single unit at the district scale. That is the most important opportunity offered by the district scale. It is important not to let human disciplines and conventions in development split one resource into many different compartments. The major benefits of planning at larger scales can be lost if resources are not evaluated holistically. Understanding the integrated nature of this resource allows the project to focus on the opportunities to create internal loops, constantly improve water quality and provide a resource of beauty and sustenance for both humans and wildlife.

Don't Wait to Set Living Infrastructure Targets

It is difficult to overstate the importance of including living infrastructure planning in the earliest phases of project planning. Key elements such as habitat and stormwater treatment are too often afterthoughts in the design process. Living infrastructure is not an overlay- it simply means including good design principles from the beginning.

Living Infrastructure Targets in Context

It is important to think about how other technical issues compete with or leverage living infrastructure targets. The simplest tradeoff is often the footprint of the developed land, whereby denser development is considered to be an asset in terms of economic growth or other metrics. Mapping out such overlap can help pinpoint opportunities to maximize multiple priorities and ask the project team to thoughtfully resolve competing priorities.

Targets Reflect Broad Vision

In a complex planning exercise, there are often projects and institutions that have momentum and existing constituents: no-brainers. However, the targets that a district develops for its living infrastructure should not be entirely driven by projects that are already considered feasible. When setting targets, it is good to pose some open-ended questions that encourage respondents to think big: "If time and money were not factors, what would your top targets be?" "If you had 100 million dollars to spend here tomorrow, what would you do?"

The best outcomes of target setting often happen when teams embrace all possibilities and are not too quick to eliminate ideas. Be willing to ask why something can't be incorporated or adopted.

Targets Are Powerful for What They Exclude

One prevailing flaw in neighborhood and district level planning is targets that are too lofty and so inclusive as to rule out nothing. In setting targets for strengthening a district's living infrastructure, it is important to make them specific enough to provide direction.

6. TARGET SETTING: IDENTIFY STRATEGIES

As in the previous step, of setting targets, selecting the best strategies to reach those targets is likely to be a familiar process for much of the audience for this document. It is also a process that relies heavily on the individual characteristics of a site, and will vary enormously according to factors such as the project's typology (e.g. brownfields offer opportunities and constraints that are distinct from those of densely populated urban neighborhoods). Generally speaking, however, living infrastructure targets are often best framed as a map of priority hubs and corridors.

Identifying and Prioritizing Strategies Is an Iterative Process

Identifying and prioritizing strategies is essentially a matchmaking process. Once the district targets are agreed upon, the team should assemble the potential strategies (the list in Section Two was created to provide a solid foundation of options to consider) and examine each through multiple lenses. The key to selecting the best strategies is bringing together experienced people and accurate baseline information to evaluate candidate strategies and then ensuring that there is adequate time to fully explore their costs and benefits.

Consider Potential Liabilities

Like all projects, living infrastructure strategies have the potential to create some liabilities. If there is a plume under the surface of the soil, infiltrating water might move contaminants downstream. Increasing access to natural water features may spur safety concerns. Creating habitat for the most vulnerable species in the area may attract federally listed species that trigger restrictions for use. Such eventualities can be addressed if they are planned for. For example, it is possible to obtain safe harbor status so that if endangered species appear in an area, their legal protections are different than in places where the species has always lived. It is possible to plan for such eventualities if project teams consider and address issues early in strategy selection.

Create a Diverse Set of Strategies

Individual strategies align along continua of initial cost, time for implementation, optimal performance window, ongoing maintenance and operations costs, associated risk, and performance power. The strategies that are selected for early implementation should represent some diversity in these characteristics. The temporal scale is particularly important in planning living infrastructure practices because plants are dynamic elements that grow and later their immediate surroundings.

Prioritize Multiple Benefits

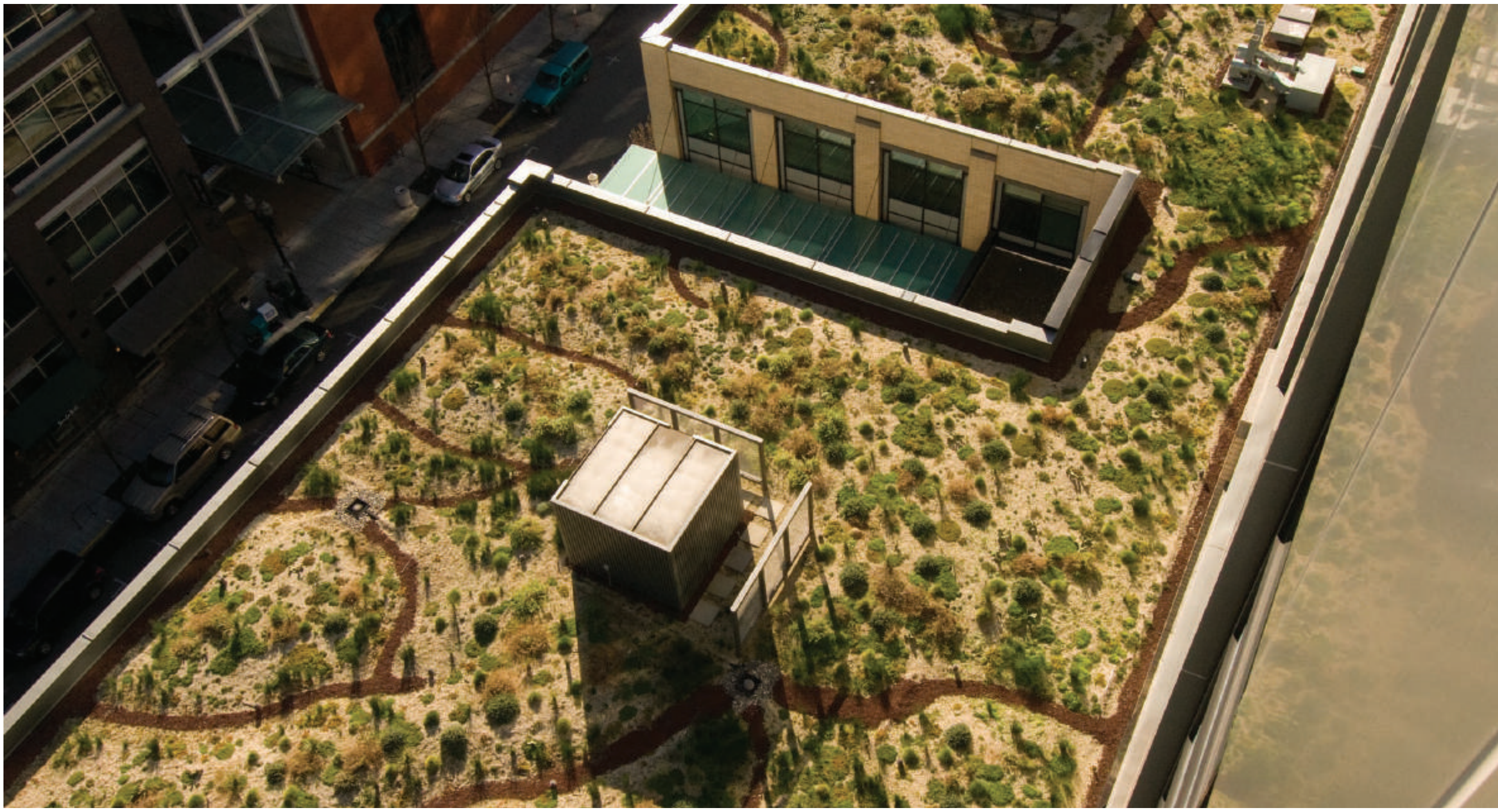
A Living Infrastructure is multifaceted, and it is the backbone of only one of six Priority Areas for planning district-scale development. As suggested throughout the EcoDistricts District Assessment Toolkit, the opportunity to benefit more than one Priority Area should boost the ranking of any strategy. How does this project interface and mesh with other technical goal, user groups, and community development initiatives? Are there synergies or conflicts that arise? What community programs/initiatives exist that this project effort can align with (e.g., climate action plans, jobs programs, urban tree canopy targets, stormwater permit requirements, etc.)

Leverage Assets

In addition to providing multiple technical benefits that meet the targets of a district, some strategies can leverage other assets. For example, an innovative urban renewal project might build political will or attract financing and public support for a suite of subsequent strategies. In addition to powerful technical results, some of the early strategies should have some star power.

Balance Formal and Informal Prioritization

In complicated planning scenarios with multiple stakeholders and many ideas, especially where there is a need for transparency or accountability to a citizenry, it can be useful to develop a scoring system for evaluating strategies with consensus-based criteria. The EcoDistricts District Assessment Toolkit provides one example of such a scoring matrix. These allow transparency and are easy to communicate. On the other hand, it is important that the strategy list make sense to experts. Therefore it can be useful to start the priority setting exercises with a confidential poll that asks experts to rank strategies. These lists can then be compared to the matrix scoring results as a final check on their validity.



7. LIVING INFRASTRUCTURE EXAMPLES

This section demonstrates how select example projects evolved during the process outlined in this Guide. The examples below, which represent an array of initial conditions and ecoregions, focus on the constraints and opportunities uncovered during the Roadmap Phase and on the decision points that shaped the projects' final forms.

OMEGA INSTITUTE ECOLOGICAL MASTER PLANNING (2014-2015)

FIRM: BIOHABITATS, INC.

The Omega Institute sits on a 200-acre property about 100 miles north of New York City. Its striking natural resources serve as a backdrop for a retreat center devoted to holistic wellness and awakening the human spirit. The campus of the Omega Institute is rich in biodiversity and has a dynamic ecology and hydrology, including several streams and a large lake. The site also supports rare species such as the pink lady-slipper orchid and the endangered northern cricket frog. Development of the campus over the last 20 years has resulted in dozens of buildings, from small cabins to large meeting centers, with the capacity to house up to 600 visitors during peak periods.

THE PROJECT CONTEXT

The buildings and infrastructure of the Omega campus were sited and designed for sustainability; some met the LEED standard and even the Living Building Challenge guidelines. However, the Institute's examination of the underlying ecology had been relatively narrow. The stormwater systems did not tie into the broader ecological context, and the discovery of the endangered frog near a building site triggered remediation. The institute had recurring water management and flooding issues.

The planners realized that, careful as they had tried to be, their approach was missing an important element- a holistic understanding of the ecology of the campus. Instead of continuing to merely react to new information, they decided to craft a master plan that relied on the natural framework of the campus and took a broad and proactive approach to stewardship. "The standard review process for building and site management has too many layers that are driven by a short-sighted relationship to nature," says Omega Institute Founder and CEO Robert Backus. "We wanted to understand what we could learn from what's here, and realize our goal of planning with a deeper, more experiential relationship to the world right here on the campus."

The master plan was designed to express Omega's values. The planning focused on an understanding of the whole site and ecological context that could guide regenerative development that works with the ecology and natural resources. Specific targeted issues included understanding native ecological communities, solving the localized flooding, and reducing erosion issues.

BASELINE ASSESSMENT

For the assessment phase, understanding the plans and needs of the owners was as critical as understanding the local ecology as the team crafted the social and cultural approach. The assessment included ecological communities, site hydrology, waste treatment, and energy consumption. Two of the most important aspects were estimating total energy and water budgets for the campus.

Much of the data, such as sediment transport modeling, were focused on understanding the impairments to the hydrology of the site and the undesirable consequences of flooding and erosion. In order to better understand the living and built infrastructure needs, a preliminary water balance was developed to consider the amount of water that naturally moves through the site and the overall water use on site.

The Omega Institute also found that the background document itself was a powerful tool. Members of the Omega community who had visited the campus regularly for over 20 years reported discovering it in a completely new light once they understood its natural structure and assets.

A central feature of the campus living infrastructure is the cascading wetland system that treats wastewater onsite. Photo credit: Biohabitats, Inc.

SETTING TARGETS

The Omega Institute Master Plan is a living document, and the effort is still in early implementation. Although general goals and recommendations were developed for the Ecology, Energy and Climate, and Living Infrastructure, the latter was the initial focus of the next steps in project development. Some of the water management issues that were the most pressing took precedence.

The plan itself has been important in leveraging further support for their targets in holistic planning and sustainable improvements. Donors and funders see it as physical evidence of a serious commitment to building resilience in the use of natural resources.

IDENTIFYING AND PRIORITIZING STRATEGIES

One of the first constructed projects was a raingarden outside of the Dining Hall that enhances the property's aesthetic and creates new habitat while treating stormwater. It was more than an improvement in the ecological function of the site, it also helped cement the social ownership of the projects because it was built by members of the wider Omega community. This project selection reflected the cultural priorities of the Omega Center and their renewed commitment to making water part of the living infrastructure of the site.

LEARNING OPPORTUNITIES

As in many master planning processes, the first projects have been a balance of needs and the funding available for immediate implementation. The mix of strategy types helped address this (the raingarden was a feasible, low-cost option). In some places, the urgencies of erosion or other immediate problems outstripped the Center's ability to invest in taking a balanced approach to addressing the underlying causes of local hydrological issues. For example, the Institute had to take some stopgap measures to address flooding, even while working on long-term plans for restoration of the extended stream network as an ultimate solution to flooding problems.

The research and resulting plan has continually provided benefits to their planning and ability to address new situations. The plan guided their response and served as a resource when a transmission line right of way was proposed nearby. As Backus stated, "It was better to have done some of these things out of a desire to be in a deeper relationship to the environment as opposed to in reaction to a particular threat."

APPENDIX 1: TERMINOLOGY

Choosing to use the term “Living Infrastructure” to describe a regenerative alternative to conventional recreational and grey infrastructure (pipes/utilities, structures, facilities, etc.) in this guide was essentially a process of elimination. Green Infrastructure is one term commonly used to denote a subset of the strategies that create living infrastructure. For example, as it is broadly defined by the Green Infrastructure Foundation, the term includes a wide swath of the strategies in this Guide, though their definition excludes engineered solutions to water management:

> “Green infrastructure is defined as natural vegetation and vegetative technologies that collectively provide society with a broad array of products and services for healthy living.”
>
> Green Infrastructure Foundation

Alternatively, and perhaps more commonly, Green Infrastructure can be understood in the narrower sense of stormwater management, as in the definition by the NY Department of Environmental protection.

> “Green Infrastructure describes an array of practices that use or mimic natural systems to manage urban stormwater runoff. Green Infrastructure controls stormwater by using it as a resource rather than a waste.“
>
> New York, Department of Environmental Protection

Given the breath of existing Green Infrastructure definition, and its sometimes narrow usage, we decided to prevent misconceptions by choosing living infrastructure.

Another central objective of this Guide is to address how a district can plan for Ecosystems Services across its extent. However, the Ecosystem Services framework also carries strong connotations that we wished to avoid. Foremost among these is that Ecosystem Services are usually defined relative to a human end user and do not recognize intrinsic values outside that framework, e.g. biodiversity. In addition, Ecosystem Services terminology is often used for audiences concerned with the valuation of such services, and our presentation and assumptions of values do not fit easily into that framework.

With these sets of limitations attached to the terminology options, we decided to strike a third course and use the emerging but less common term “Living Infrastructure”.

APPENDIX 2: EXAMPLE GUIDANCE DOCUMENTS

This section presents a few examples of resources about some of the strategies listed in Section Two. This list is only intended to provide examples of the detailed guidance available.

HARBORS AND SUPPORTS INDIGENOUS FLORAL, FAUNA, MIGRATORY SPECIES AND POLLINATORS.

Guidance for local authorities on implementing the biodiversity duty.

http://archive.defra.gov.uk/environment/biodiversity/documents/la-guid-english.pdf

Landscape biodiversity planning and design system

http://www.aecom.com/deployedfiles/Internet/Capabilities/Design%20and%20 Planning/_documents/130403_LandscapeBiodiversitySystem_TM.pdf

Guidelines for improving connectivity for terrestrial and aquatic wildlife on the I-70 mountain corridor

www.codot.gov/projects/contextsensitivesolutions/docs/pdfs/i-70-guidelines-for-enhancing-wildlife.pdf

CONSERVES AND REPLENISHES FRESH WATER, PROTECTS SOILS, AND PROVIDES FOOD.

Basic guidlines for creating water conservation plans

http://www.epa.gov/WaterSense/docs/part3_508.pdf

Community backyard composting programs

http://www.bae.ncsu.edu/topic/composting/pubs/backyard-composting.pdf

Creating gardens of goodness

http://www.ecoliteracy.org/downloads/creating-gardens-goodness

Central Texas community gardening manual

http://worldhungerrelief.org/wp-content/uploads/2011/04/Central-Texas-Community-Gardening-Manual-1.pdf

CONNECTS PEOPLE TO NATURE

14 patterns of biophilic design

http://www.terrapinbrightgreen.com/report/14-patterns/

Children and Nature Network Community Action Guide

http://www.childrenandnature.org/documents/C119/

EMPLOYS STRATEGIES TO ELIMINATE OR REGULATE IMPACTS TO CLIMATE, HYDROLOGIC CYCLES, NUTRIENT FLOWS, NATURAL HAZARDS, AND PESTS.

Assorted green infrastructure design manuals

http://water.epa.gov/infrastructure/greeninfrastructure/gi_design.cfm

A Practical Guide to Cool Roofs and Cool Pavements

http://www.coolrooftoolkit.org/read-the-guide/

The BPM Database

http://www.bmpdatabase.org/

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