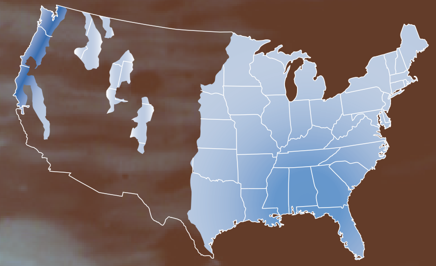
How to Use This Manual

Environmental planning typically enjoys success in natural settings, but the real challenge for developing sustainable cities is ensuring ecosystem integrity within urban contexts. Naturally-determined ecosystems have been irrevocably altered by human activity. Indeed, the greatest ongoing problem in planning involves designing within human-dominated ecosystems. After all, 80% of the US population now lives in urban areas. *Low Impact Development: A Design Manual for Urban Areas* introduces general audiences to designing landscapes for urban stormwater runoff—a primary source of watershed pollution. This manual can be reviewed episodically, much like a lifestyle publication, or read in its entirety for a comprehensive understanding. The goal is to motivate awareness and implementation of LID in a wide cross-section of stakeholders, from property owners to municipal governments that regulate infrastructure development. Though not exhaustive in its coverage of LID techniques (i.e., you will not be able to engineer a LID project from this manual), this manual does provide a holistic framework in which a novice homeowner and an experienced developer can each find an equally transformative role to enact.



If you live in the blue, this manual is for you!

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Low Impact Development: a design manual for urban areas

Arkansas

LID

Low Impact Development

a design manual for urban areas

LID

Low Impact Development

a design manual for urban areas

University of Arkansas Community Design Center

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> *...in many cases the first flush of stormwater in an urban area may have a level of contamination much higher than normally present in sewage...*

Craig Campbell and Michael Ogden,
Constructed Wetlands in the Sustainable Landscape

impervious surfaces

What if urban stormwater infrastructure enhanced ecological functioning to serve as a civic asset rather than an environmental liability?

> *Lawns use more equipment, labor, fuel, and agricultural toxins than industrial farming, making lawns the largest agricultural sector in the United States.*

Richard Burdick, “The Biology of Lawns”,
Discover, July 2003

industrial landscapes

> “By replacing the stream that was once here, the bare and sterile concrete replaces the fecundity of soil and plants. The concrete has just one purpose, ignoring the multiplicity of other purposes served by the landscape it replaced...”

John Tillman Lyle, “Landscape: Source of Life or Liability”, *Reshaping the Built Environment*

urban stream syndrome

"Research indicates that when impervious area in a watershed reaches 10 percent, stream ecosystems begin to show evidence of degradation, and coverage more than 30 percent is associated with severe, practically irreversible degradation."

Metro Portland, *Green Streets: Innovative Solutions for Stormwater and Stream Crossings*

urban sprawl

“death by a thousand cuts”

flash flooding

water contamination

stream scouring

What Low Impact Development (LID) does is make hard engineering...

work more like soft engineering.

offering the 17 ecosystem services

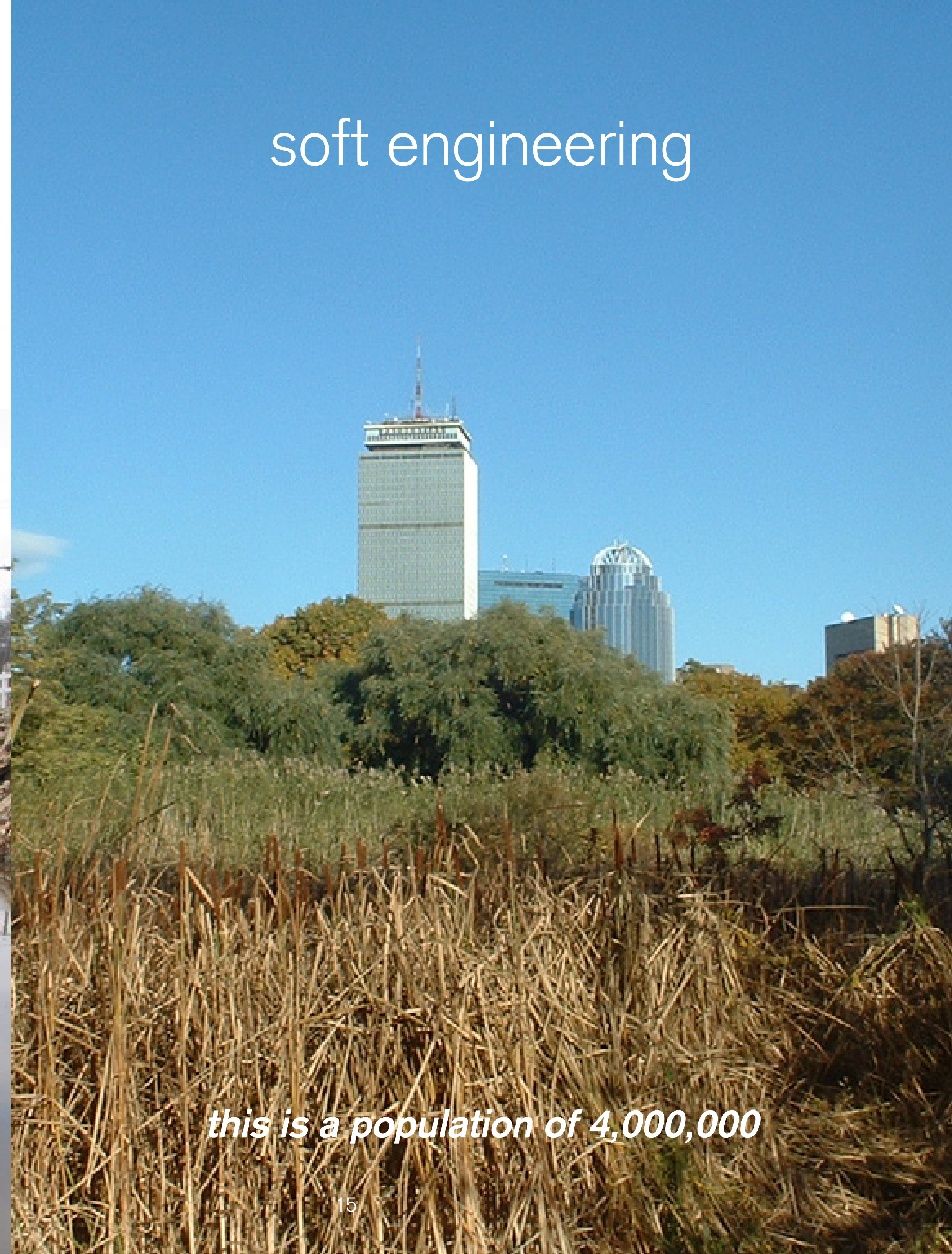
1. atmospheric regulation
2. climate regulation
3. disturbance regulation
4. water regulation
5. water supply
6. erosion control and sediment retention
7. soil formation
8. nutrient cycling
9. waste treatment
10. pollination
11. species control
12. refugia/habitat
13. food production
14. raw material production
15. genetic resources
16. recreation
17. cultural enrichment

hard engineering

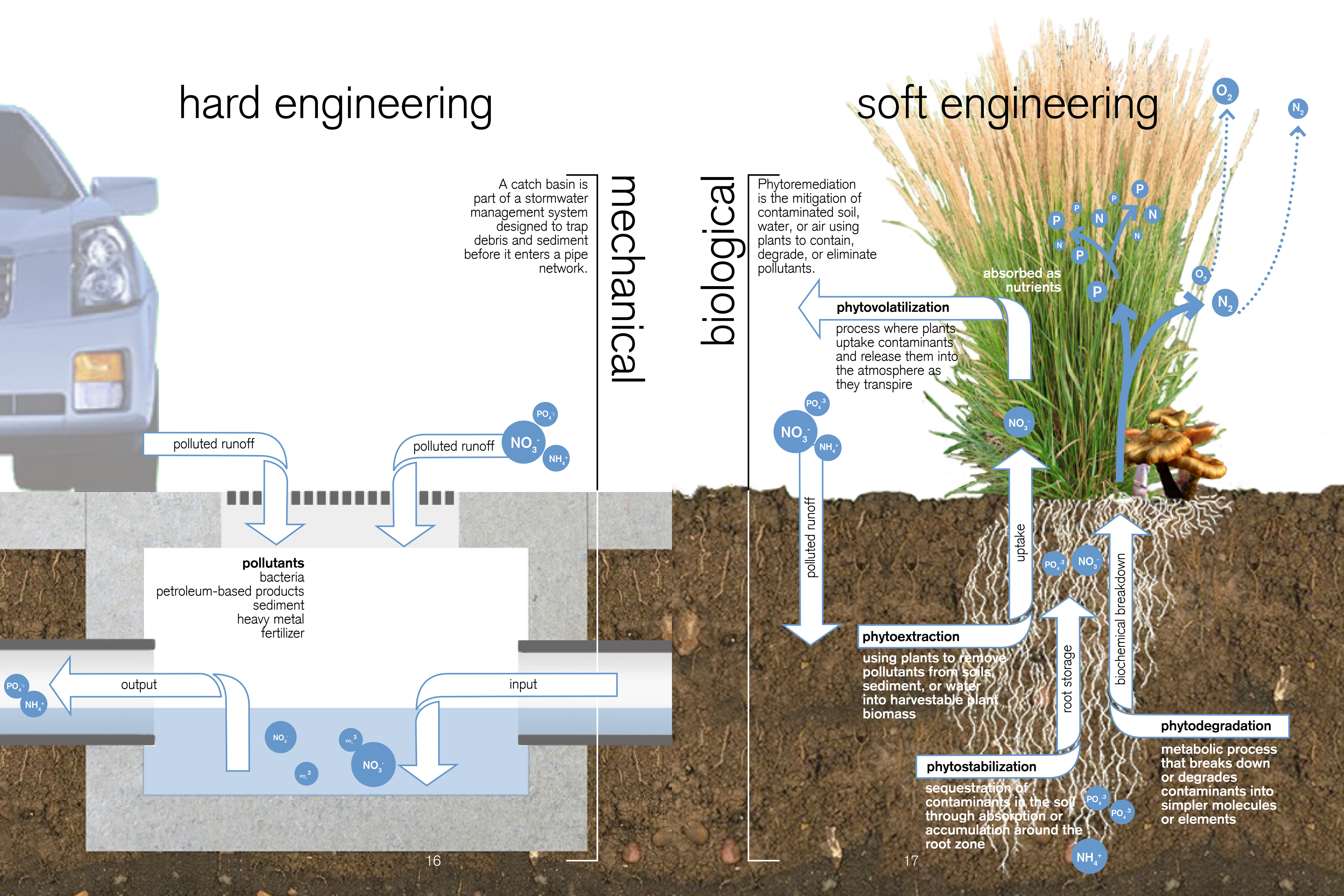
Some believe that ecologically-based stormwater management is unattainable in dense urban areas, but consider the following...

this is a population of 8,000

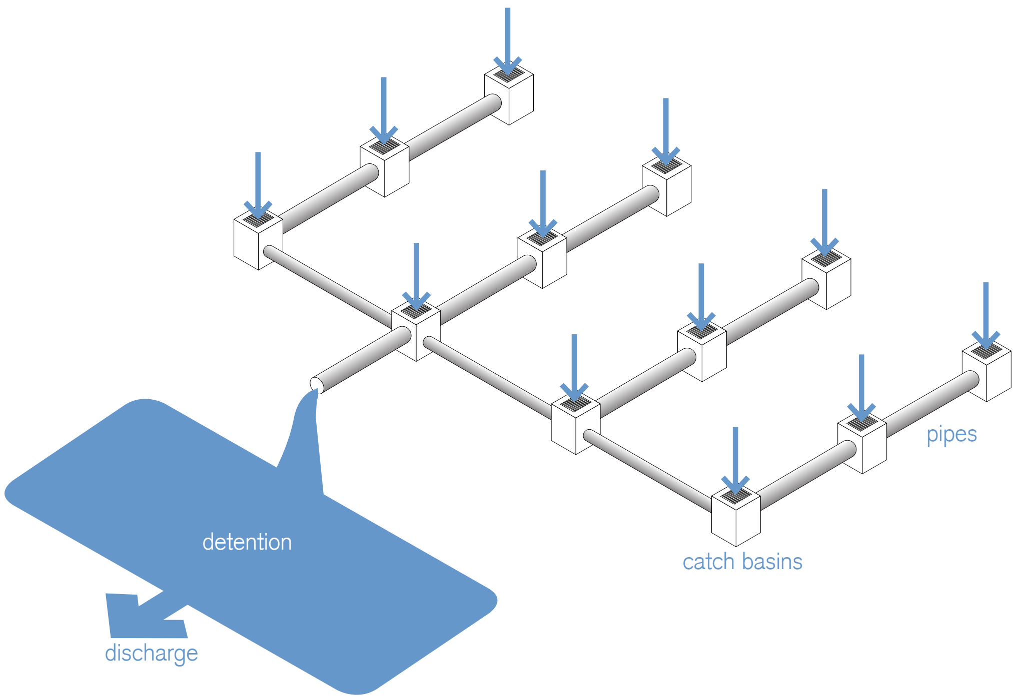
soft engineering



this is a population of 4,000,000

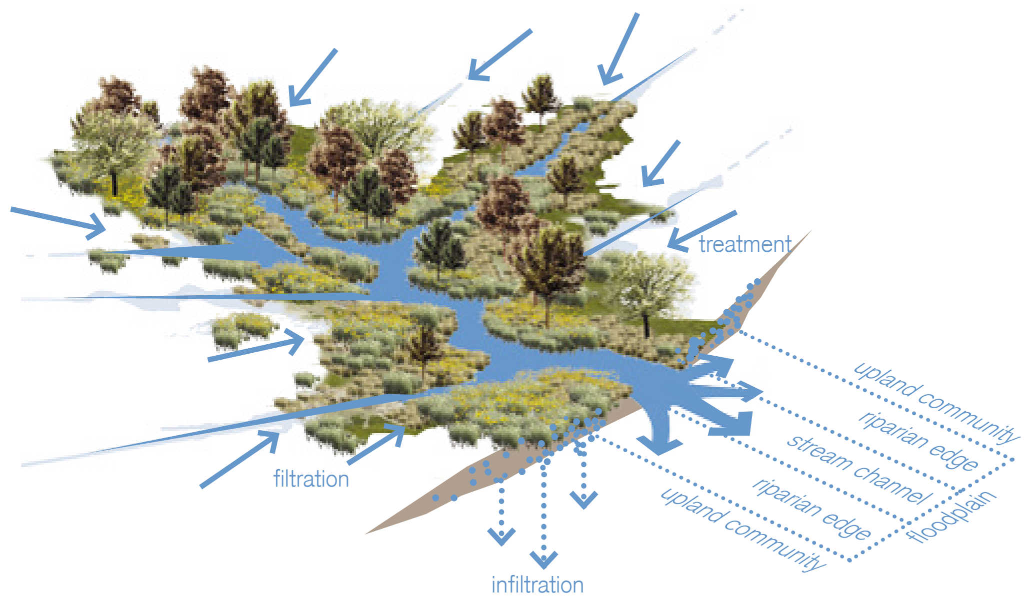

hard engineering
mechanical
A catch basin is part of a stormwater management system designed to trap debris and sediment before it enters a pipe network.
polluted runoff
polluted runoff
NO_3^-
PO_4^{-3}
NH_4^+
pollutants
bacteria
petroleum-based products
sediment
heavy metal
fertilizer
output
input
PO_4^{-3}
NH_4^+
NO_3^-
PO_4^{-3}
NO_3^-
PO_4^{-3}
soft engineering
biological
Phytoremediation is the mitigation of contaminated soil, water, or air using plants to contain, degrade, or eliminate pollutants.
phytovolatilization
process where plants uptake contaminants and release them into the atmosphere as they transpire
absorbed as nutrients
O_2
N_2
O_2
N_2
P
N
polluted runoff
NO_3^-
PO_4^{-3}
NH_4^+
uptake
root storage
biochemical breakdown
phytoextraction
using plants to remove pollutants from soils, sediment, or water into harvestable plant biomass
phytostabilization
sequestration of contaminants in the soil through absorption or accumulation around the root zone
phytodegradation
metabolic process that breaks down or degrades contaminants into simpler molecules or elements

hard engineering ...just transfers pollution to another site



conventional management: “pipe-and-pond” infrastructure
drain, direct, dispatch

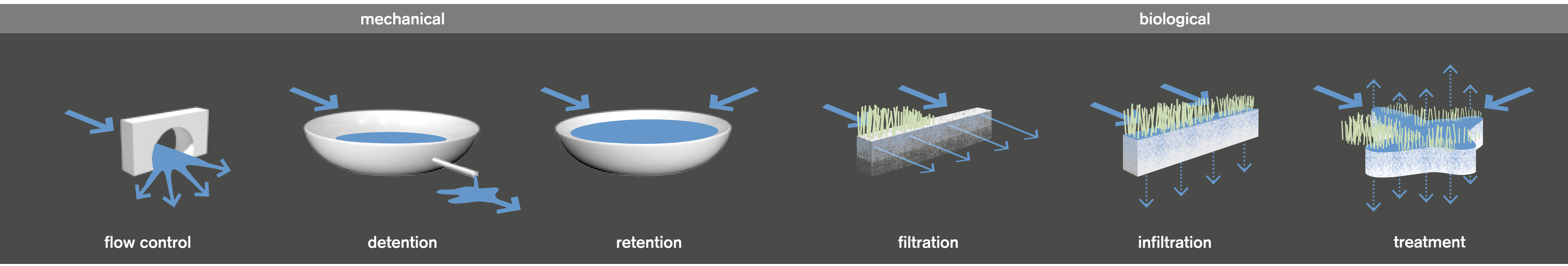
soft engineering ...metabolizes pollutants on site—parks, not pipes!



low impact management: watershed approach
slow, spread, soak

integrating hard engineering

...and soft engineering toward a LID approach



slow ⟶ spread ⟶ soak

flow control: The regulation of stormwater runoff flow rates.

detention: The temporary storage of stormwater runoff in underground vaults, ponds, or depressed areas to allow for metered discharge that reduce peak flow rates.

retention: The storage of stormwater runoff on site to allow for sedimentation of suspended solids.

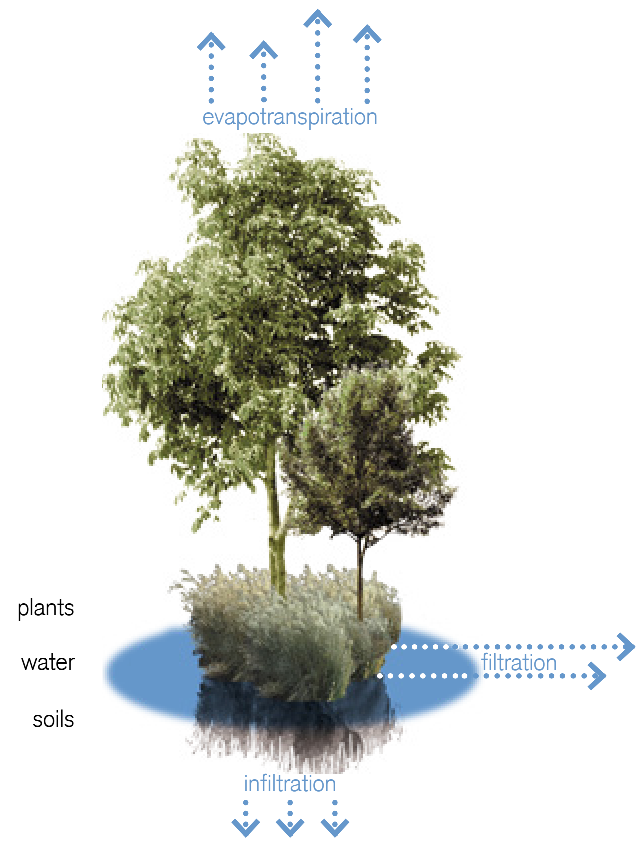
filtration: The sequestration of sediment from stormwater runoff through a porous media such as sand, a fibrous root system, or a man-made filter.

infiltration: The vertical movement of stormwater runoff through soil, recharging groundwater.

treatment: Processes that utilize phytoremediation or bacterial colonies to metabolize contaminants in stormwater runoff.

What is LID?

Low Impact Development (LID) is an ecologically-based stormwater management approach favoring soft engineering to manage rainfall on site through a vegetated treatment network. The goal of LID is to sustain a site's pre-development hydrologic regime by using techniques that infiltrate, filter, store, and evaporate stormwater runoff close to its source. Contrary to conventional "pipe-and-pond" conveyance infrastructure that channels runoff elsewhere through pipes, catchment basins, and curbs and gutters, LID remediates polluted runoff through a network of distributed treatment landscapes.



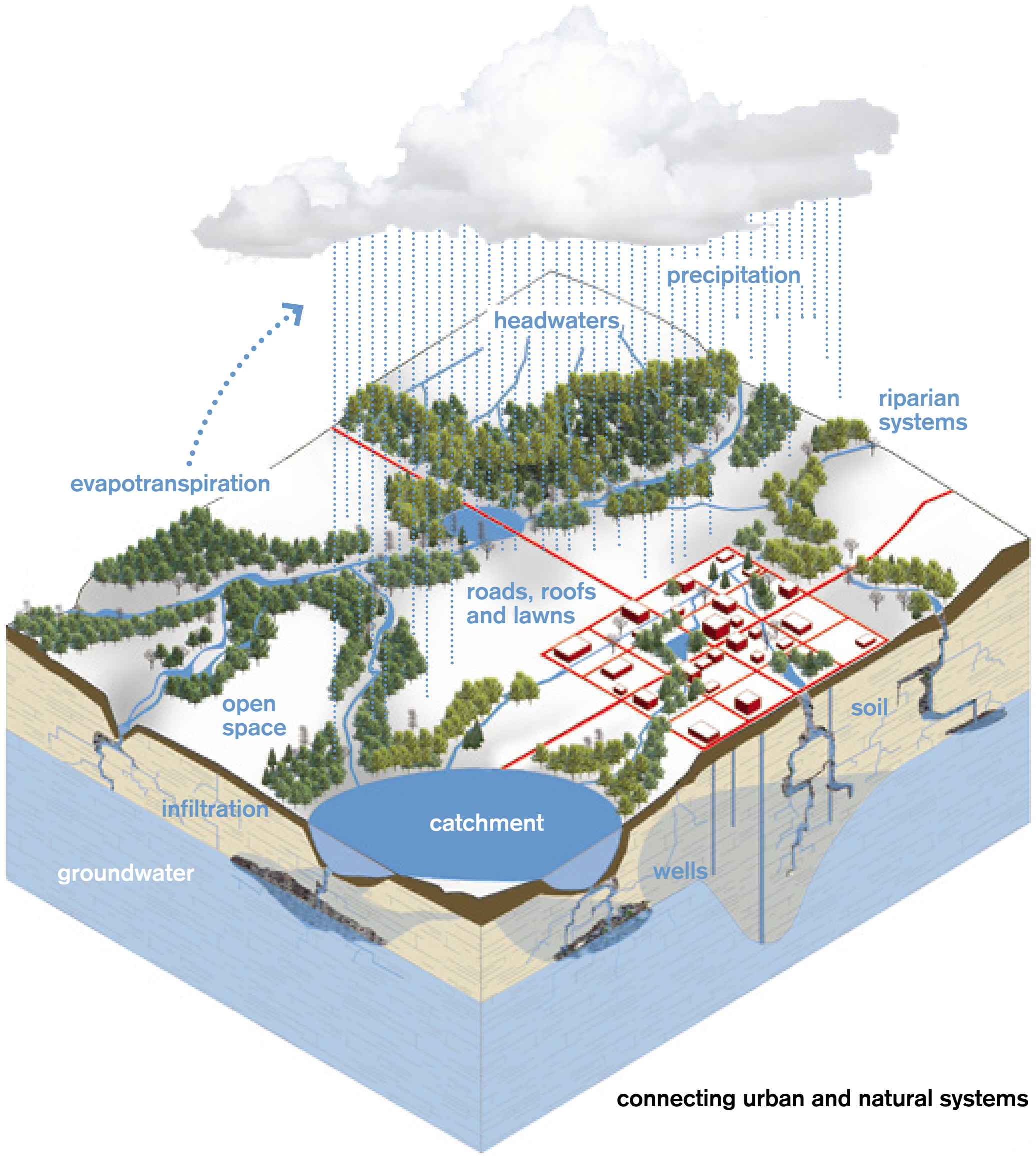
media and processes of LID

Stormwater infrastructure can be planned to deliver valuable ecological benefits to botanize the city...

Summary: Botanizing the City

Experts roundly believe that water is the next oil. Both are naturally occurring resources, and ever-increasing demand is creating economic, social, and environmental conflict in allocating their finite supplies. While water problems vary from place to place, access to safe drinking water has become a global challenge. In developing nations, access to potable water is limited—8,000 children worldwide die every day due to illnesses contracted from consuming contaminated water. In arid regions that lack natural water supplies, energy costs from transporting water and resulting scarcities have led to rationing. Large-scale diversions of natural water supplies like those for industrialized farming have depleted continental aquifers, interrupting groundwater recharge, altering stream base-flows, and eroding geological stability. The latter has resulted in subsidence, or the gradual sinking of cities like Mexico City and New Orleans due to water drawdowns. Water ownership and stream management conflicts between neighboring governments have led to water wars and, much like oil, the emergence of water as a market commodity subject to privatization and trade. One of the more pernicious domestic water problems is the effect of rapid urbanization on groundwater quality, particularly in regions with substantial rainfall like the American southeast and northwest. This manual is about the relationship between water and urbanization—specifically stormwater runoff—and the role of "green" development in ensuring good water quality.

While the US does not typically suffer from unclean drinking water, our waterbodies are toxic. The United States Environmental Protection Agency's (USEPA) Index of Watershed Indicators shows that only 16 percent



connecting urban and natural systems

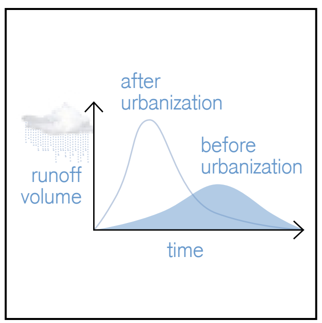
of the nation's watersheds exhibit good water quality. Besides discharges from agricultural land uses and site construction, much of this can be attributed to nonpoint source pollution from urban stormwater runoff channeled by impervious surfaces—roofs, sidewalks, parking lots, and roads—during the "first flush" of a storm event.

Indeed the first hour of urban stormwater runoff has a pollution index much higher than that of raw sewage.

Stormwater runoff in our auto-dominated communities is toxic because it concentrates hydrocarbon residues from household and lawn care chemicals, oil, gasoline, brake fluid, asphaltic products in roads and roofs, and heavy metals, which are ultimately deposited into our watersheds. Conventional hard-engineered stormwater management—neither aware nor responsive to runoff's harmful consequences—employs "pipe-and-pond" methods to drain, direct, and dispatch untreated runoff from a site. As with most conventional waste management infrastructure, pipe-and-pond systems simply transfer pollution problems from one place to another.

Besides reduced water quality, stormwater runoff has led to another major pollution problem, widespread stream impairment commonly known as "urban stream syndrome". Urban stream syndrome describes unhealthy stream flow regimes marked by chronic flash flooding, altered stream morphologies, elevated nutrient and contaminant levels, excessive sedimentation, loss of species diversity, and higher water temperatures.

This imbalance in stream metabolism impairs ecological functioning and disrupts the 17 ecological services that a healthy stream delivers (see list p.13). These life-affirming services constitute four basic categories; *provisioning services* that supply food, water, and energy; *regulating services* that purify water, air, and control disease; *supporting services*, which promote nutrient cycling and reproduction; and *cultural services* for intellectual, recreational, and spiritual well being. Escalating costs associated with the loss of these ecological services due



stormwater discharge before and after urbanization

to flood damage, property loss from erosion, heat island effect, pollution, and need for irrigation have prompted greater regulatory oversight over nonpoint source pollution and a call for green development solutions. Infrastructure can be designed to provide greater ecological and urban services at lower costs. With LID, streets no longer have to be ecological liabilities, and stream and lake ecological functioning are enhanced.

Water and land should be developed in harmony. New LID practices based on ecological soft-engineering can mitigate the deleterious impacts of urbanization on the environment, particularly in the substitution of natural ground cover or porous media for impervious surfaces.

Shockingly, the rate of increase in impervious surfaces has exceeded the rate of population growth by 500 percent over the last 40 years.

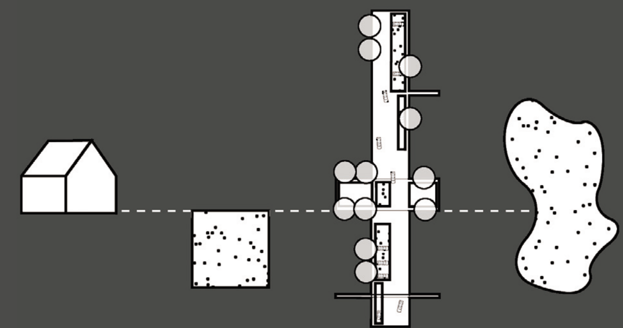
From Individual Facilities to Networks: BMP to LID

Best Management Practice (BMP) has been commonly used in conventional hard-engineering to identify lot-based management facilities such as a detention pond. However, BMPs are focused more on engineering rather than planning. In recognizing the need to comprehensively address stormwater runoff, the USEPA has recently redefined the term as "a practice or combination of practices that are an effective, practicable means of preventing or reducing the amount of pollution generated by nonpoint sources". BMPs now address stormwater runoff quantity and quality by employing both mechanical and biological processes.

From the lot to the neighborhood, city, and region, BMPs, or LID facilities, are connected in a distributed network to reduce and treat urban stormwater runoff before it enters receiving waterbodies. LID facilities are combined with smart growth practices, such as compact, walkable neighborhoods and open space preservation (see www.epa.gov/smartgrowth), resulting in LID. Successful LID requires participation from property owners, developers, cities, and regulatory agencies in a comprehensive planning process. Everyone has an important role to play.

How can we implement LID?

LID concepts are scalable to various sized projects and land-use types. Dividing urban development into its constituent components—building, property, street and open space—illustrates stakeholder action opportunities within each component. The goal is not just to minimize impact, but to develop regenerative and productive urban landscapes that continually renew ecosystem functioning.



building
pp. 46-57

design the building as a net energy producer that recharges groundwater and harvests rainwater

property
pp. 58-89

substitute an ecologically-based stormwater treatment system for an otherwise decorative landscape

street
pp. 90-123

design the street as a garden to achieve traffic calming and stormwater management

open space
pp. 124-141

comprehensively plan open space as a green network that delivers vital ecological services at the scale of a watershed

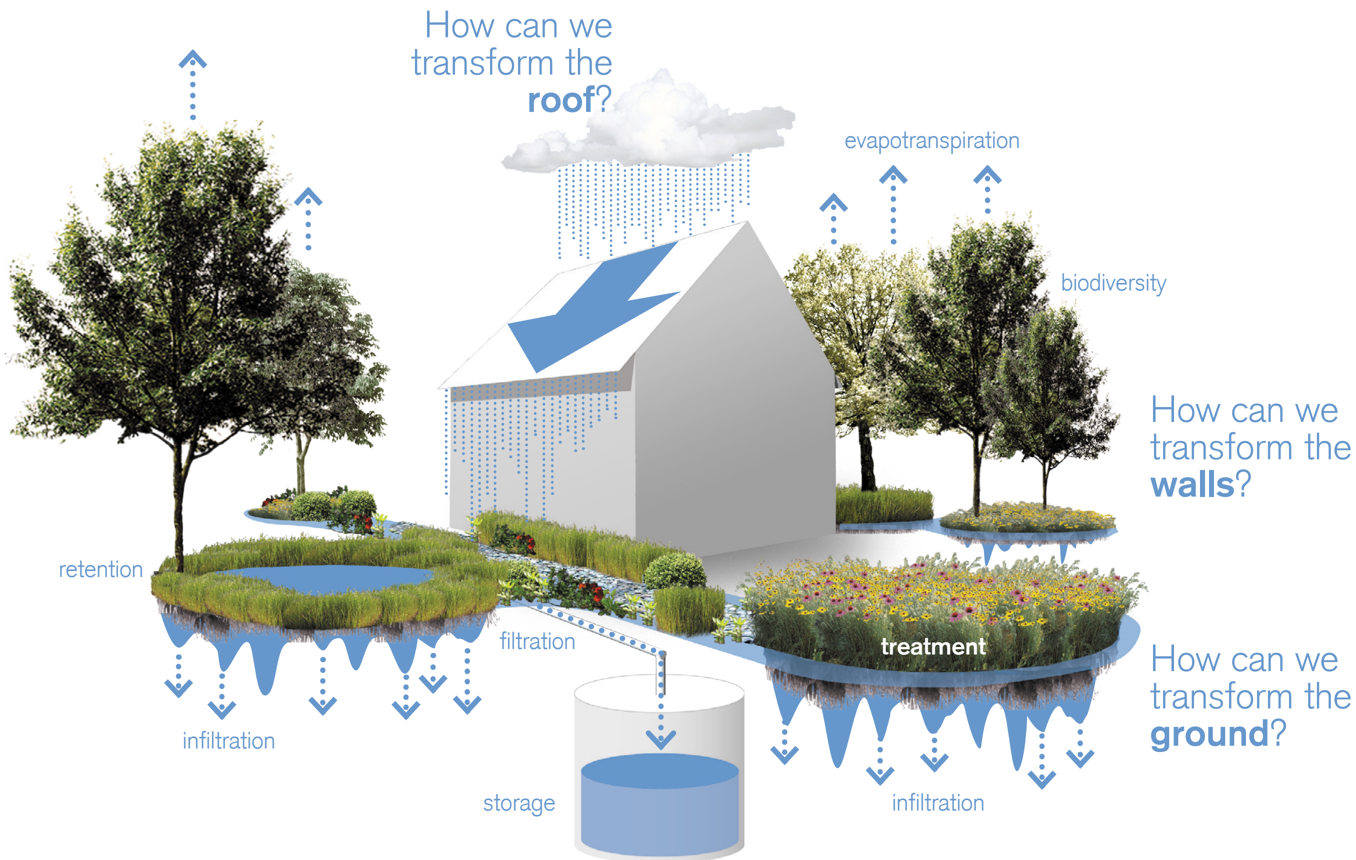
LID Overview

building

Buildings present ready opportunities for harvesting stormwater runoff from roofs through small-scale embedded technologies. LID facilities are one aspect of “smart building” development that optimize feedback between environment and building to achieve net energy production, or regenerative development (versus sustainable development, which is carbon neutral). LID facilities are chosen according to the level of ecological service desired. The simplest service is groundwater recharge from roof stormwater runoff. Gutters and leaders that channel rainwater create concentrated discharges and are avoided in favor of devices that slow, spread, and soak rainwater throughout the site. A higher level of service involves vegetated or green roofs, which absorb and evaporate rainwater through a cultivated plant and soil community. Green roofs are superior building insulators, minimizing heating and cooling demands. Green walls minimize solar gain during the summer and wind loading during the winter.

Rainwater harvesting offers three basic levels of service, involving storage cisterns with options for treatment. The simplest service is rainwater reuse for outdoor landscape irrigation. A more complex harvesting service incorporates a greywater building supply with additional treatment for non-potable water uses like toilet flushing and landscape irrigation. The highest level of service involves harvesting for potable (drinking) water which requires UV light disinfection for a private water system, and when combined with water from a public utility includes proper back-flow prevention.

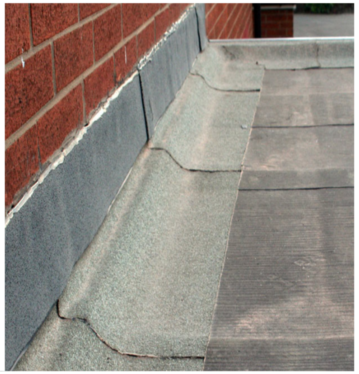
Placement of LID facilities on a building site should be carefully considered. Infiltration and treatment facilities can be used next to a building to capture roof runoff. Infiltration facilities, however, should be located at least 10 feet away from buildings, as they may cause the shrinking and swelling of soils, which can negatively affect foundations.

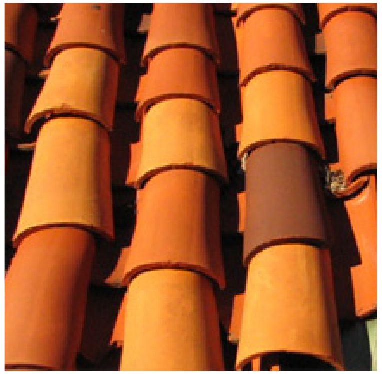


Roof Materials

building

...one inch
of rainfall on a 1,000 square-foot roof yields about 623 gallons of water.



asphalt/fiberglass shingle
Stormwater runoff from these roofs have high levels of pollution; treatment is needed at the wall and/or ground. If harvesting is desired do not use to irrigate edible landscapes or for potable needs.
- Harvesting Potential: Low
- Heat Island Mitigation: Low
- Initial Cost: Low
- Durability: 15-20 years

membrane roof system
Membrane roofs, like EPDM, modified bitumen, and tar and gravel, are petroleum-based and have high levels of pollutants; treatment is needed at the wall and/or ground. If harvesting is desired do not use to irrigate edible landscapes or for potable needs.
- Harvesting Potential: Low
- Heat Island Mitigation: Low
- Initial Cost: Low-Medium
- Durability: 10-30 years

wood shingle
Leaching from treated wood products may contain toxins and carcinogens. Make every effort to use products made from cedar since it is typically untreated and thus a safe harvesting alternative.
- Harvesting Potential: Moderate
- Heat Island Mitigation: Moderate
- Initial Cost: Medium
- Durability: 10-20 years

clay tile roof
Stormwater runoff from a clay tile roof may produce minor sediment. Clay tiles can offer high albedo surfaces for heat island mitigation. Clay roof tiles have excellent harvesting potential.
- Harvesting Potential: High
- Heat Island Mitigation: Moderate
- Initial Cost: Medium
- Durability: 50-75 years

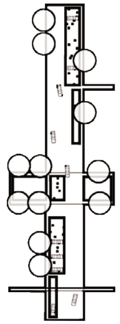
metal roof
Stormwater runoff from a metal roof has very low pollutant levels. Metal roofs have excellent harvesting potential.
- Harvesting Potential: High
- Heat Island Mitigation: High
- Initial Cost: Medium to High
- Durability: 40-60+ years

vegetated roof
Also known as a "green roof," they can treat and retain 60-100% of the stormwater they receive. Other benefits include improved air quality, heat island mitigation, and urban biodiversity. (see "Vegetated Roof" pp. 170-171)
- Harvesting Potential: High
- Heat Island Mitigation: High
- Initial Cost: High
- Durability: 40+ years

alert on harvesting rainwater → safe harvesting potential

When considering rainwater harvesting, keep in mind that petroleum-based roofing and treated wood products leach toxins. Studies have shown that these products are known to cause cancer and mental defects. Harvested rainwater from these surfaces should only be used for ornamental landscape irrigation.

Harvesting rainwater from these surfaces is safe for use on edible landscapes because they do not pose contamination risks, but will require filtration and disinfection for potable (drinking) water uses.



Designing for Urban Trees

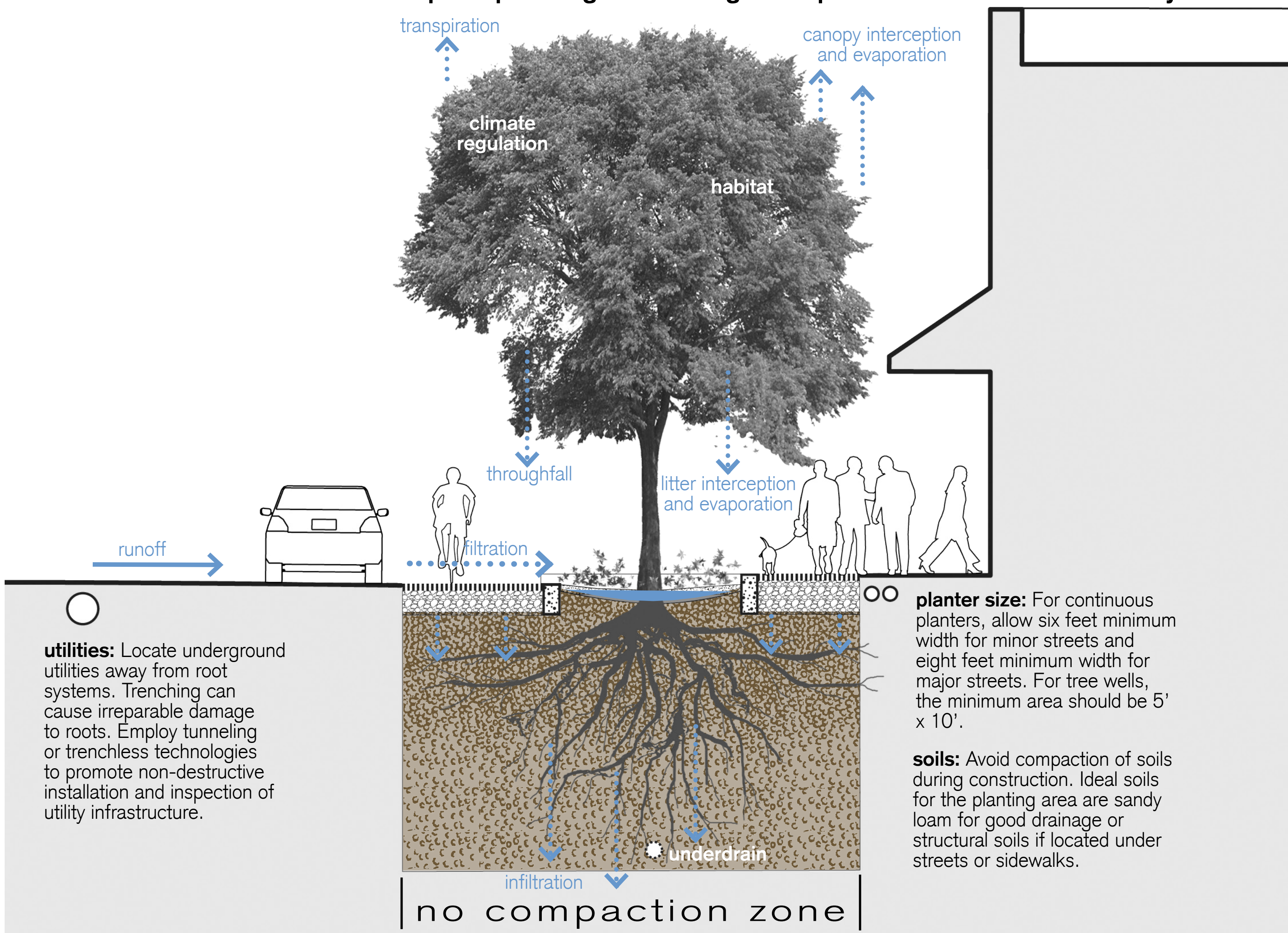
Streets should be designed to accommodate tree root growth—the most critical factor in implementing tree lined streets.

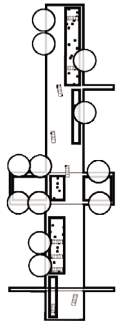
Healthy trees are essential components of green infrastructure and urban forestry. Shade trees planted along hard surfaces reduce the heat island effect and improve air quality. Besides functioning as carbon sinks, trees also reduce stormwater runoff through interception, evapotranspiration, throughfall, and flow attenuation. Trees help create a sense of place, reduce noise and glare, and provide a safety barrier for pedestrians from traffic, which is why neighborhood value is increased by their presence.

Trees vary in their growth requirements and rates based on the biological and physical conditions of the site. Trees should be chosen based on cold hardiness, mature size and shape, drought tolerance, rooting characteristics, and resistance to insect and disease problems. For a list of suitable urban trees, consult a local nursery or landscape design professional (also see "Urban Trees for Zones 4-8" pp. 100-101).

The planting area should accommodate the anticipated root structure at maturity, ensuring absorption of water and nutrients. Remember that roots can extend well beyond the canopy of the tree. Spacing between trees should reflect species' crown size at maturity. With proper planning and care, street trees can live well beyond their average 13-year lifespan.

Due to compaction and poor planning the average lifespan of an urban tree is 13 years.



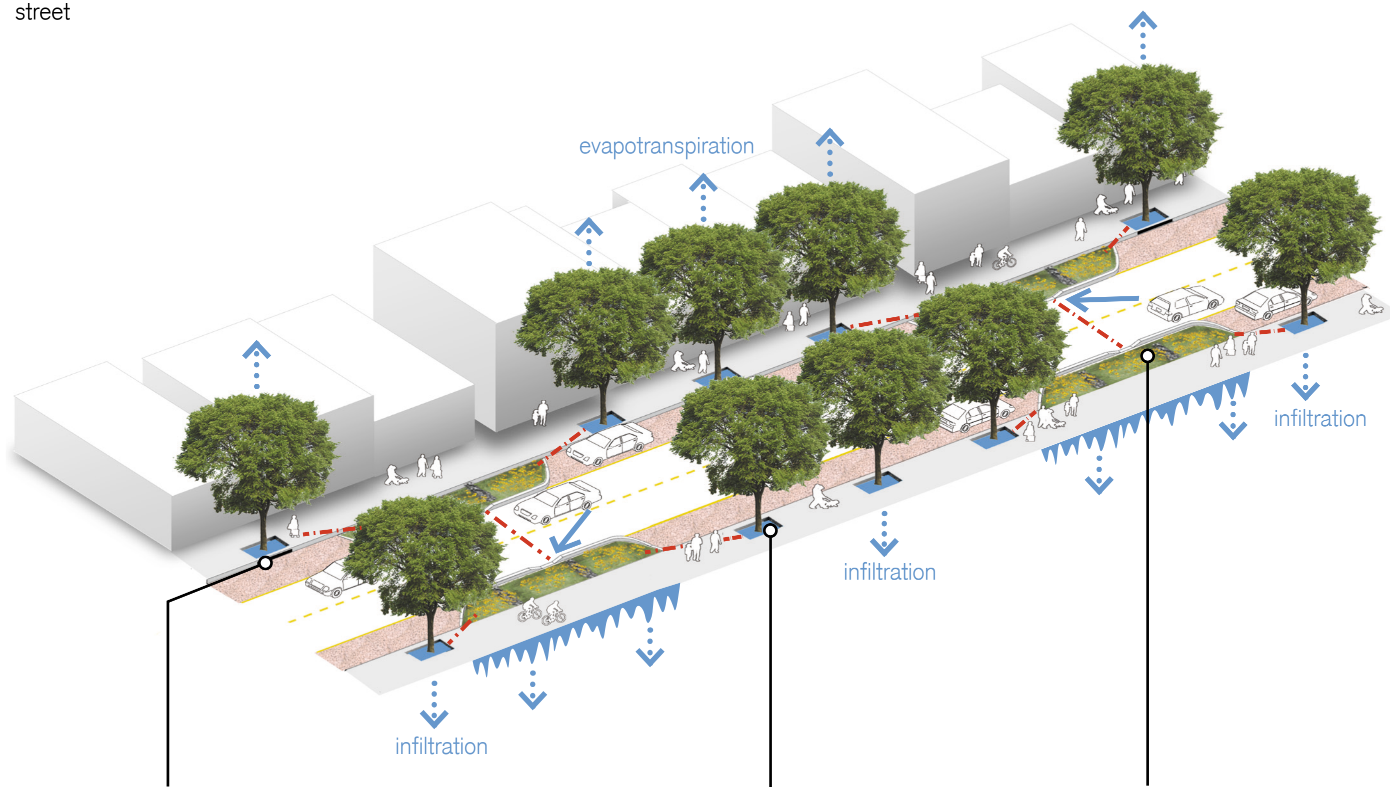


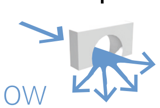
Skinny Streets

Create narrower streets to reduce runoff loading and substitute pervious paving for impervious surfaces to encourage stormwater infiltration.

Residential street design standards dating back to the 1960s called for local street widths as high as 36 feet. Miles of American streets have been designed and built to these standards, which are now recognized as unsafe, and an unwise use of fossil fuel-based resources. Wide streets generate large stormwater runoff peak loads due to their extensive impervious surface area. Since the 1990s, many cities have revisited their street design standards, subsequently adopting narrower street profiles, some as narrow as 20 feet wide for low traffic volumes, while still accommodating emergency vehicle access.

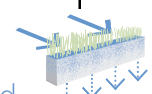
Reducing the width of streets provides a number of benefits. While many may initially assume they are unsafe, these narrow roads, or "skinny streets" actually reduce average speeds and vehicle accident rates. For instance, a 24 foot wide street has about 0.32 accidents per mile per year, while a 36 foot wide street has 1.21 (Walker Macy - *Villebois* v.4). Economic benefits include reduced street maintenance and resurfacing costs, while environmental benefits include reduced urban heat island effect. Soft-engineered streets provide stormwater runoff attenuation and filtering. However, such facilities handle only one to two-year storm events, requiring connection to a treatment network for larger events.





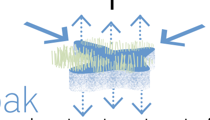
Slow

Cut curbs to allow for stormwater flow into curb extensions or other LID facilities. *Flow Control Devices* pp. 148-149



Spread

Construct tree box filters along the right-of-way to filter and attenuate stormwater runoff during **one to two-year storm events**. Connect in a series or to rain gardens using perforated pipe to handle larger events. *Tree Box Filter* pp. 176-177



Soak

Use curb extensions to retrofit existing parking lanes with rain gardens. This reduces impervious surface area, and encourages infiltration during **10 to 25-year storm events**. *Rain Garden* pp. 178-179


heat island mitigation
climate regulation
curb extension
infiltration
non-invasive facultative landscapes
erosion control and
sediment retention
Siskiyou Street
Portland, Oregon

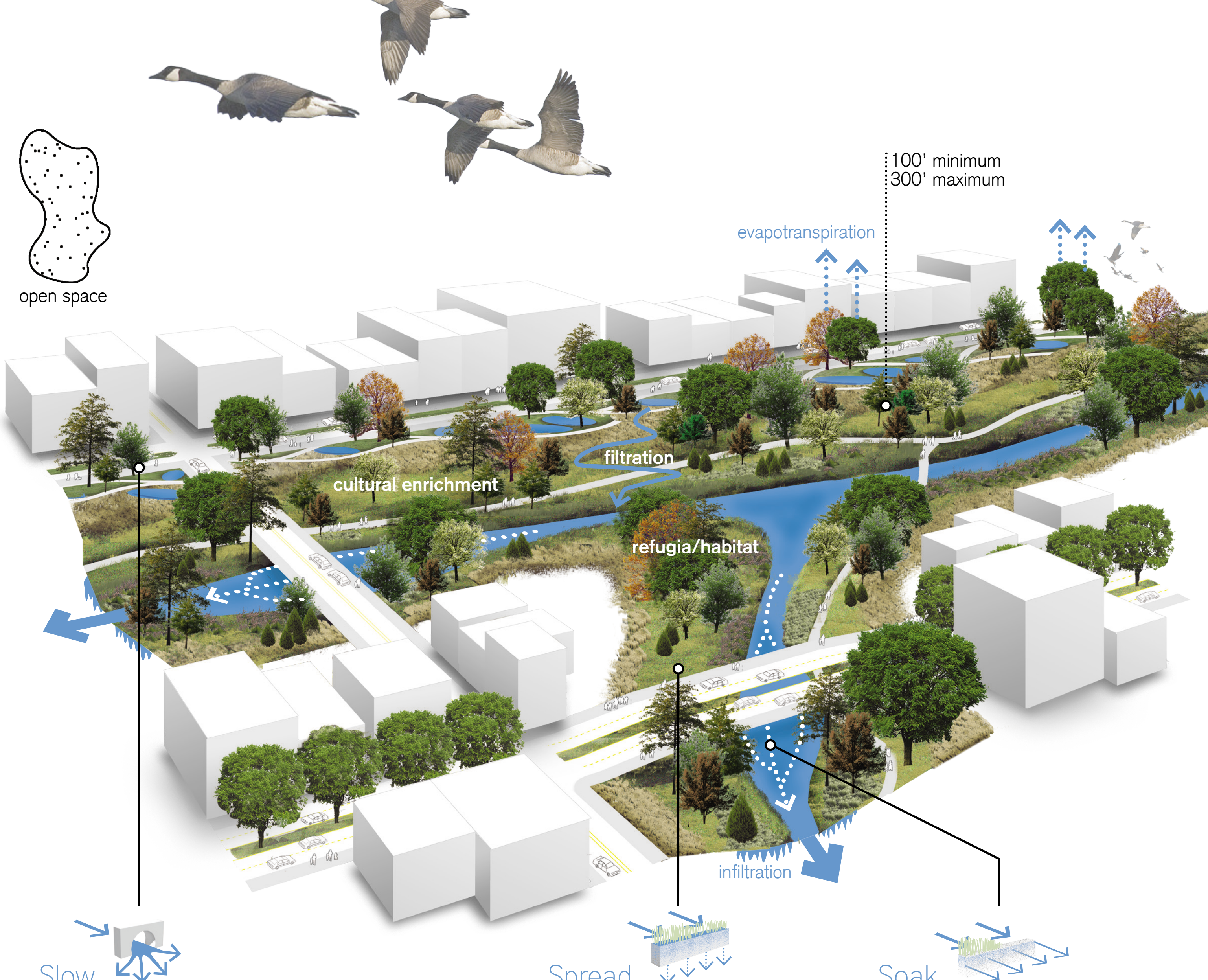
Greenways

Connect open spaces to create an urban greenway that maintains nutrient, natural resource, and habitat flows through the city.

Greenways are an essential connective tissue in open space networks. These pathways preserve and restore nature in urban developments, and have the ability to revitalize underutilized urban sectors. Their delivery of ecological, economic, and social services ensure their favored status as important planning tools. While open space networks will be enjoyed at a local level, regional coordination is often essential for comprehensive design solutions using an ecological approach to development.

Besides creating value for abutting properties and generating economic activity, greenways provide alternative transportation systems free of traffic conflict, and are ideal for casual transit and recreation. They also improve health by accommodating active living and physical activity. Greenways are key to large-scale stormwater treatment and flood protection, acting as vegetated buffers and flood basins that minimize property damage from flooding.

Besides use of the greenway as an agricultural belt or a rails to trails conversion, its most significant incarnation is the riparian buffer. A riparian buffer is part of a larger system known as the riparian corridor, which consists of a floodplain, stream banks, and a stream channel. Riparian buffers are important ecotones between land and water, offering unique habitat while regulating sediment inputs from upland land uses. Riparian buffers are essential to sustaining healthy streams and watersheds.



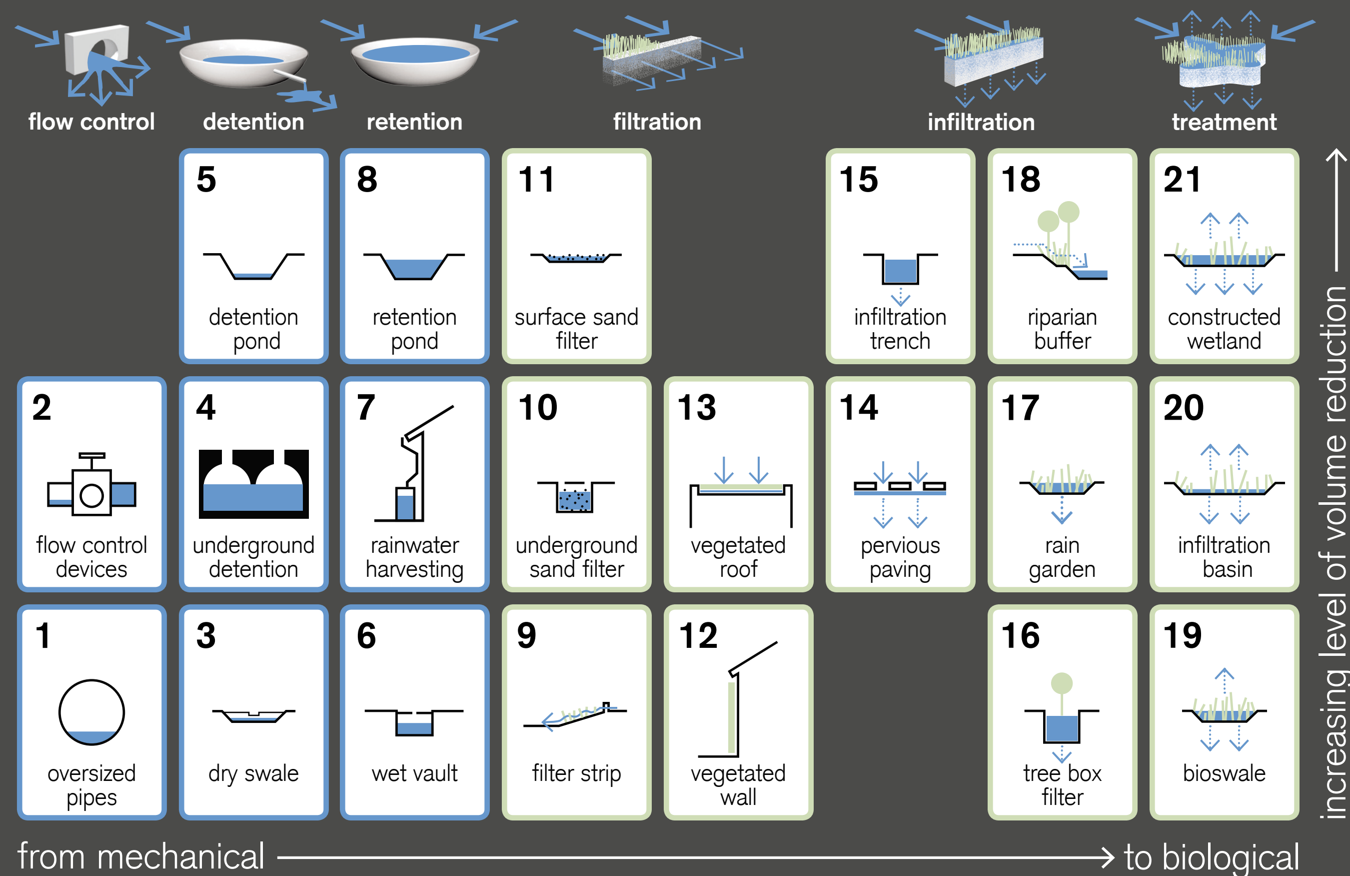
Slow
Implement flow control devices such as curbs and level spreaders to slow the flow of water before reaching the greenway. *Flow Control Devices* pp. 148-149

Spread
Use vegetated riparian buffers to filter and attenuate urban stormwater runoff before reaching sensitive stream corridors. *Riparian Buffer* pp. 180-181

Soak
Maintain natural sinuosity in streams to create erosion and deposition zones that regulate stream flow and sedimentation.

What are the LID facilities?

The Facilities Menu organizes the LID facilities based on increasing level of treatment service (quality) as well as increasing level of volume reduction (quantity). Therefore, number one (1), flow control devices offer the least amount of treatment services while number twenty-one (21), constructed wetland offers the most. Most municipalities require drainage infrastructure to manage 100-year storm events. Though one facility alone will likely not satisfy performance requirements, facilities with varying levels of service in a treatment network will provide superior levels of treatment and volume reduction.



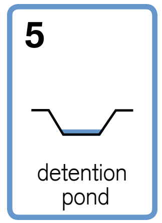
LID facilities menu

optimal level of service
detention

location in LID network
downstream of catchment and runoff, upstream from off-site stormwater management systems

scale
watershed runoff area of 10 acres and greater

management regime
regular trash and intermittent sediment removal, pollutants accumulate in soils and may require amendments and clean out

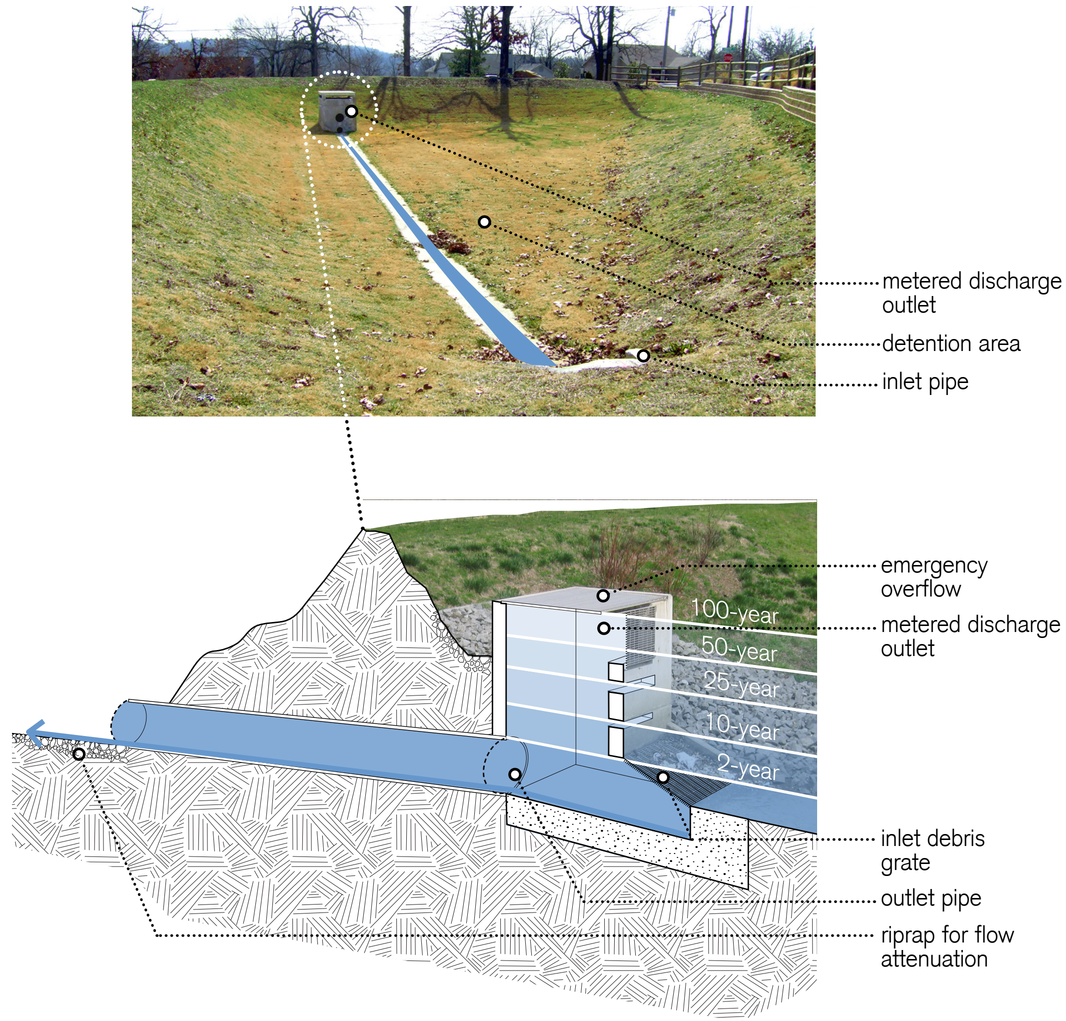


Detention Pond

Detention ponds, or dry ponds, are stormwater basins designed to intercept stormwater runoff for temporary impoundment and gradual release to a conveyance system or a receiving waterbody.

Detention ponds are designed to completely evacuate water from storm events, usually within 24 hours. They primarily provide runoff volume control reducing peak flows that cause downstream scouring and loss of aquatic habitat. As a general rule, detention ponds should be implemented for drainage areas greater than 10 acres. On smaller sites it may be difficult to provide control since outlet diameter specifications needed to control small storm events are small and thus prone to clogging. Also, treatment costs per acre are reduced when implemented at larger scales.

Re-suspension of settled material is a large concern in these systems, requiring periodic sediment, debris, and pollutant removal. Detention ponds do not provide infiltration and are therefore best used within a network that provides biological treatment.



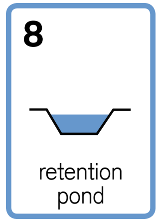
References:
Low Impact Development Manual for Michigan
Minnesota Urban Small Sites BMP Manual

optimal level of service
retention/treatment

location in LID network
downstream of catchment and runoff, usually constructed at the lowest point of the site

scale
can be used for residential, commercial, and industrial sites, with watershed runoff areas no smaller than 10 acres depending on regional precipitation

management regime
inspected semiannually to confirm that drainage is functioning properly and to remove sediment, accumulated trash, and debris

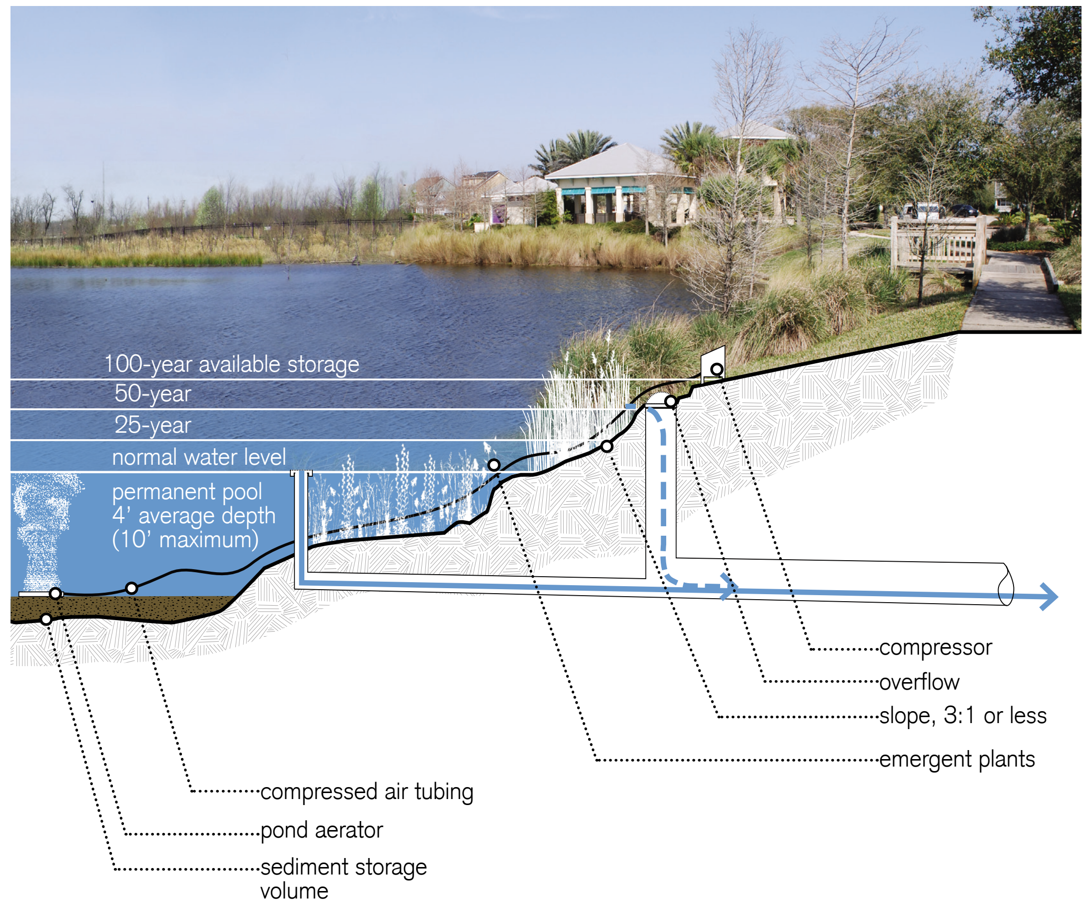


Retention Pond

A retention pond, also known as a wet pool or wet pond, is a constructed stormwater pond that retains a permanent pool of water, with minor biological treatment.

Wet ponds remove pollutants through biological uptake processes and sedimentation. The amount of pollutants that are removed from stormwater runoff is proportionate to the length of time runoff remains in the pond, as well as the relation of runoff to retention pond volume. Since retention ponds must maintain a permanent pool, they cannot be constructed in areas with insufficient precipitation or highly permeable soils, unless the soil is compacted or overlain with clay. Generally, large contributing watersheds are required to maintain permanent pool levels.

One advantage of a retention pond is the presence of aquatic habitat when properly planted and maintained. The use of a pond aerator is necessary to avoid stagnation and prevent algae growth that can lead to eutrophication, or an anaerobic environment. A heathy aerobic environment is a necessary condition for aquatic life and Integrated Pest Management (IPM). Regular maintenance inspections are needed to ensure proper drainage, aerobic functioning and aeration, and vegetative health. Trash, debris, and sediment will need to be removed periodically.



References:
Low Impact Development Manual for Michigan
Minnesota Urban Small Sites BMP Manual
EPA Storm Water Technology Fact Sheet-Wet Detention Ponds

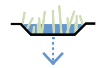
optimal level of service
filtration/infiltration/treatment

location in LID network
downstream of filtration facilities,
but upstream of primary treatment facilities

scale
500 sq ft, to allow for adequate
irrigation between small storm events

management regime
occasional removal of trash and
pruning of vegetation

17



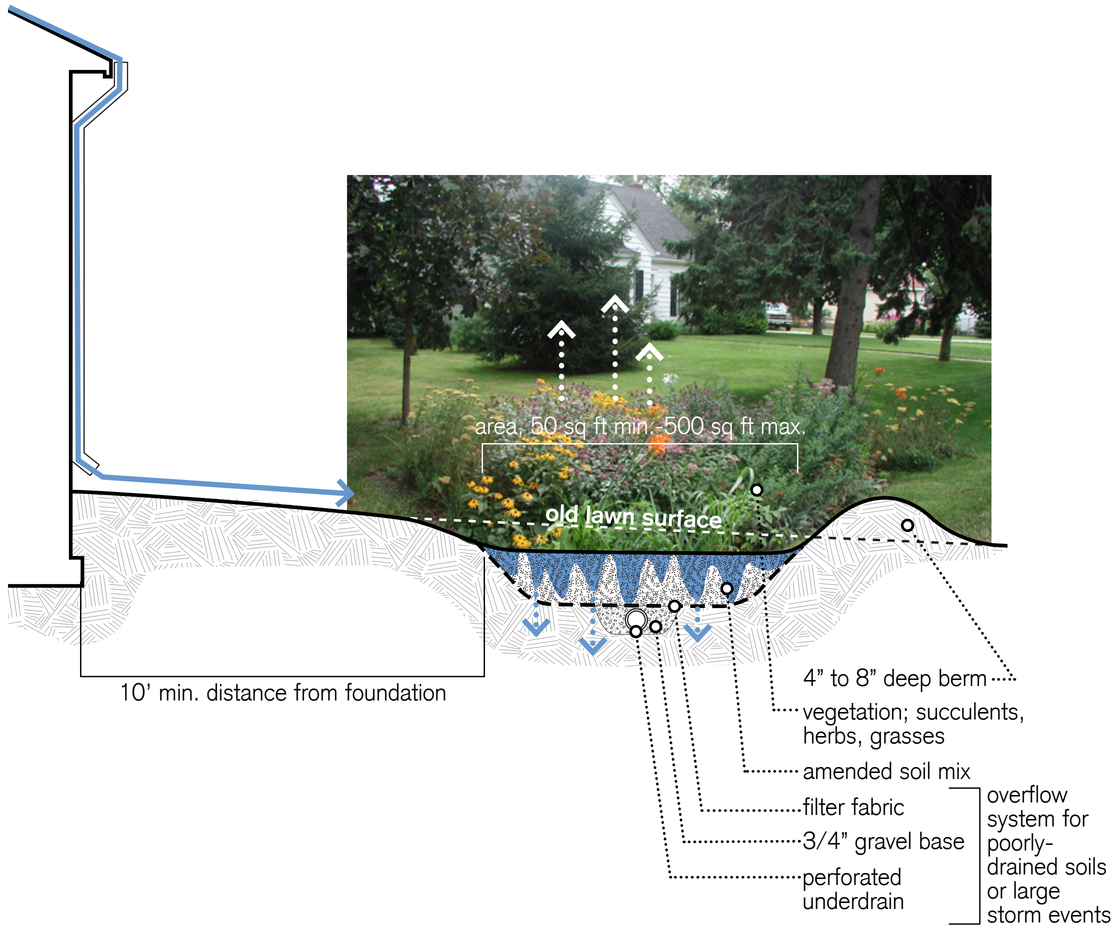
rain
garden

Rain Garden

A rain garden is a planted depression designed to infiltrate stormwater runoff, but not hold it.

A rain garden is a type of treatment facility, commonly known as bioretention. The primary pollutant removal mechanisms are filtration by native vegetation through phytoremedation processes that clean water as it passes through the facility. Rain gardens contain layers of organic sandy soil, and mulch for vegetation. Low-maintenance plants are recommended for rain gardens based on their suitability to local climate, soil, and moisture conditions without the use of fertilizers and chemicals. Rain gardens are best applied on a relatively small scale. They work well along driveways and in low lying areas of a property.

Rain gardens should be located at least 10 feet away from buildings to prevent water seepage into foundations or underneath houses, causing mold and mildew problems. Also, location away from large trees allows exposure to sunlight so that rain gardens may dry out between storm events.



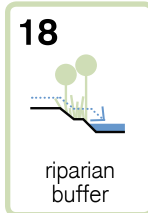
References:
Low Impact Development Design Strategies–An Integrated Design Approach
Low Impact Development Manual for Michigan
Low Impact Development Technical Guidance Manual for Puget Sound
United States Department of Housing and Urban Development
Minnesota Urban Small Sites BMP Manual

optimal level of service
filtration/infiltration/treatment

location in LID network
downstream of all LID facilities, before waterbodies

scale
from 100' to 300' wide is most effective, however smaller widths may also be used

management regime
trash and sediment removal as necessary, and occasional mowing in zone 3

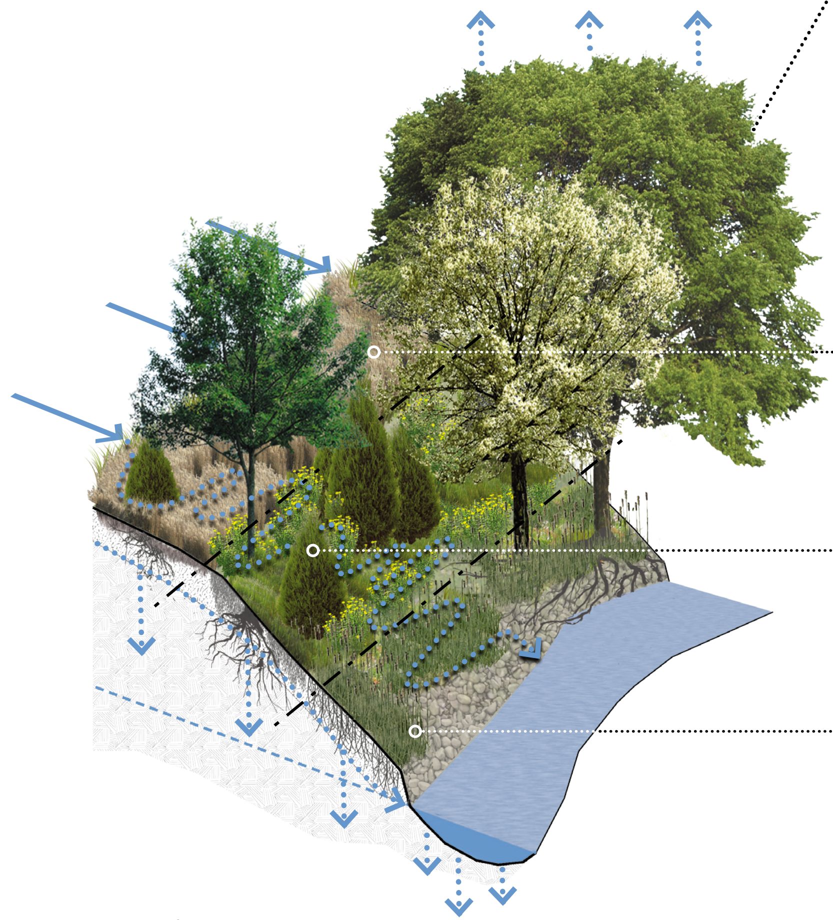


Riparian Buffer

A riparian buffer is a vegetated strip along the banks of moving bodies of water.

Riparian buffers are a simple, inexpensive way to protect and improve water quality through local plant communities. Between 50 percent and 85 percent of stormwater pollutant loads can be filtered within 100 to 300 foot vegetation buffers. Buffer strips structurally stabilize banks and shorelines to prevent erosion and slumping. Trees and shrubs provide shade to maintain consistent water temperature necessary for the survival of some aquatic life. Width of the buffer is based on surrounding context, soil type, size and slope of catchment area, and vegetative cover.

Riparian buffers are most effective when combined with flow attenuation devices throughout a watershed in order to avoid high velocity flows into riparian buffer areas. Some management is required when riparian buffers are near urban development. Avoid disturbing Zone 1 as tree litter aids in flow control and filtration.



References:
Low Impact Development Manual for Michigan
Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways

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“Our space planning should take its cue from the patterns of nature itself—the water table, the floodplains, the ridges, the woods, and above all, the streams.”

William Whyte, *The Last Landscape*

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