Conway Urban Watershed Framework Plan

A Reconciliation Landscape for
Little Creek-Palarm Creek Sub-watershed

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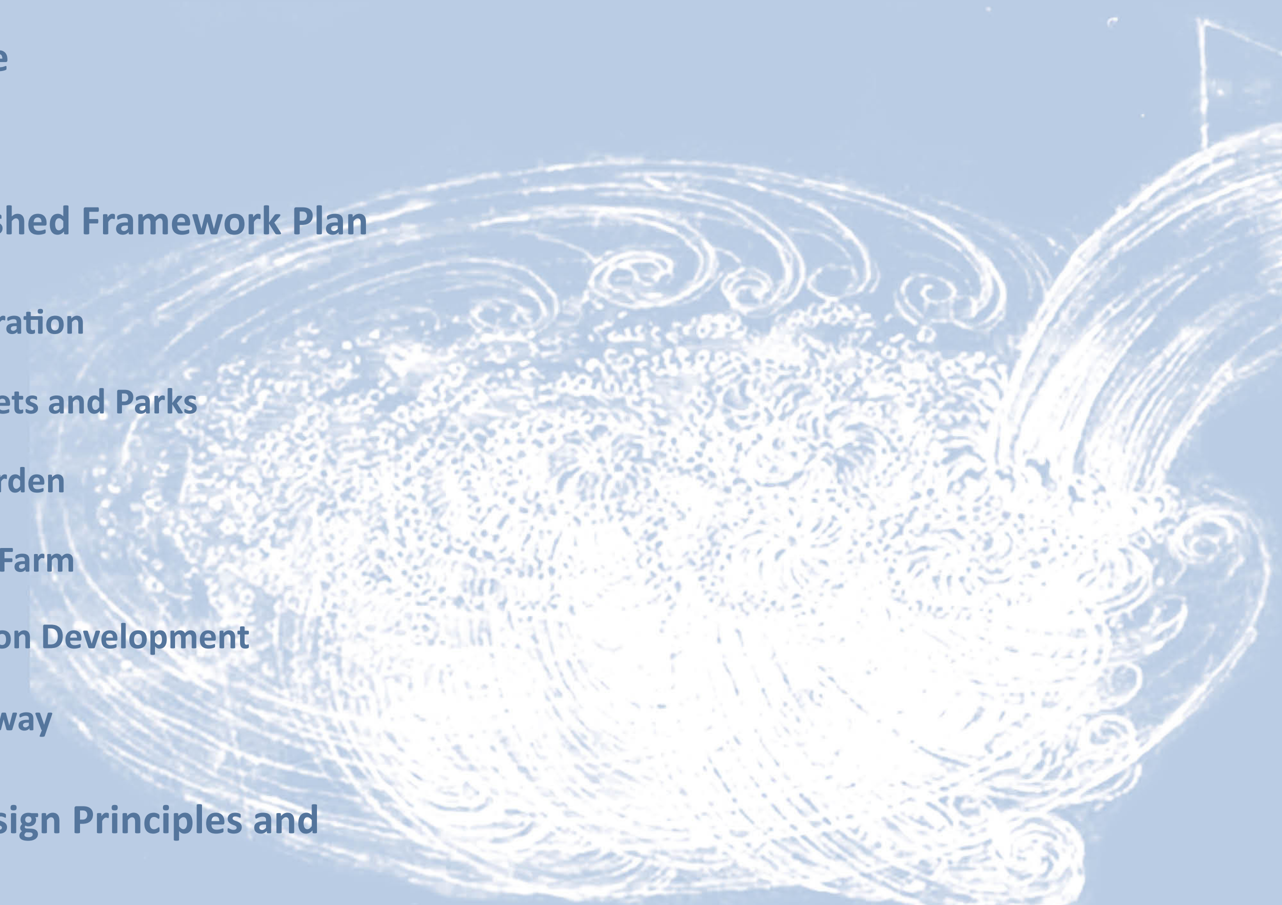
Table of Contents

The Village at Hendrix, Conway



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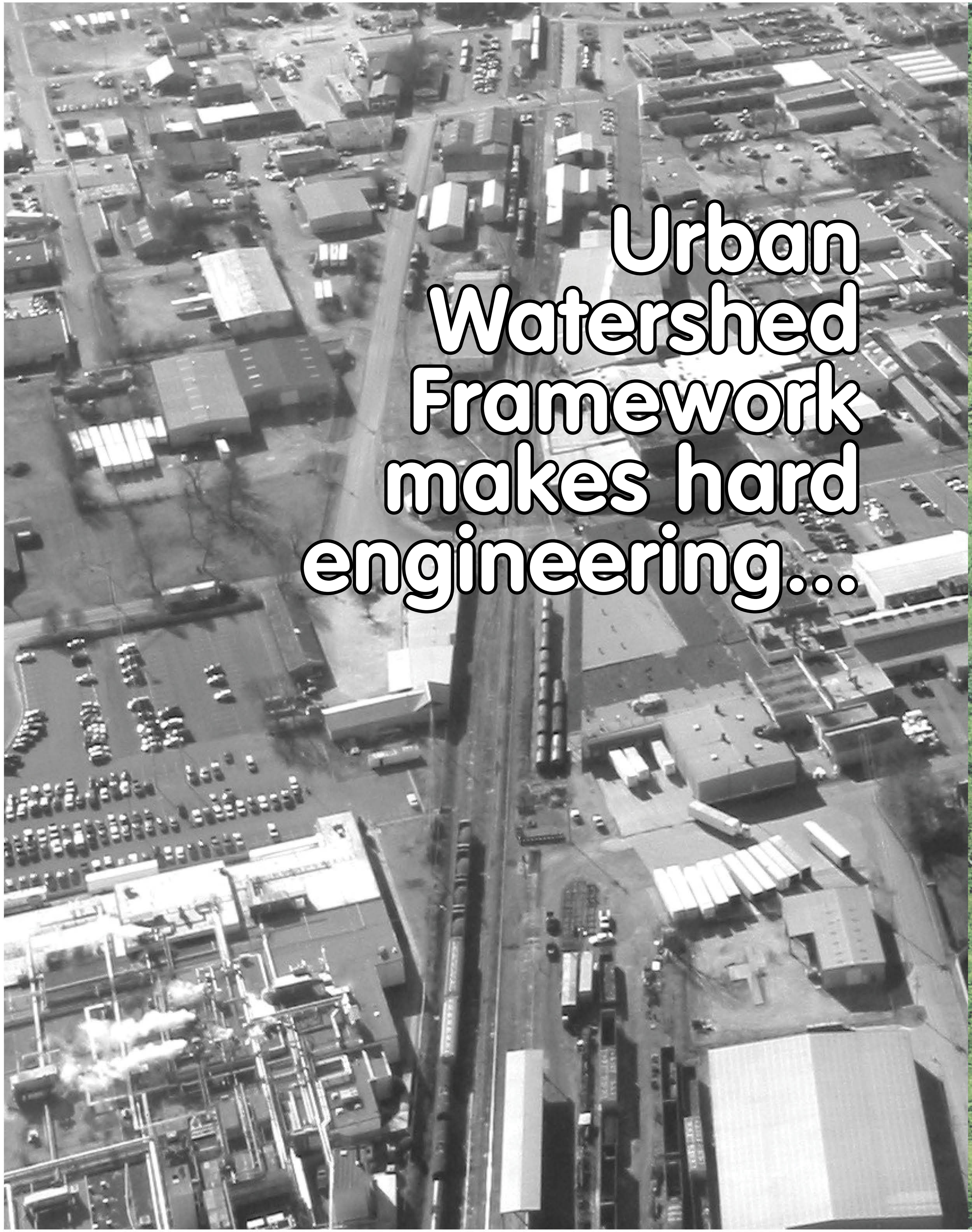


Urban Watershed Framework makes hard engineering...

Source: *Low Impact Development: a design manual for urban areas*, UACDC

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

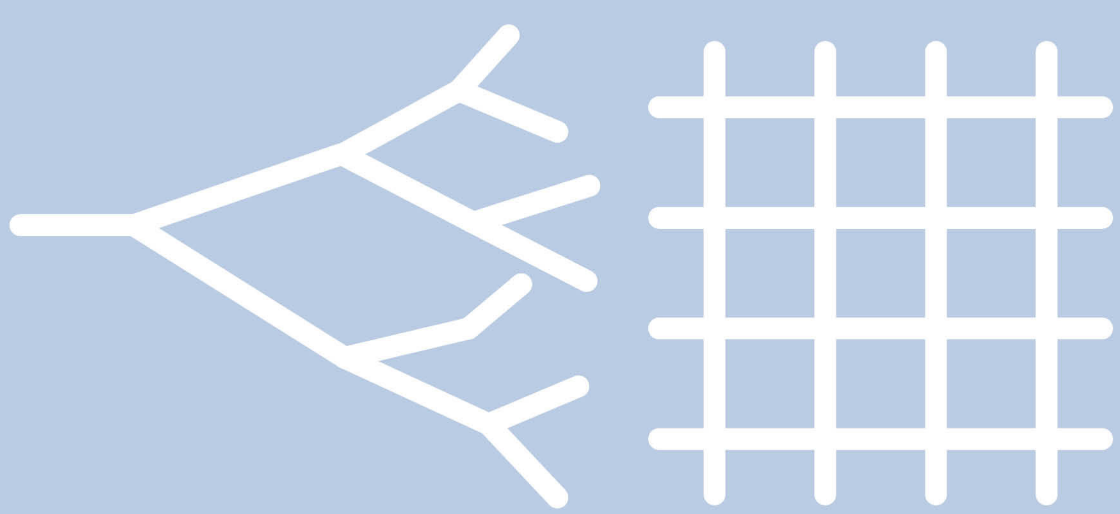
re-imagining Conway

From existing scrap yard on Markham Street ...

... to proposed Neigborhood Town Square on Markham Street

Executive Summary

> *"Where two distinct types of network meet, flow slows down to diffusion. This is where the network structure is most vulnerable—and interestingly where living processes occur."*
>
> ***Design for a Living Planet: Settlement, Science, and the Human Future***
> Michael Mehaffy and Nikos Salingaros



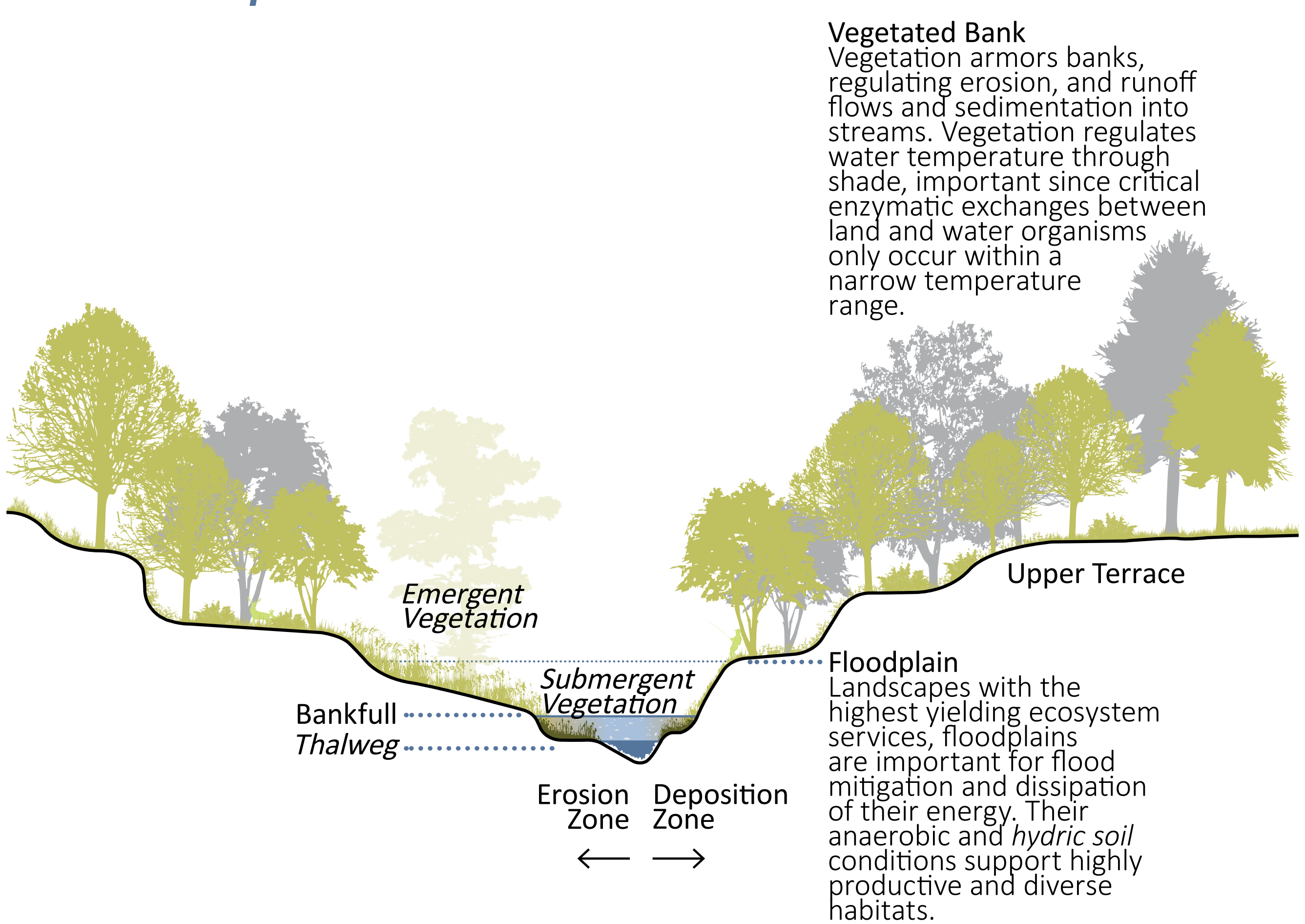
The City and the Watershed: A Reconciliation Landscape

How can city form fix the watershed? The city and the watershed are distinct systems of flow that generate shape and structure across the landscape to maximize their intrinsic objectives. The city, consisting of a place's street fabric, neighborhoods, and buildings, is a flow network designed to facilitate human social and economic exchange. Despite a bewildering variation in form, livable cities deliver *urban services** related to housing, mobility, and commerce usually at densities that minimize nature's presence and the underlying benefits from its biological processes. Cities, like all flow systems, tend to evolve into ever more efficient configurations inclined to privilege the specialized currents that pass through them—in this case, cars, people, and goods.

Likewise, the watershed's flow system, consisting of a catchment area's streams and lakes, is a flow network modeled by hydrological and biological processes. Akin to all healthy ecosystems, watersheds deliver the 17 life-affirming *ecosystem services* that underpin our collective economic and individual well-being, including pollination, atmospheric regulation, food production, nutrient cycling, maintenance of a genetic pool, disturbance regulation, water quality, flood and erosion control, soil health, etc. As streams, or *riparian corridors*, feed larger streams their channels and floodplains require more undisturbed land area with complex biotic communities of healthy soil structure, plant guilds, and wildlife chains to support ecological functioning. The ecosystem services framework is a fundamental benchmark for reconnecting streams' normative sediment and water flows to Lake Conway, while assessing the overall quality of interactions among natural and social infrastructure. How might city form play a role in restoring lost ecological services?

*terms in italics are included in glossary at end of the report

Streams, like streets, buildings, or any complex system for that matter, possess their own architecture comprised of components with specialized purposes toward a functioning whole (see Typical Riparian Corridor Cross-Section). All natural streams, from the first order stream like the ones in this sub-watershed to a 10th order stream like the Mississippi River, have a *bankfull* (stream proper), a sinuous path with alternating erosional and depositional zones, and a floodplain 10-30 times the width of the bankfull (at its widest point the Mississippi River floodplain would be 10-30 miles wide). Before improved environmental regulations in the 1970s, floodplains were typically the first stream organs eliminated in urbanization. Watersheds, like cities then, thrive by way of their own specialized throughputs. ***Hence, watersheds in urban areas are in direct competition with cities over the very ways in which the surface area should be shaped.***



Typical Riparian Corridor Cross-Section

Where the flow systems of the city and the watershed meet—their *ecotone*—arise the greatest dysfunctions. Peak stormwater flows into streams after rainfalls compound downstream flooding and erosion, leading to recurrent property damage and permanent decline in value. Riparian corridors in cities often exhibit what ecologists call *urban stream syndrome*. Here, stream metabolism as measured by flow energy and sediment transport is so elevated beyond its norm that streams lose their capacity to function as ecological systems, simply becoming destructive conduits for moving the city's pollution around. ***Keep in mind that the first hour of urban stormwater runoff can have a pollution index far higher than that of raw sewage.*** Much of this is due to urban runoff's concentrations of *hydrocarbons* and metals, residues of the automobile and fertilizer industries captured during the *first flush*. Additionally, research shows that more than 10 percent coverage of surface area with hard—*impervious*—surfaces from roofs, parking lots, and roads leads to regional watershed damage, while more than 30 percent coverage can lead to irreversible watershed destruction. The resulting 'flashy' hydrological cycles yield chronic and expensive environmental impairments difficult to correct.

Where the city and the watershed meet also presents the greatest opportunities for creative development solutions reconciling the demands of each. Thus, new development patterns should appear. The land-water interface is Earth's most productive ecotone with the greatest degree of nutrient exchange and novel life forms arising exclusively within the seam of these two media. Conventional civil engineering has never known how to address this seam between city and water, the *hard* and the *soft*, or the artificial and the ecological. Conventional hard-engineered drainage solutions are costly, and their sole function to evacuate polluted water imposes a low return on investment while compounding regional watershed dysfunction. ***Herein lies the planning challenge for cities in wet places: to develop an urban infrastructure that simultaneously solves for ecologically-based water management while facilitating the city's functioning and growth.*** Some cities, like Austin, have adopted a "non-degradation clause" into their water management plans, requiring that new development not affect water quality. This expanded definition of utility entails a hybrid hard/soft infrastructure incorporating principles of natural hydrology that delivers both ecological and urban services in one infrastructure. This expanded definition of utility also entails multiple returns on investment, the only fiscally responsible approach to ongoing infrastructure funding challenges. Infrastructure for the 21st century city will simply have to do more work!

The Framework Plan: Develop a Representative Cityscape for Conway
The City of Conway, the state's second fastest growing city in the nation's 75th fastest growing county (out of 3,143 counties and county-equivalents in the U.S.), resides in the eastern portion of the Lake Conway-Point Remove Watershed. Lake Conway-Point Remove Watershed is a designated 2011-2016 Priority Watershed by the Arkansas Natural Resources Commission. The Conway Urban Watershed Framework Plan is part of a larger USEPA funded initiative to mitigate water quality problems in the Little Creek-Palarm Creek sub-watershed incorporating the urbanized area of Conway. The sub-watershed drains approximately 42 square miles and contains two major streams of concern, Stone Dam Creek and Little Creek, both exhibiting urban stream syndrome. The immediate goal is to enact steps leading to the removal of Stone Dam Creek from the Arkansas Department of Environmental Quality 2010 *303(d) list of impaired water bodies* due to ammonia and nitrate concentrations from a municipal source. Downstream sedimentation and nutrient loading are contributing to the continued decline of Lake Conway. A major natural and economic asset to the area, Lake Conway at 6,700 acres, is the largest reservoir built by a game and fish commission in the United States. Conway's current urbanization patterns, mostly of low-density, automobile-oriented development, are incompatible with the sustained hydrological functioning of Lake Conway.

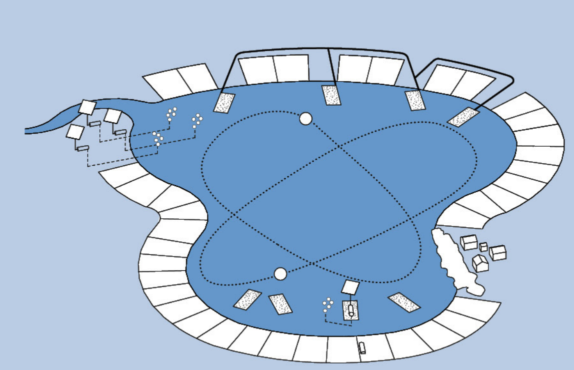
The Conway Urban Watershed Framework Plan focuses on the seam between city and water to create a ***reconciliation landscape***. Imagine

Conventional Hard Engineering

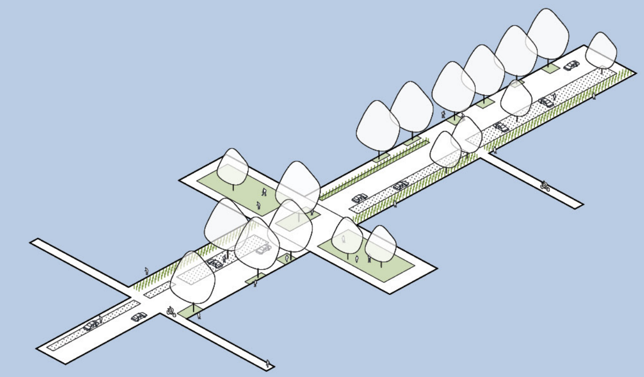
Hendrix Creek Preserve, Conway - Soft Engineering a cityscape that cultivated an amenity-rich, highly livable green urban environment made through "low-tech/high concept" enhancements to ordinary infrastructure investments already scheduled to service the city's growth. ***To that end, the Framework Plan proposes a portfolio of value-added infrastructural retrofits—green streets, water treatment art parks, urban eco-farms, conservation neighborhoods, parking gardens, riparian corridor improvements, lake aerators, vegetative harvesters and floating bio-mats, and a city greenway—complementing mainstream infrastructural investments*** (see Adaptive Infrastructure). Each retrofit type—or adaptation—offers operational competencies in a framework responsive to the urban environment's complexities. While the immediate objective is to restore ecological functioning in impaired water bodies, eventually removing Stone Dam Creek from the impaired water bodies list, building a legacy of high-quality, *resilient* public space is the greater long-term objective. Here, building a representative cityscape expressive of the city's rising growth and status through a highly-productive civic green utility is within easy grasp for Conway.

Sponge City Gradient: City and Watershed Interfaces

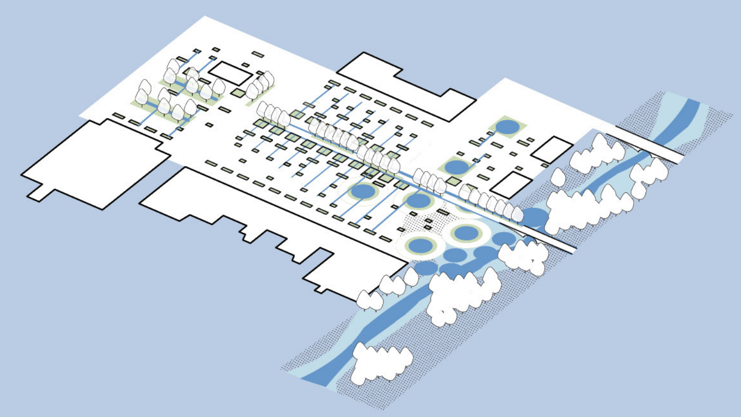
Cities are discrete, whereas nature is inherently continuous. Optimal ecosystem functioning entails ***physical connectivity among landscapes***—the very quality urbanization tends to erase. In downtown Conway, with impervious surface averaging more than 50 percent coverage, opportunities for implementing ecologically-based infrastructure adaptations are highly localized and sporadically distributed. Alternatively, riparian corridors and land-rich suburban development readily accommodate large-scale retrofits characterized by high connectivity for optimal ecological functioning. Nonetheless, all sectors of the city, whether high density development or undeveloped sites, hold capacities for water management that contribute to healthy watershed functioning. Aligning such capacities is a matter of design. ***The city can be engineered to work like a sponge.***



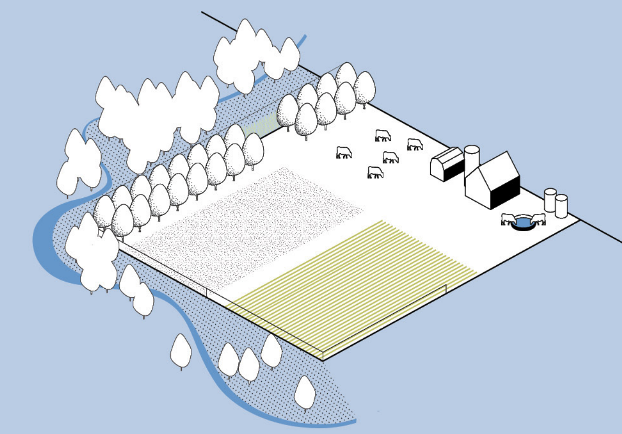
Lake Restoration



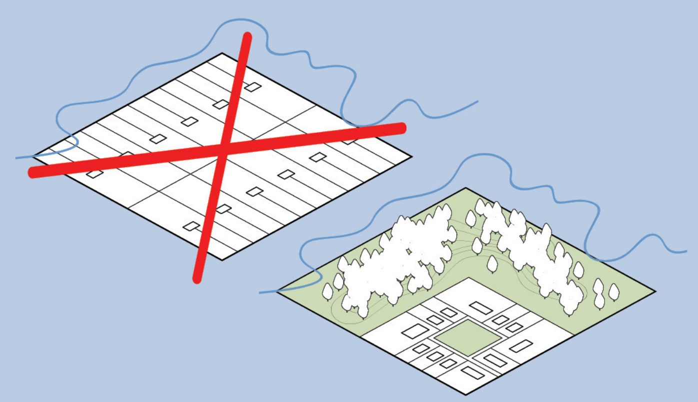
Green Streets and Parks



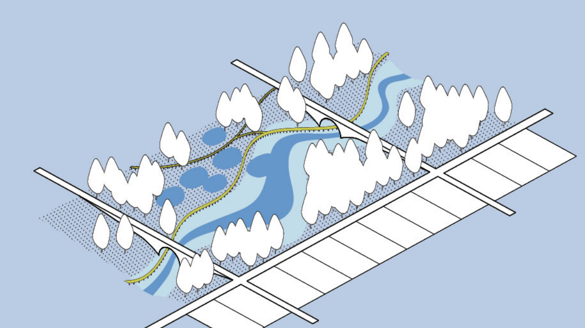
Parking Gardens



Urban Eco-Farm

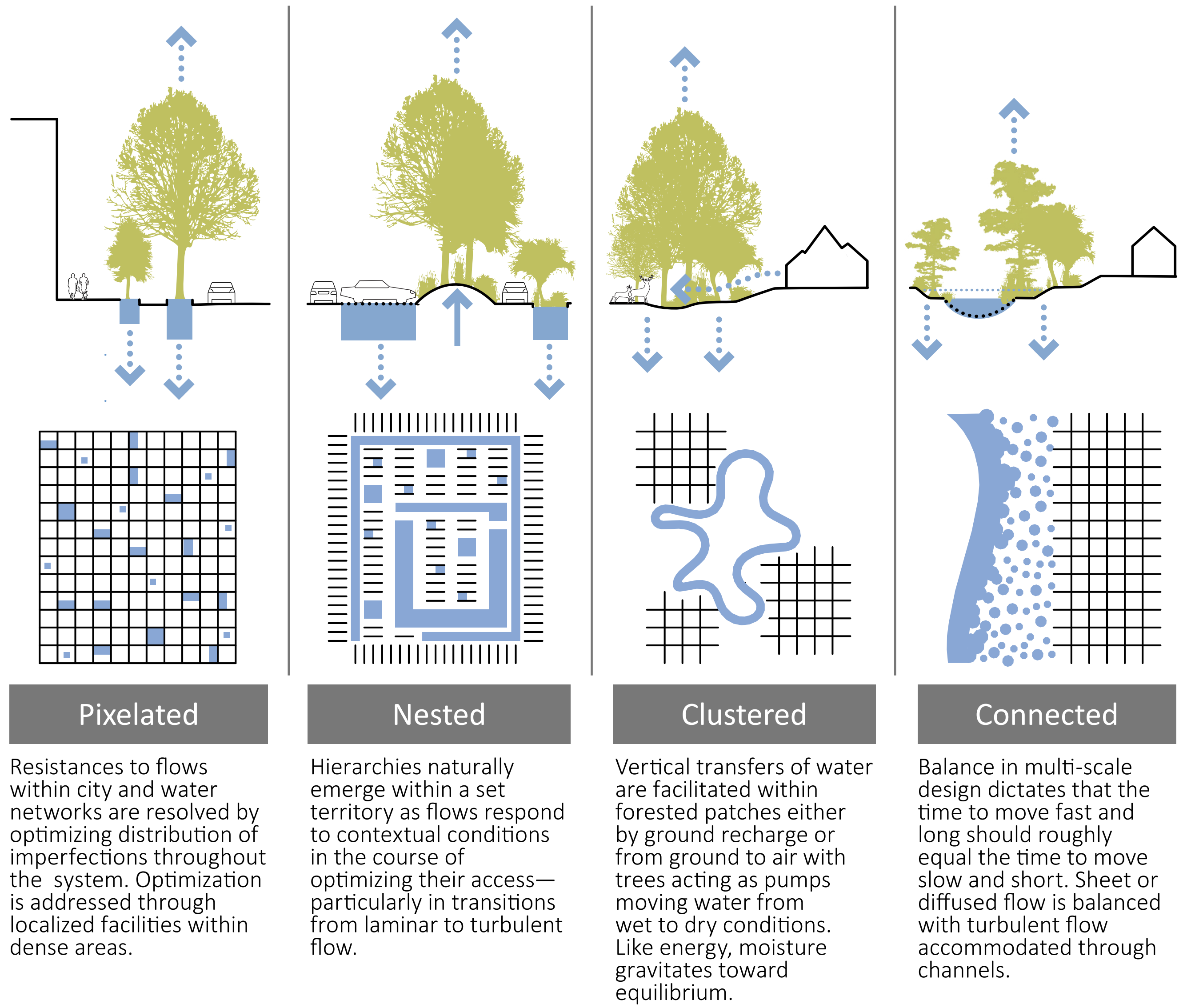


Conservation Development



City Greenway

Adaptive Infrastructure



Sponge City Gradient

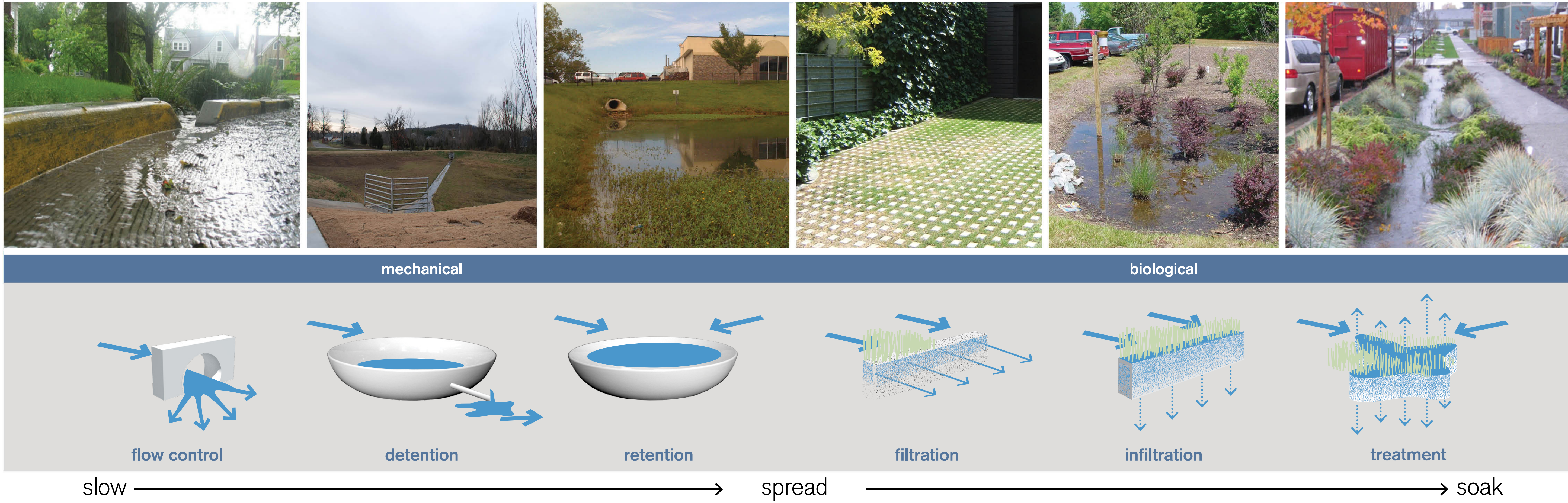
The Sponge City Gradient (see diagram above) illustrates the structural interfaces between land use characteristics (i.e., function, intensity, and surrounding development patterns) and natural hydrology in the city-nature continuum. Since land uses offer radically uneven opportunities for water management, ecological infrastructure is configured accordingly to prevailing development profiles shaping downtown, suburban, exurban, and rural territories. Four typological configurations recognize these cross-sectional differences. ***Pixelation*** works within fragmented and hardened downtown landscapes. ***Nesting*** engages the pulsed frequencies of activity in parking lots and other large commercial sites. ***Clustering*** is an ideal pattern language for land-rich development. ***Connection*** in rural areas and along riparian corridors continues the imperative that large-scale natural systems connect. The gradient's usefulness as a general planning tool is complemented by attention to specific ecological-based water treatment technologies incorporating both mechanical and biological techniques.

The Six Water Management and Treatment Technologies

The hydrological design objective is to **slow**, **soak**, and **spread** urban runoff through landscape systems, given their intrinsic capacity for biologic treatment and metabolization of contaminants. Whereas urban runoff management for most cities has entailed a hard-engineered drainage network designed primarily for flood protection and quick evacuation of water, soft engineering using landscapes approaches employ ***flow attenuation, filtration, infiltration, detention, retention,*** and ***bioremediation*** with better management results while achieving collateral environmental benefits (see Water Treatment Technologies diagram next page). Both soft and hard engineering techniques can be assembled as customized landscapes employing a combination of Low Impact Development, riparian corridor improvements, and green urban infrastructure. These hybrid infrastructural solutions also offer a highly resilient urban landscape foundational to achieving a holistic *watershed approach*.

The six water treatment technologies provide the building blocks for developing a citywide treatment landscape in the watershed approach. To slow, soak, and spread runoff, first enhance landscape biodiversity since ecological-based management solutions require healthy soils, plant communities, and riparian systems. This subsequently allows the treatment system to maximize water infiltration and eliminate peak flow runoffs damaging to both urban and ecosystem functioning. Runoff treatment systems should be engineered in distributed networks based on redundancy, high connectivity, and modularity to create a resilient urban landscape. This recalls Wendell Berry's adage in his book, *The Gift of Good Land*, that "a good solution in one pattern preserves the integrity of the pattern that contains it." The Sponge City Gradient and the Six

Source: *Low Impact Development: a design manual for urban areas*, UACDC



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.

Water Treatment Technologies

Water Management and Treatment Technologies combined provide a city-building vocabulary and watershed approach for remedying water resource management problems.

A Plan that Works Incrementally

The Framework Plan operates evolutionarily through a set of retrofit types that are incremental, contextual, and *successional*. The Framework Plan is incremental, relying on participation from various interests—public, private, or a combination thereof—to develop projects as funding and opportunity permit. Projects can be implemented step-wise and successively across various fronts in the urbanized area. Unlike the master plan which is totalizing and shows only a climax condition, the Framework Plan can be pioneered beginning with modest cumulative efforts that cohere from shared ecological design practices.

The Framework Plan is contextual, working through landscape architectural adaptations responsive to local ecologies and urban water problems. Soft engineering accounts for local soils, and vegetative and wildlife communities in place-based solutions that substitute for universal metrics and costly “over-engineered” outcomes driven by worst-case scenarios. The goal is to deliver ecological services through installing sustainable soft infrastructure. Soft engineering's use of adaptive management lessens long-term maintenance burdens associated with hard-engineered infrastructure.

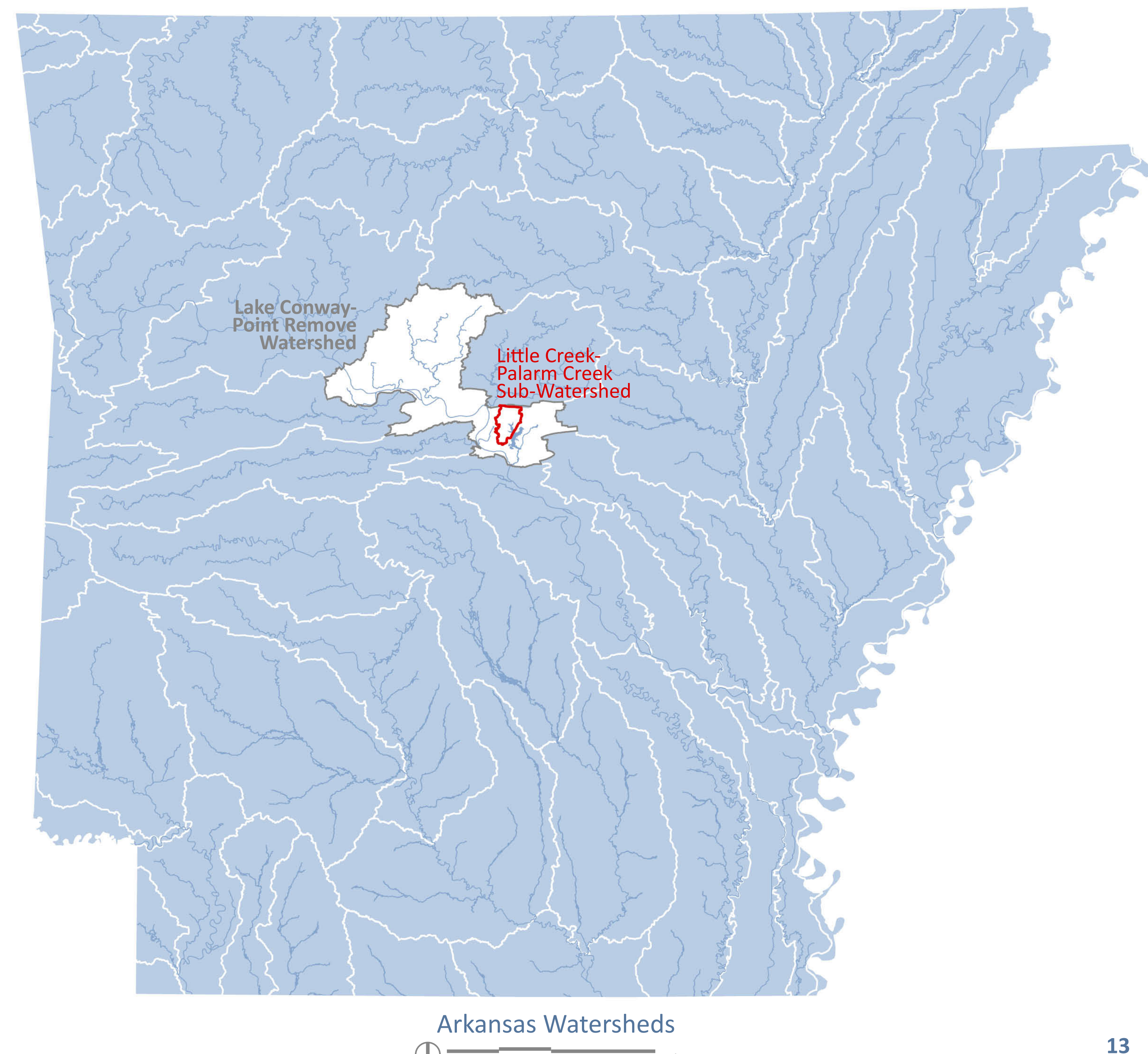
The Framework Plan is successional, understanding that cities are not built at once and that pioneer stages of development are rudimentary as they minimize start-up costs. ***The Framework Plan works initially through tactical demonstration projects,*** which if approved after assessment, can be mainstreamed into future projects and policies. This way the city or project developer can evaluate new practices without committing permanently to an untested development and business model. Cities do not have to retool policies without the chance to pursue due dilligence. Stakeholders in decision-making, including the city and the area's new watershed alliances (e.g., the Lake Conway-Point Remove Watershed Alliance), can collaborate as ***learning communities*** removing adversarial relationships so redolent in municipal planning processes. Without demonstration projects, conventional development approaches will remain entrenched despite the presence of more value-added approaches. Conway's growth and governance successes suggest that it is prepared for the next development stage toward holistic and high-value outcomes.

Conclusion

Where the two networks meet—the city and water—can certainly be a source for many solutions to myriad development problems. The Framework Plan places Conway ahead of the curve in addressing the greatest ongoing challenge to planning: development of urban form in human-dominated ecosystems. More cities are tasking urban infrastructure with regeneration of diminished ecosystems to support livable communities. Besides solving for water management problems like flooding, the collateral benefits of implementing the plan include greater livability, sustained economic development, improved community resilience to disruption and shocks, and exemplary beauty in the civic realm that creates enduring value and symbolism.

Context Characterization

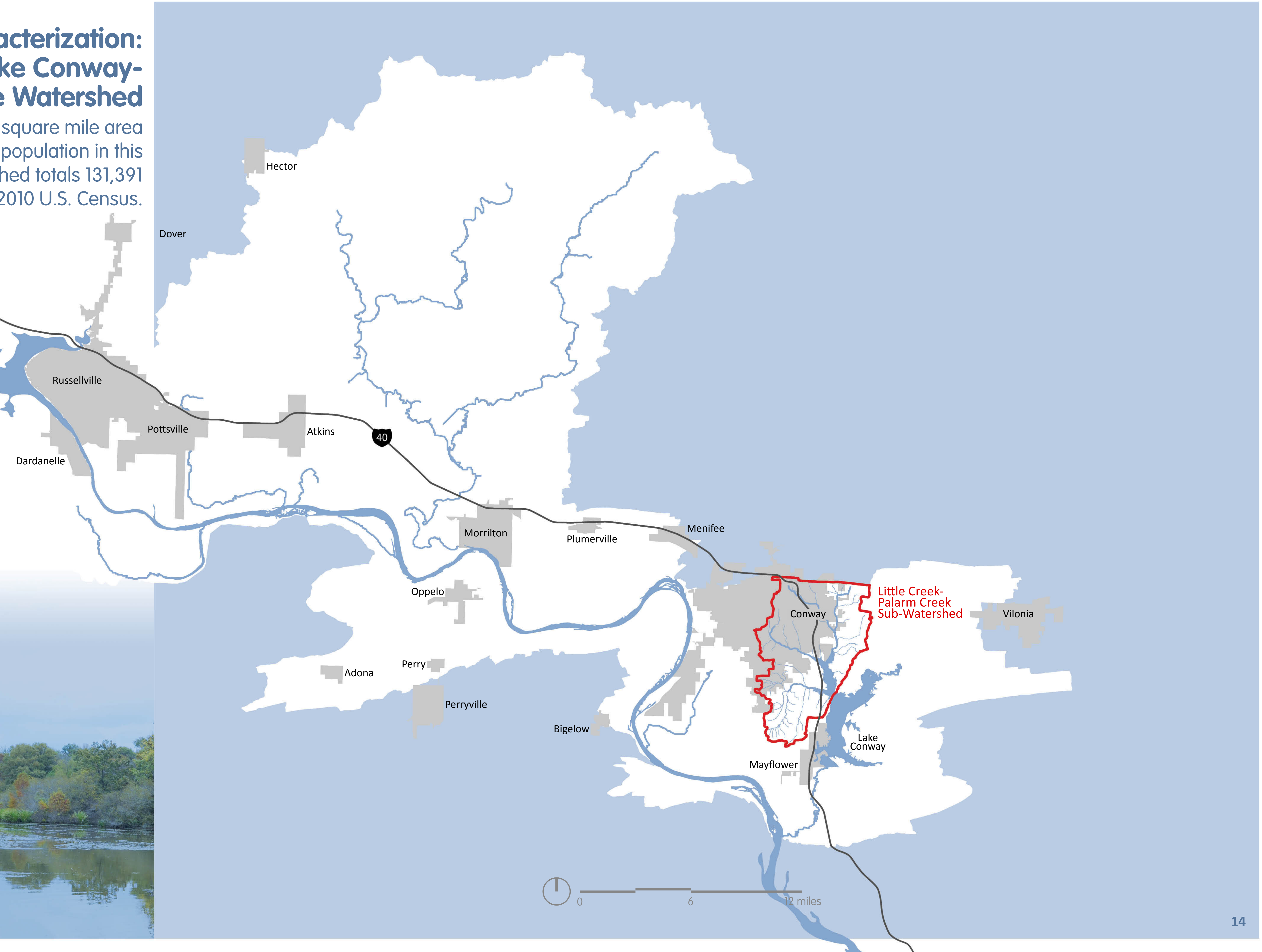
Arkansas has 58 watersheds of which 10 have been designated as priority watersheds due to *nonpoint source pollution*, including the Lake Conway-Point Remove Watershed. LCPRW is without a USEPA approved management plan, limiting the area's access to funding for implementing urban watershed improvements. The Little Creek-Palarm Creek sub-watershed—the focus of this Framework Plan—drains over half of the City of Conway, with Lake Conway, the state's largest game and fish lake, as the receiving water body. Rapid urban growth without proper water management planning is resulting in watershed dysfunction and lake impairment. Recent studies indicate significant increases in sedimentation, phosphorus and organic matter in Lake Conway. Extreme flooding events in 2008, 2009, and 2011 appear to have driven these increases. Stone Dam Creek and Palarm Creek exhibit the highest average sedimentation rates. Erosion and sedimentation are significant problems in the Little Creek-Palarm Creek corridors and a majority of the watershed's urbanized area lacks the riparian cover recommended by the National Resources Conservation Services.

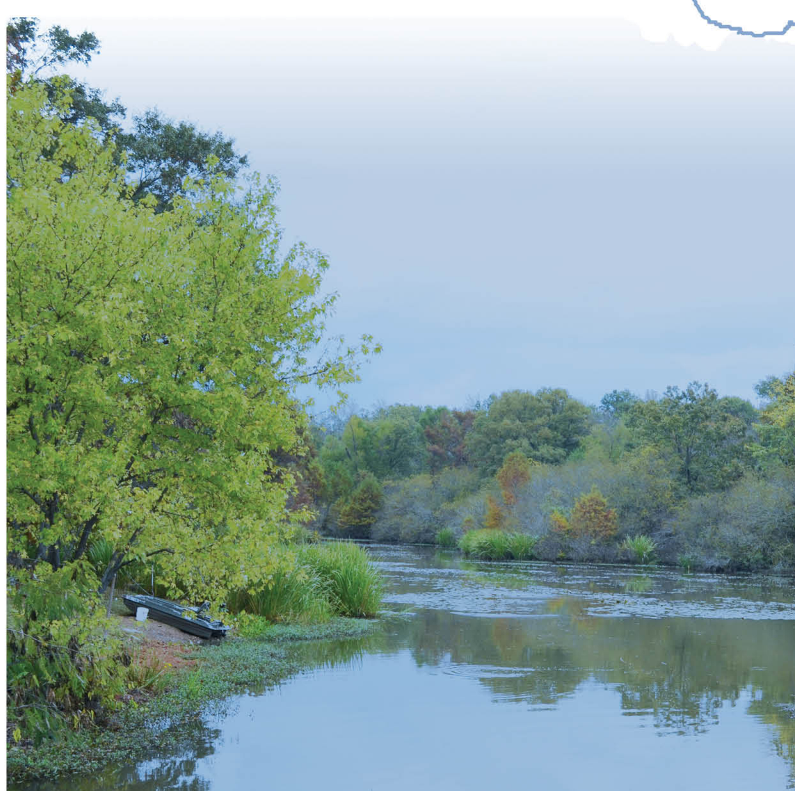


Arkansas Watersheds

Context Characterization: Lake Conway-Point Remove Watershed

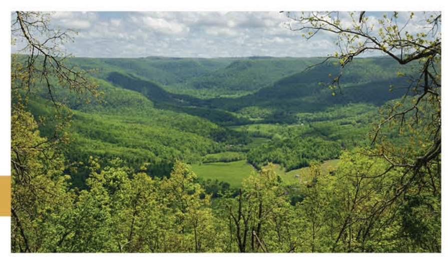
Covering over a 1,144 square mile area (*HUC* 11110203), the population in this watershed totals 131,391 based on 2010 U.S. Census.



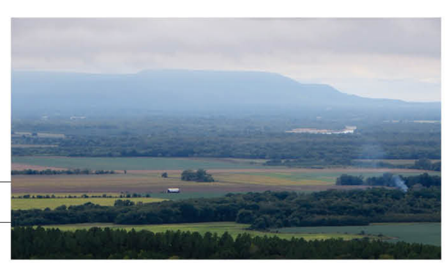


Context Characterization: Ecoregions of Arkansas

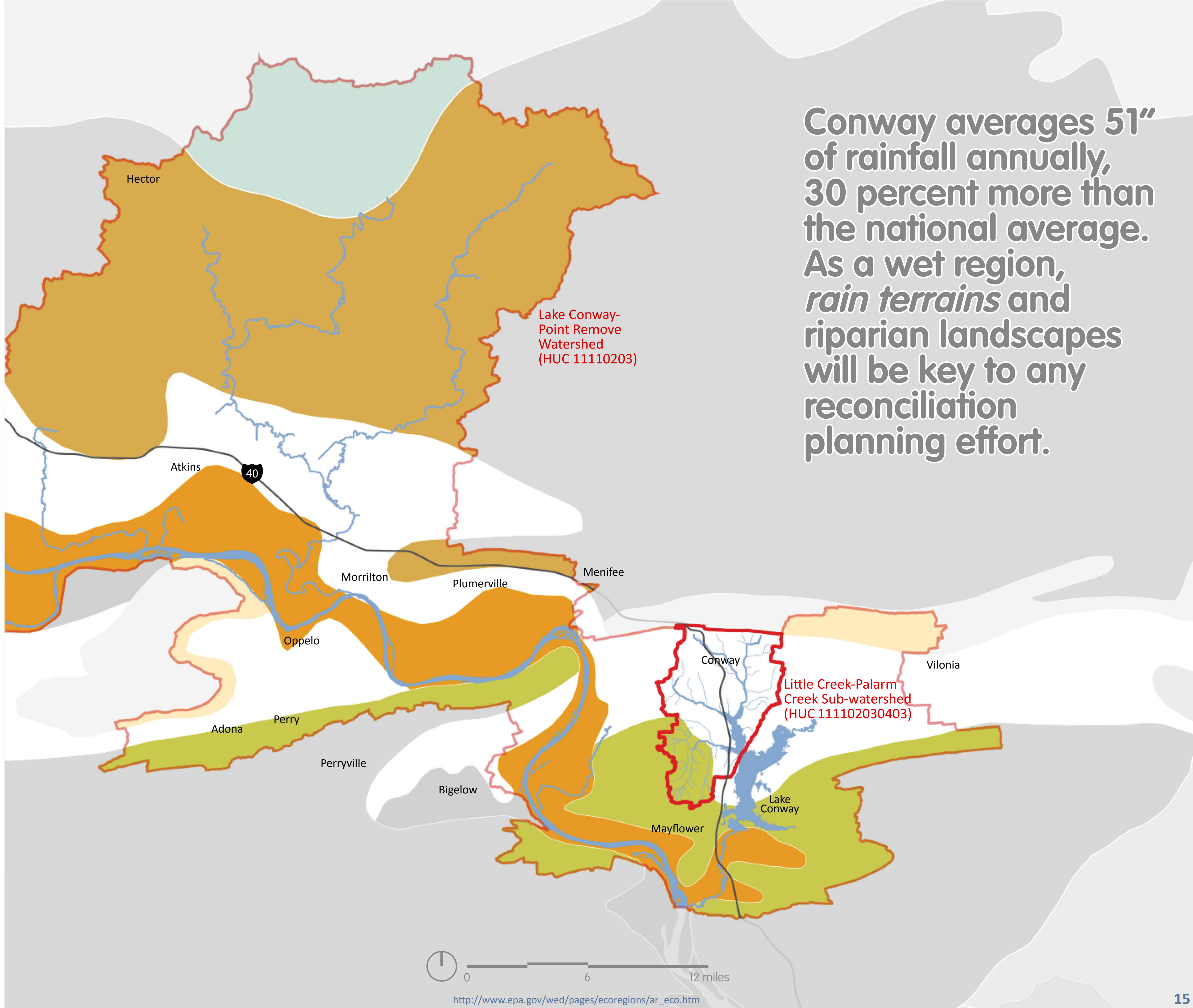
The Lake Conway-Point Remove Watershed lies in the interface of four distinct Level IV ecoregions, Arkansas Valley Hills, Scattered High Ridges, Arkansas Valley Plains, and the Fourche Mountains with each region having distinct soil types, topography and biota. The majority of the watershed lies within the Arkansas Valley with hills and plains comprising the greatest portion. Watershed vegetation types are composed of oak-hickory-pine forest in the hills and savanna-prairie in the plains.


37c
Arkansas Valley Hills


37a
Scattered High Ridges


37d
Arkansas Valley Plains


36d
Fourche Mountains



http://www.epa.gov/wed/pages/ecoregions/ar_eco.htm

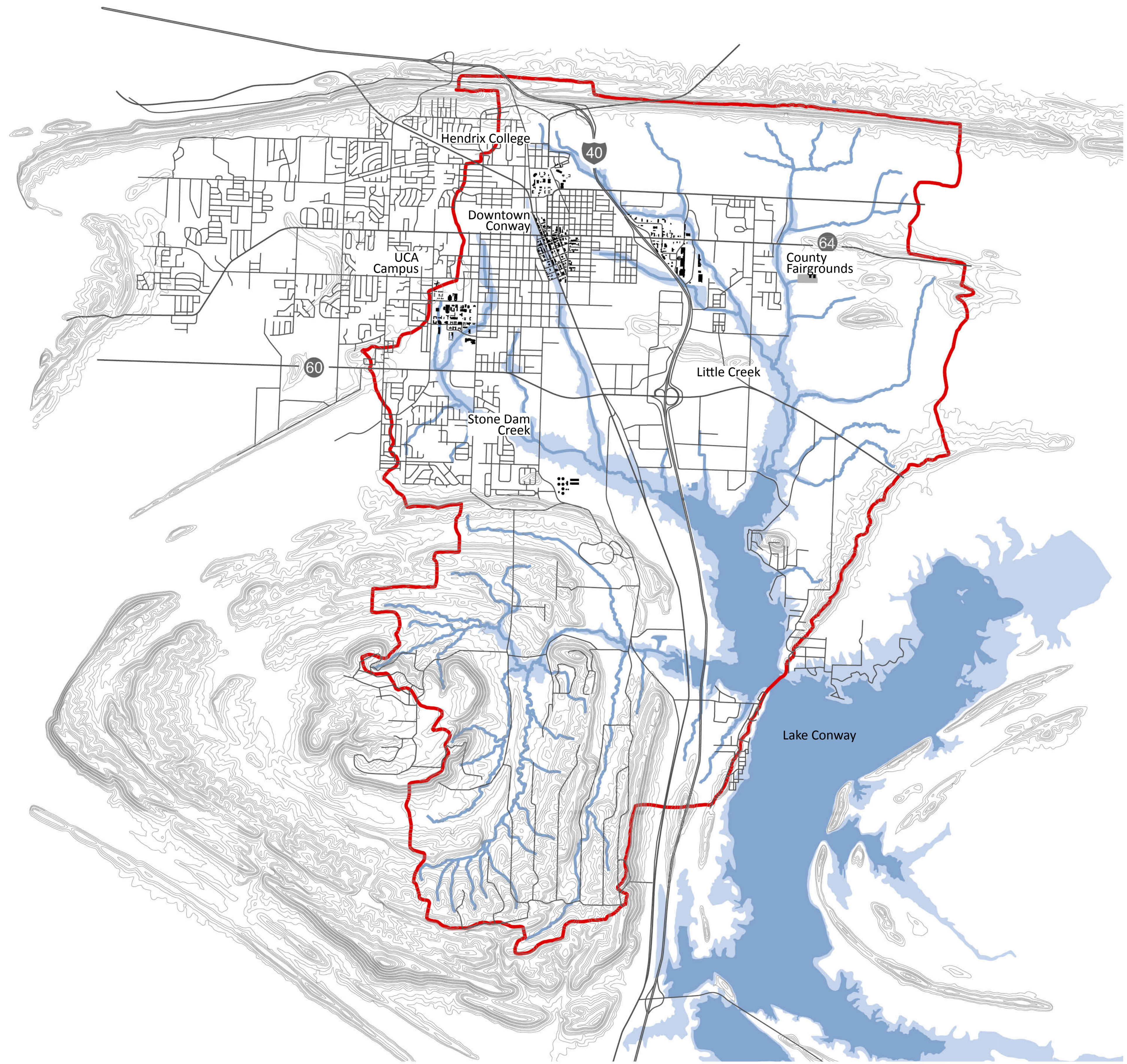
Conway averages 51" of rainfall annually, 30 percent more than the national average. As a wet region, *rain terrains* and riparian landscapes will be key to any reconciliation planning effort.

Context Characterization: Urban Impacts

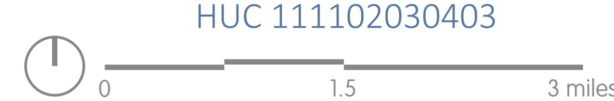
Since the first hour of urban stormwater runoff can have a pollution index greater than that of raw sewage, stormwater treatment becomes imperative because everything upstream within the sub-watershed eventually makes its way into Lake Conway.

The urbanized portions of the City of Conway with the greatest impervious surface area drain into the lake. Known as nonpoint source pollution, surface level pollutants generated by diffused human activities are concentrated and transported by stormwater runoff into local water bodies since there is no municipal underground storm sewer system.

Nonpoint source pollution can be natural or human-made pollutants including synthetic fertilizers, herbicides, and insecticides from urban and agricultural lands; oil, grease, metals and coolants from automobiles; toxic chemicals from road construction, industrial sites, and energy production; sediment from construction sites, agricultural and forested land and eroding stream banks; and bacteria and nutrient loading from livestock, pets, and failing septic and sewer treatment systems.



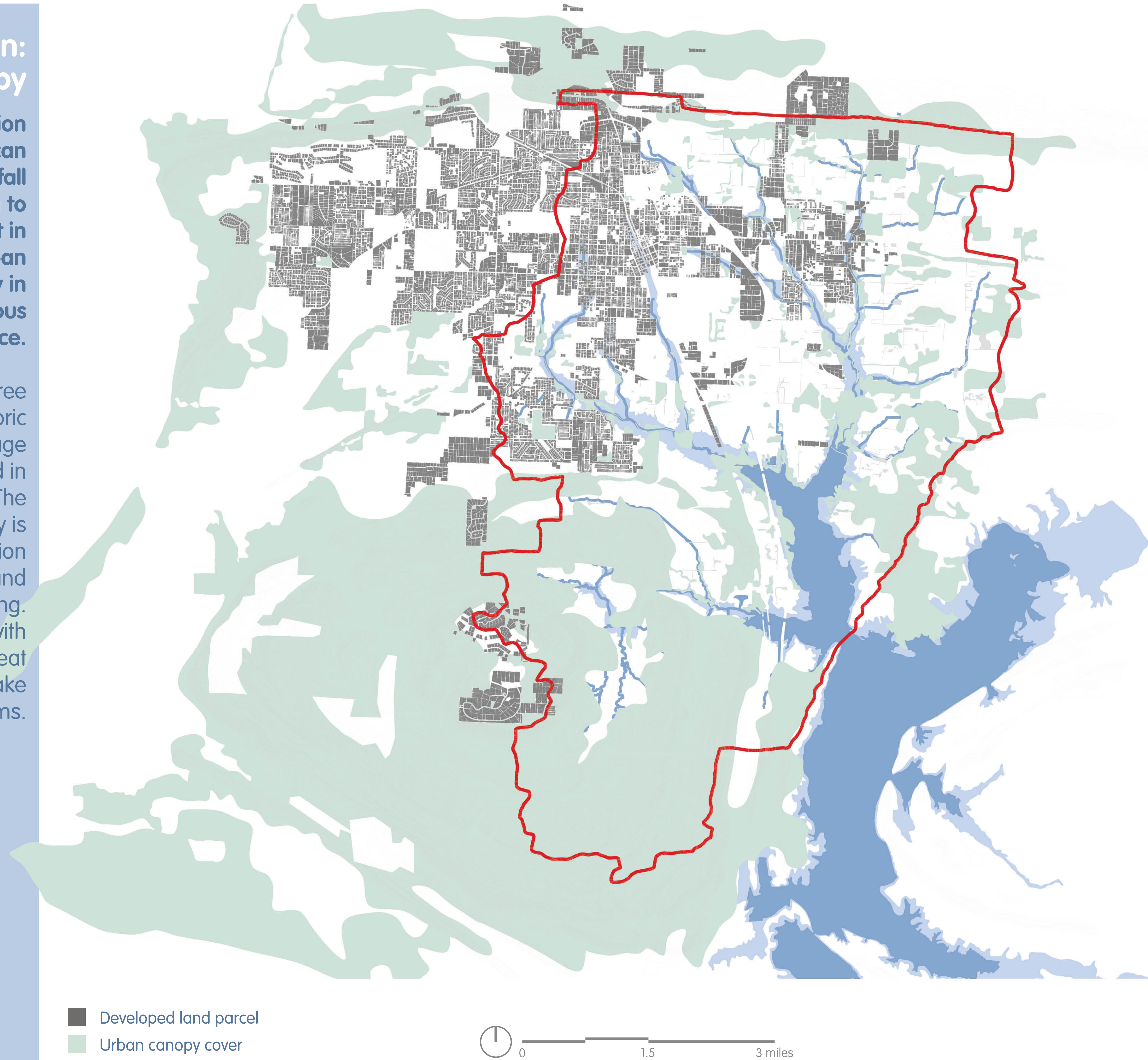
Little Creek-Palarm Creek Sub-watershed
HUC 111102030403



Context Characterization: Urban Tree Canopy

Forested areas in Conway's ecoregion with a high *leaf area index* can intercept up to 35 percent of rainfall before it hits the ground according to foresters. High LAI can result in significant mitigation of urban stormwater impacts, particularly in areas with high levels of impervious surface.

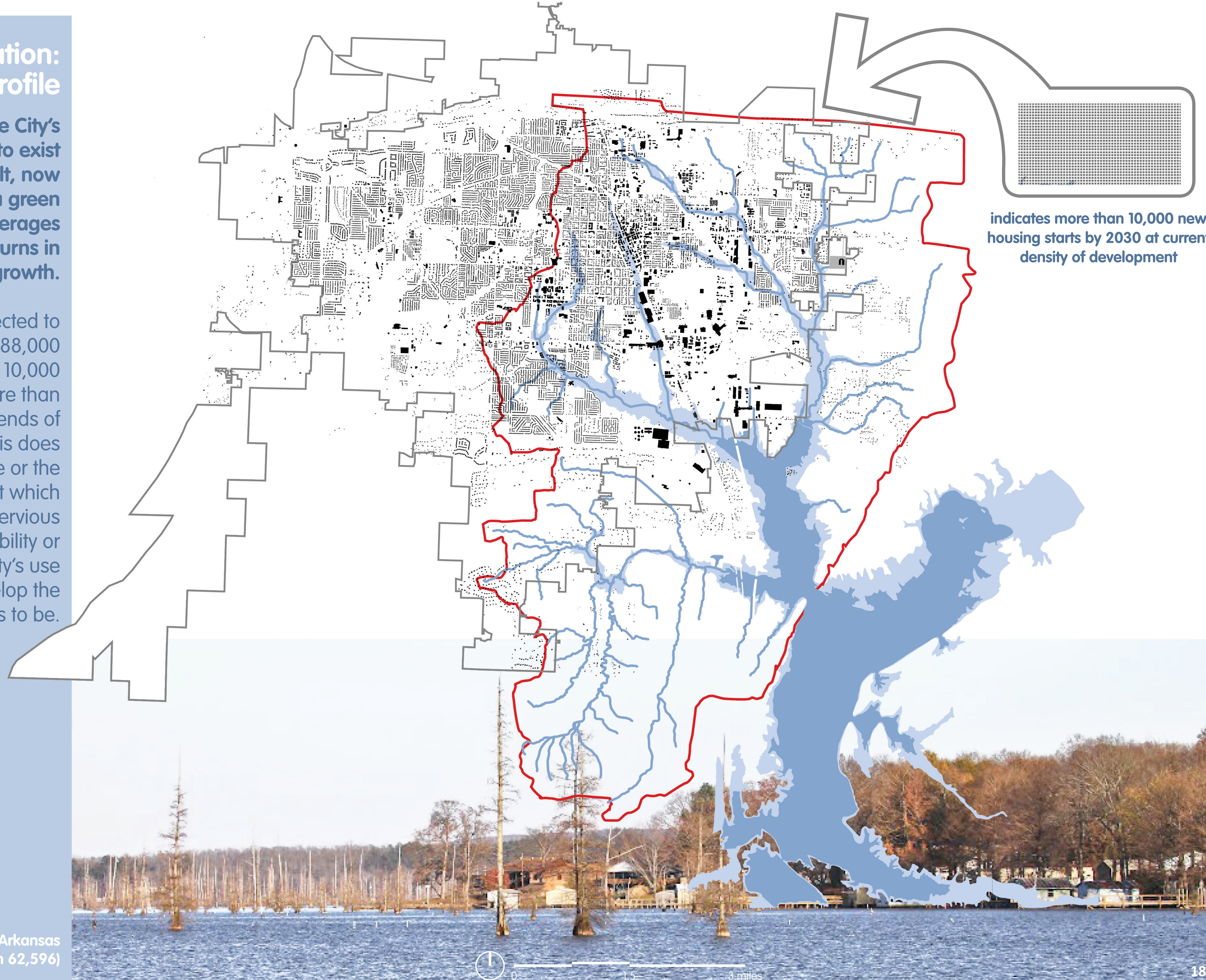
The sub-watershed has good tree coverage to the south and in the historic neighborhoods. However, tree coverage is inadequate in the suburbs and in areas where the city is growing. The forested plateau south of Conway is beginning to show signs of deforestation due to residential development and conversion to pasture land and mining. The loss of vegetative cover coupled with steep topography is a potential threat for increased sedimentation and lake flooding, already chronic problems.



Context Characterization: Growth Profile

Since more than a third of the City's built environment projected to exist by 2030 has not yet been built, now is the time to implement a green infrastructure plan that leverages ecological and economic returns in future growth.

Conway's population is projected to grow by more than 25,000 to 88,000 by 2030. This entails more than 10,000 new dwelling units covering more than 3,400 acres if current density trends of three units per acre persist. This does not factor in the infrastructure or the non-residential land use footprint which will add considerably more impervious surface area. Growth can be a liability or an asset, dependent upon the City's use of planning as a resource to develop the type of place it aims to be.



Conway, Arkansas
38,528 acres (population 62,596)

Context Characterization: Asphalt Coverage

Research shows that more than 10 percent coverage of surface area with impervious surfaces from roofs, parking lots, and roads can lead to regional watershed damage, while more than 30 percent coverage can lead to irreversible watershed destruction.

Many of the parking lots shown are, by design and policy, oversized for their programmatic needs. They were constructed in a time when the need for ecologically-based management of stormwater runoff was not well understood, especially the direct discharge of untreated urban runoff into local streams. These parking lots are great opportunities for green infrastructure retrofits that effectively manage stormwater runoff while creating great places and branding opportunities for commercial land uses.

Context Characterization: Ecological Stressors

The City's robust industrial legacy has left behind brownfield sites with large impervious surface areas and/or areas of highly compacted soil that discharge urban runoff directly into urban streams. Area soil structure is not conducive to deep infiltration of stormwater, compounding problems in surface water conveyance.

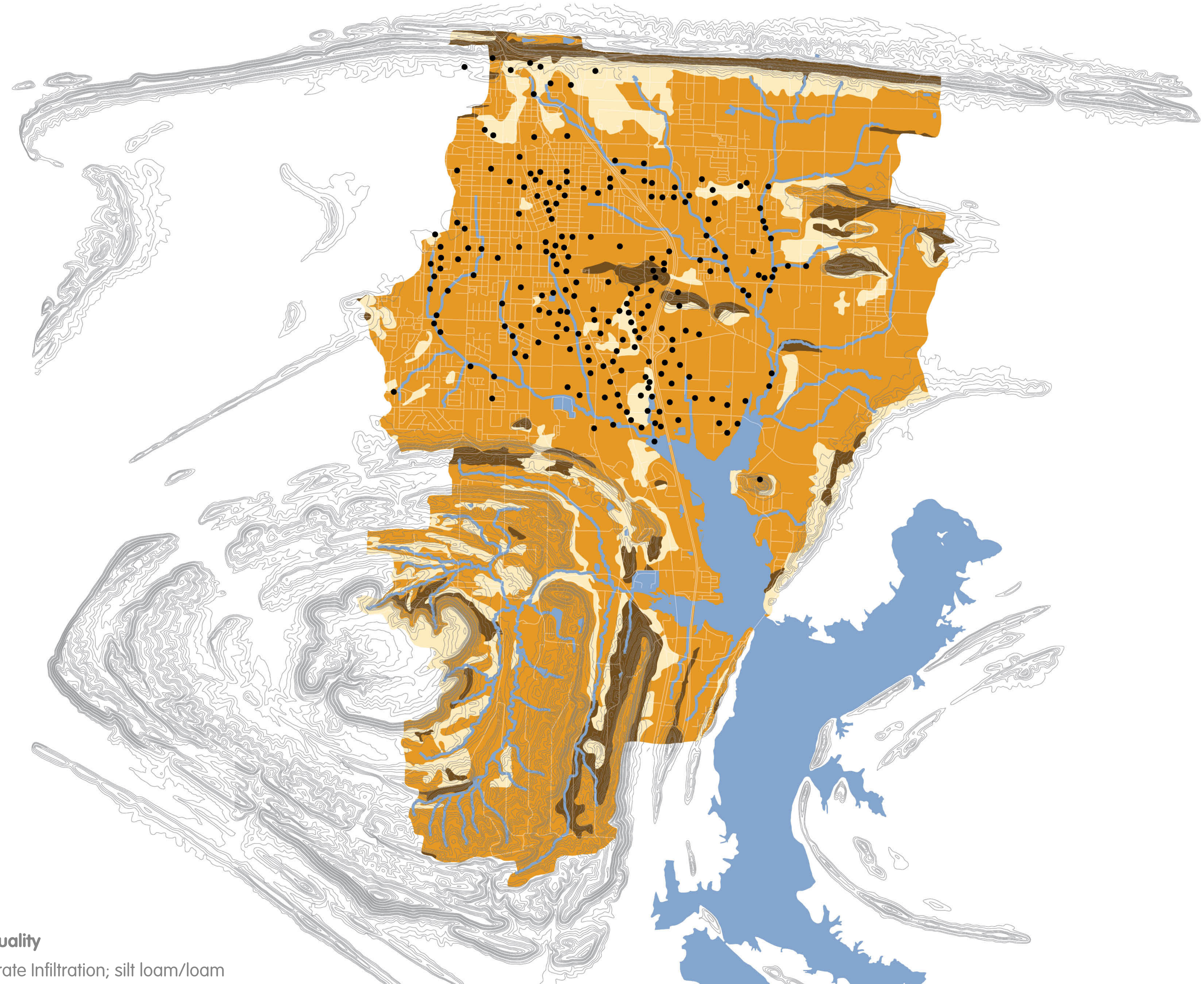

structures built on top of stream


loss of riparian landscape


stream channelization


large impervious tarmac


stream inputs from industry + construction



Soil Quality

- Moderate Infiltration; silt loam/loam
- Low Infiltration; sandy clay loam
- No Infiltration; high runoff; clay loam/silty clay/clay
- ● Ecological stressor

0 1.5 3 miles

Infrastructure for the 21st century city simply will have to do more work! The City's growth and governance successes suggest that it is prepared for the next development stage toward holistic and high-value outcomes.

re-inventing Conway

so then let's examine the present challenges...

wrong kind of seam

Direct discharge of polluted stormwater runoff into streams was a common practice before improved understanding of environmental and biological processes. The best practice is to manage and retain water on-site, or treat urban runoff before its release into a water body....remember, the first flush can have a pollution index far higher than that of raw sewage.

Problemscape

A map of the myriad manifestations of nonpoint source pollution, and their expressions in stream dysfunction across the sub-watershed, forms the starting point for an Urban Watershed Framework Plan. While the human activities indicated are not intrinsically defective, but rather essential to our economies, their unregulated outputs become "negative externalities"—i.e., the public's problems and cost burdens—when not reconciled with watershed functioning. A holistic approach to watershed management is within easy grasp.

Parking + Brownfields

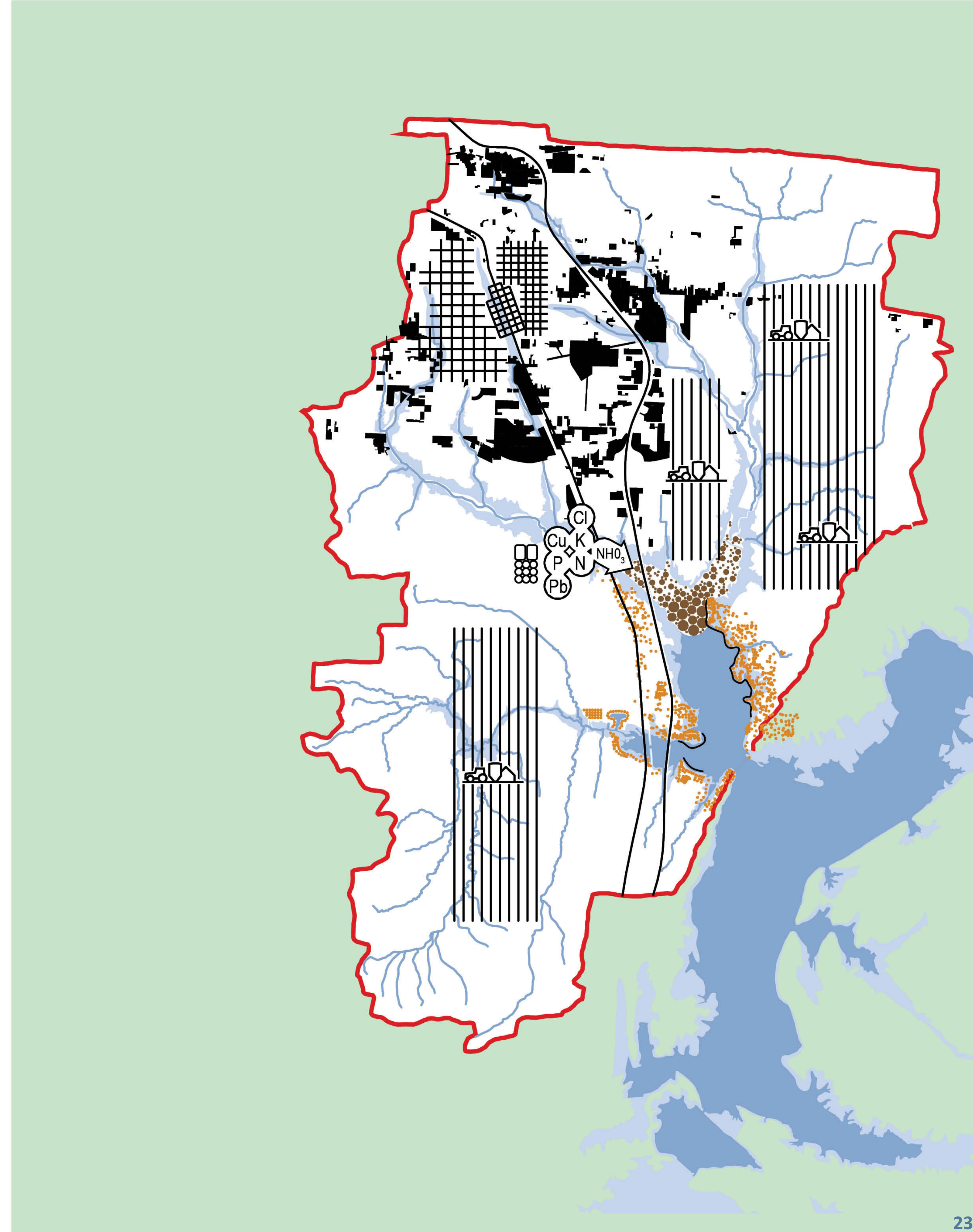
Agriculture

Septic Tank + Lake Flooding + Concrete Walls

Sedimentation

Impervious Urban Area

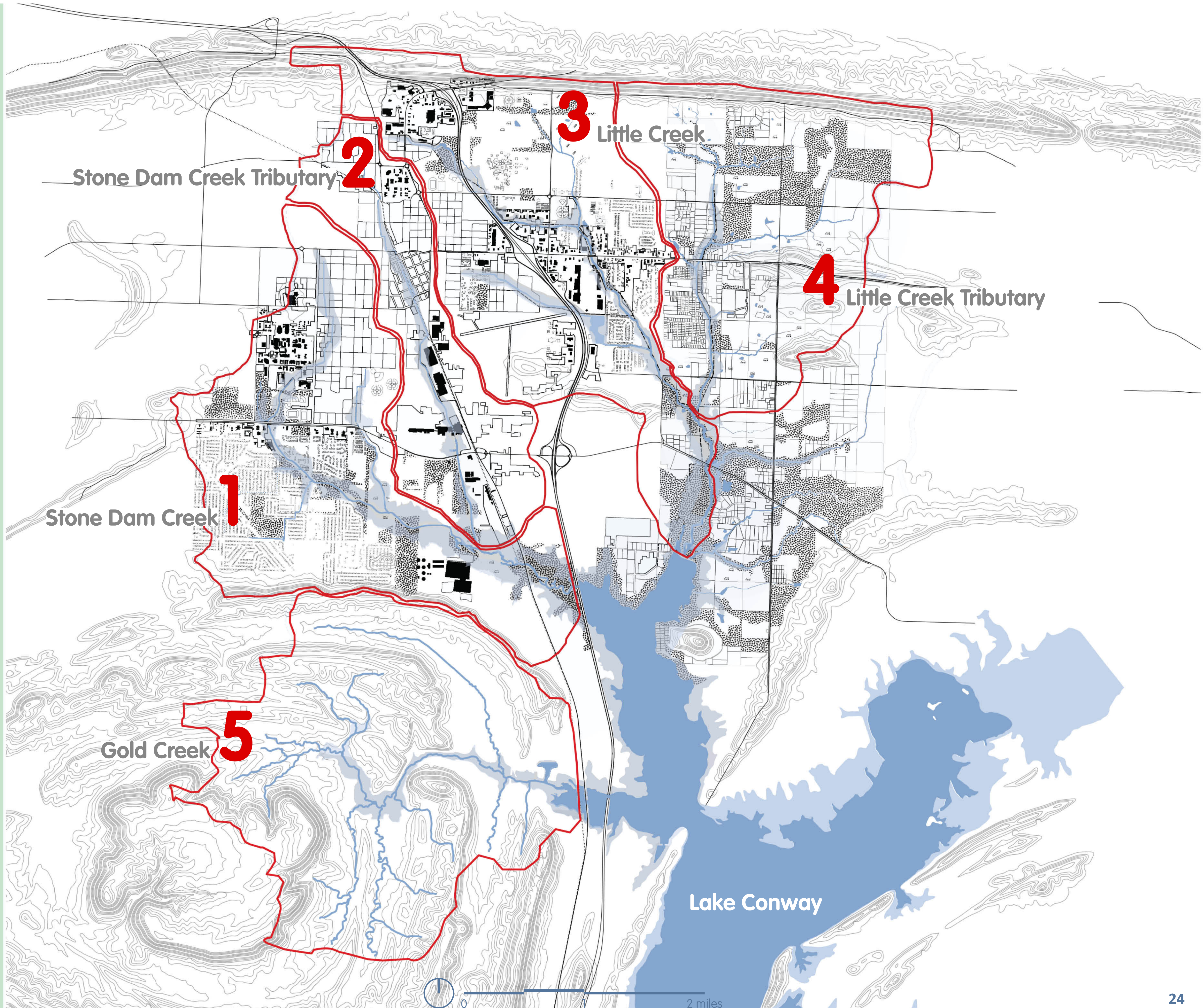
Nutrient + Chemical Loading



Problemscape: Five Riparian Corridors

The watershed is only as healthy as its constituent streams and the respective characteristics of the ecoregions in which they originate. Each of the five riparian corridors shaping the Little Creek-Palarm Creek sub-watershed reside in human-dominated ecosystems.

These five riparian corridors bear the imprints of urbanization and/or intensive agriculture, much of it developed before widespread understanding of the value of watershed integrity. While streams in this sub-watershed have traditionally been treated as stormwater detention and conveyance facilities—leading to urban stream syndrome—the good news is that these dated practices are easy to correct leading to multiplier benefits in watershed health and urban livability. This entails restoration of necessary corridor components like floodplains, vegetated banks, and sinuosity in stream geometries. Indeed, fixing the problems gives rise to a unique urban brandscape otherwise elusive in conventional planning processes.



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Stone Dam Creek Problemscape

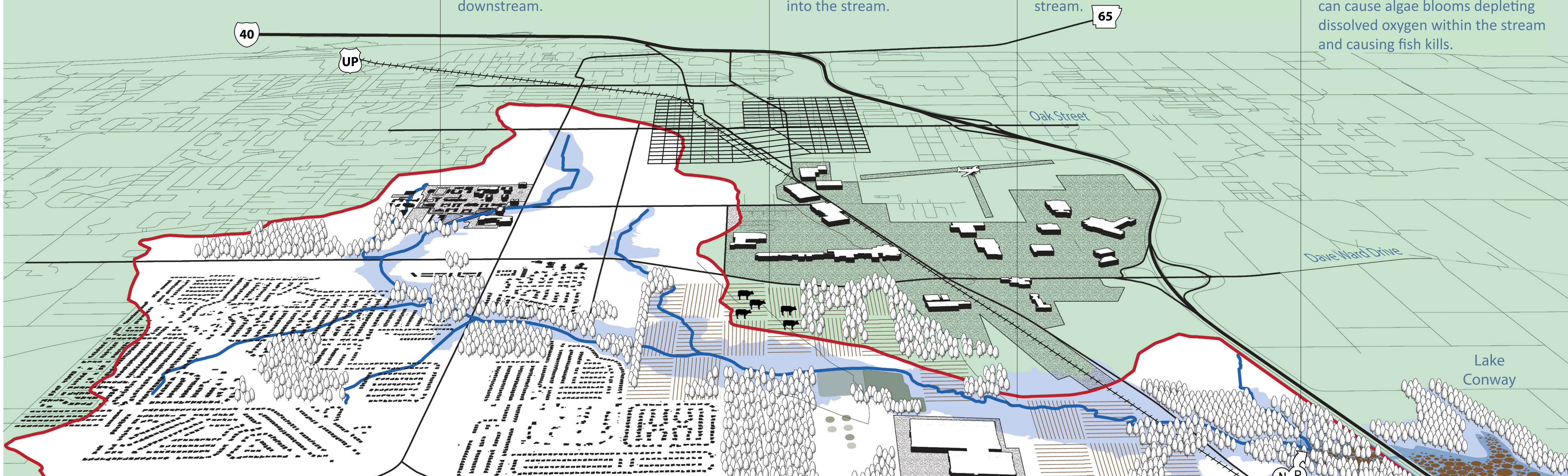
Flowing through the City's first-ring suburbs, this riparian corridor receives sheet flows from invasive turf lawns supplemented by industrial herbicides, pesticides, and fertilizers, as well as nonpoint source inputs from campus parking lots and vacated industrial parcels.

1 Unprotected headwaters
Impervious pavement adjacent to the stream, and piping and channelization of the stream's headwaters increase runoff velocity and volume which diminishes aquatic habitat downstream.

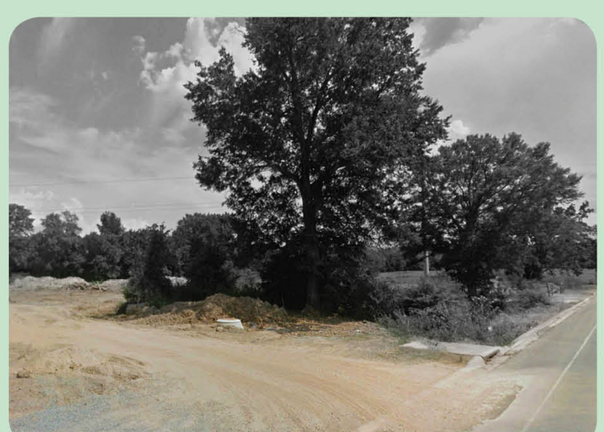
2 Loss of riparian vegetation
Livestock grazing and trampling increases sedimentation and accelerates pollutant flows into the stream.

3 Unprotected and unvegetated riparian edge
Lack of vegetated and armored edges allow unregulated flow of sediment, nutrients, and pollutants into the stream.

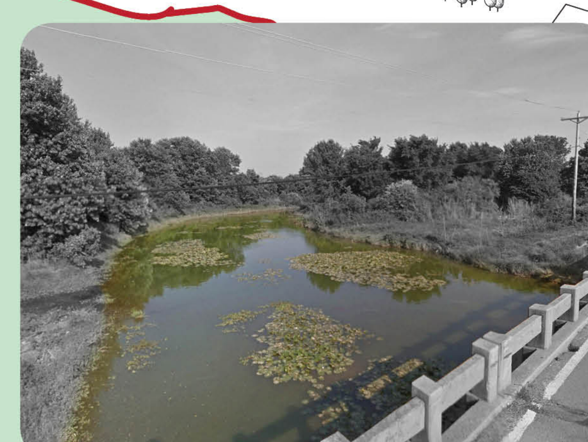
4 Chemical inputs
Runoff from agricultural chemicals, fertilizers, and pesticides can adversely affect aquatic and wildlife habitat. Fertilizers (NPK) can cause algae blooms depleting dissolved oxygen within the stream and causing fish kills.




Campus development and parking within floodplain


Loss of riparian edge


Industrial pollutants within floodplain


Algae bloom leading to anaerobic water bodies

2 Stone Dam Creek Tributary Problemscape

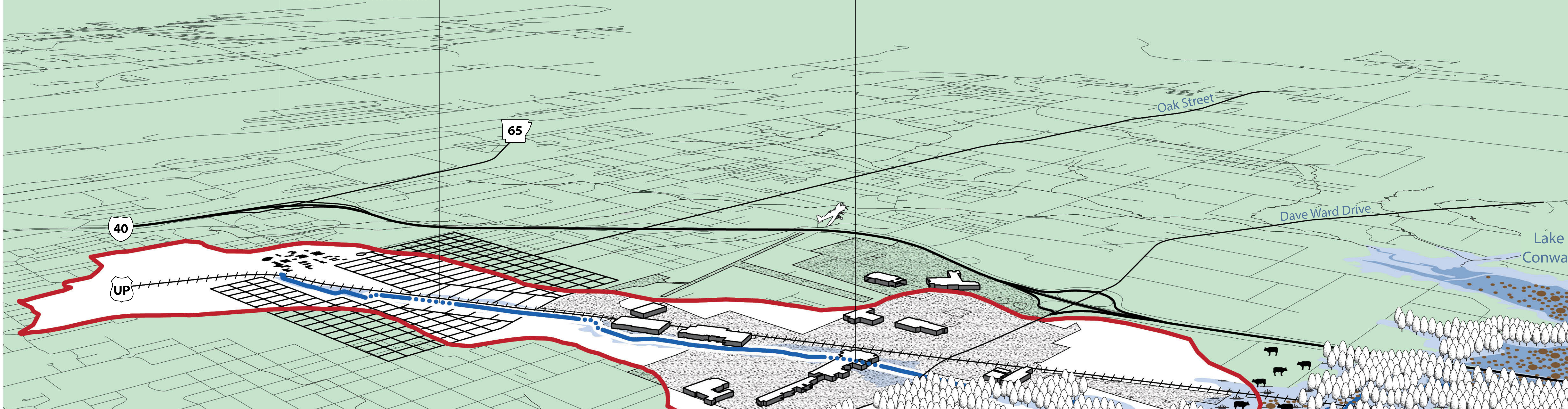
Flowing through downtown and the industrial district along the railroad—and piped underneath industrial structures—this riparian corridor is managed through channelization and piping that exacerbate downstream problems.

1 Unprotected headwaters
Headwater shortcomings compound physical, biological and chemical aquatic health downstream.

2 Channelization and piping
Hard engineered solutions eliminate the self-correcting capacity intrinsic to the stream's natural ecology.

3 Industrial development over stream
Piped streams increase threats from chemical pollutants entering surface waters as well as decrease water retention time, creating velocity and flow problems further downstream.

4 Chemical inputs
Runoff from agricultural chemicals, fertilizers, and pesticides can adversely affect aquatic and wildlife habitat. Fertilizers (NPK) can cause algae blooms depleting dissolved oxygen within the stream and causing fish kills.




Loss of riparian edge at headwaters


Channelization of stream


Industrial development over stream

3 Little Creek Problemscape

Flowing through suburban contexts populated with auto-oriented commercial centers, large parking lots and scrap operations, this riparian corridor receives peak storm inputs with minimal floodplain and vegetation to mitigate high flow energy and sedimentation.

Expanse of impervious paving along stream ①
Impervious surfaces prevent rainwater infiltration and groundwater recharge while increasing the velocity and flow of stormwater runoff.

Loss of riparian vegetation due to urbanization and agriculture ②
Vegetated corridors regulate sediment, nutrients, and chemical inputs, as they are the major metabolizer of contaminants.

Chemical inputs ③
Fertilizers (NPK) and chemicals from lawn care practices and farming damage aquatic habitat. Fertilizers cause algae blooms, depleting dissolved oxygen within the stream.

Excess sedimentation within the lake ④
Sedimentation damages aquatic habitat by reducing lake depth and transporting suspended solids that create an oxygen-starved enviroment.


Loss of cover crop to retain top soil


Expanse of impervious paving adjacent to degraded riparian edge


Industrial pollution sources within floodplain

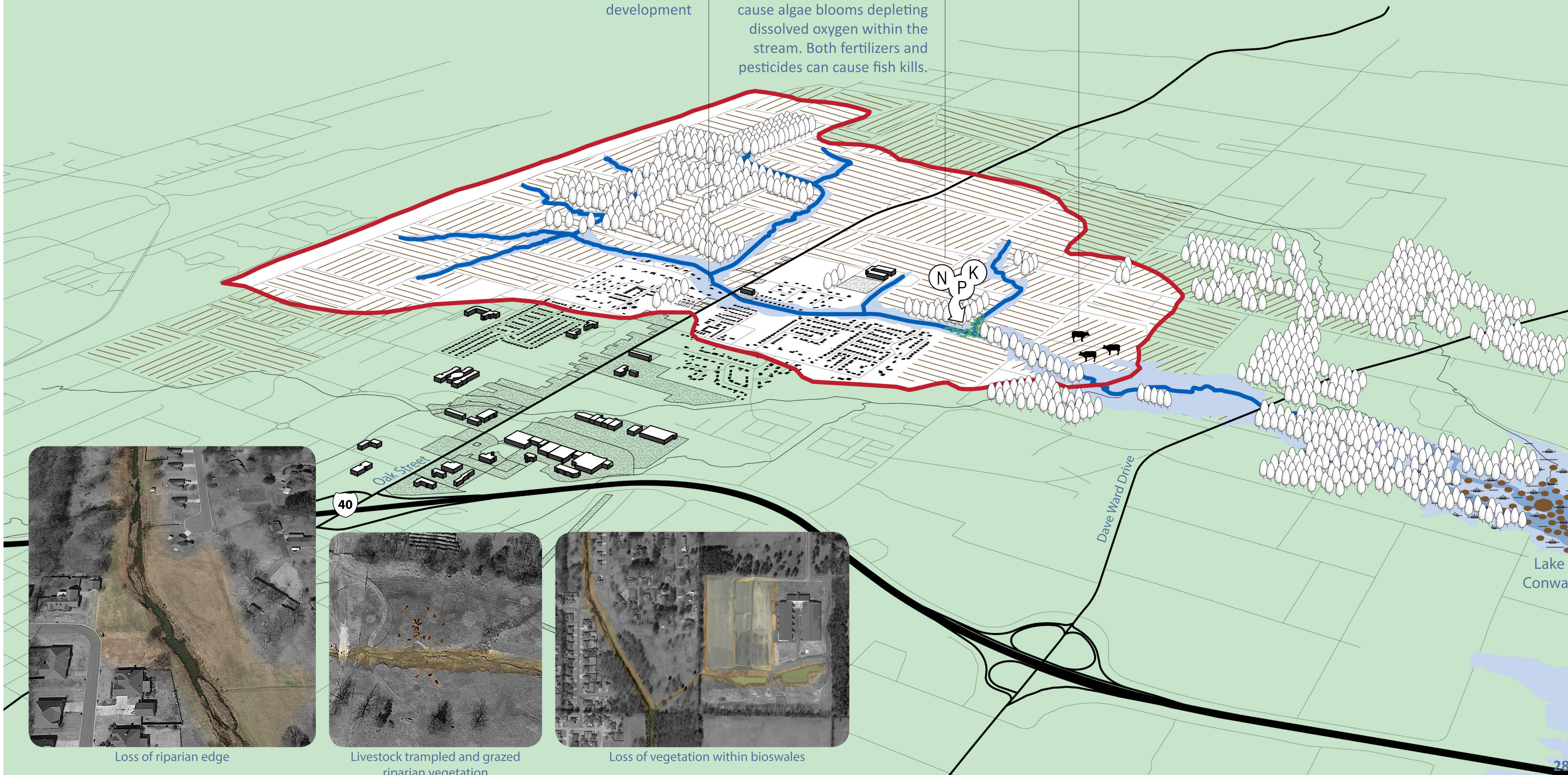
4 Little Creek Tributary Problemscape

Flowing through primarily agricultural land uses and low-density residential development, this riparian corridor suffers from loss of functioning riparian edges due to land use encroachments on the stream system.

1 Loss of floodplain by residential and agricultural encroachment
Floodplains deliver a high rate of ecological services and are usually the first riparian elements eliminated by encroaching development

2 Agricultural Chemical inputs
Runoff from agricultural chemicals can adversely affect aquatic and wildlife habitat. Fertilizers (NPK) can cause algae blooms depleting dissolved oxygen within the stream. Both fertilizers and pesticides can cause fish kills.

3 Livestock adjacent to stream
Results in animal waste migration to the stream and destruction of the riparian edge from grazing and trampling.



Loss of riparian edge

Livestock trampled and grazed riparian vegetation

Loss of vegetation within bioswales

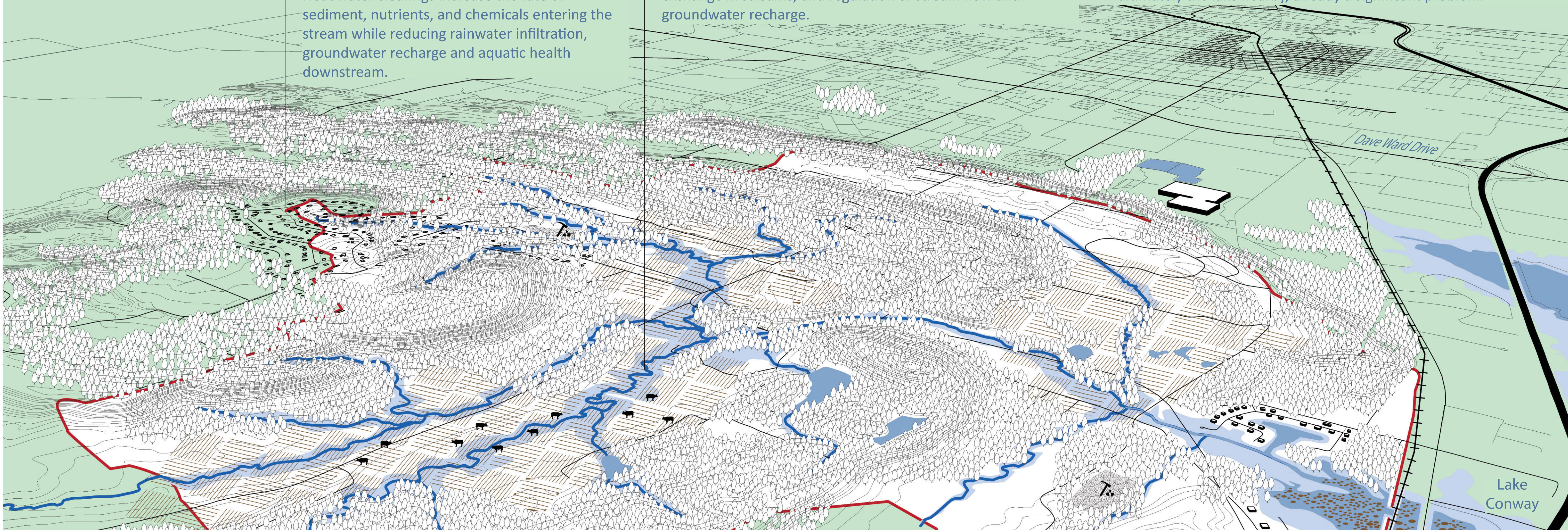
5 Gold Creek Problemscape

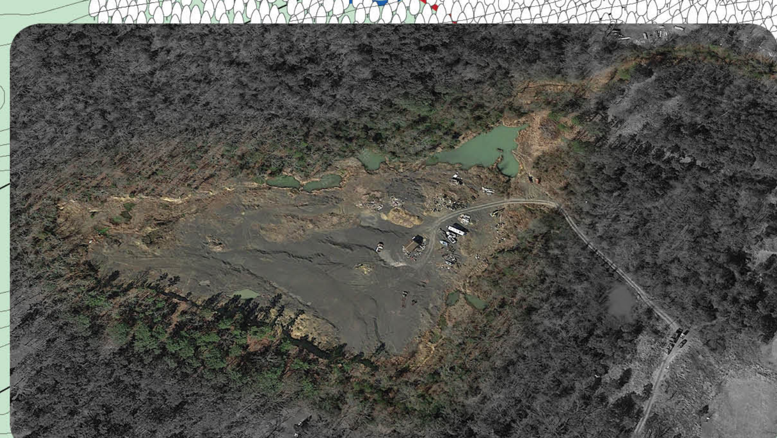
Flowing down a primarily forested hilltop, this riparian corridor has experienced encroachment from agricultural and residential land uses on the stream system.

1 Residential development that clear cuts vegetation from headwaters
Headwater clearings increase the rate of sediment, nutrients, and chemicals entering the stream while reducing rainwater infiltration, groundwater recharge and aquatic health downstream.

2 Elimination of riparian edge vegetation for pastures
Clearings eliminate shaded buffers important to enzymatic exchange in streams, and regulation of stream flow and groundwater recharge.

3 Gravel mining and erosion adjacent to stream
Unvegetated corridors increase sediment loading of the stream and ultimately the lake nearby, already a significant problem.





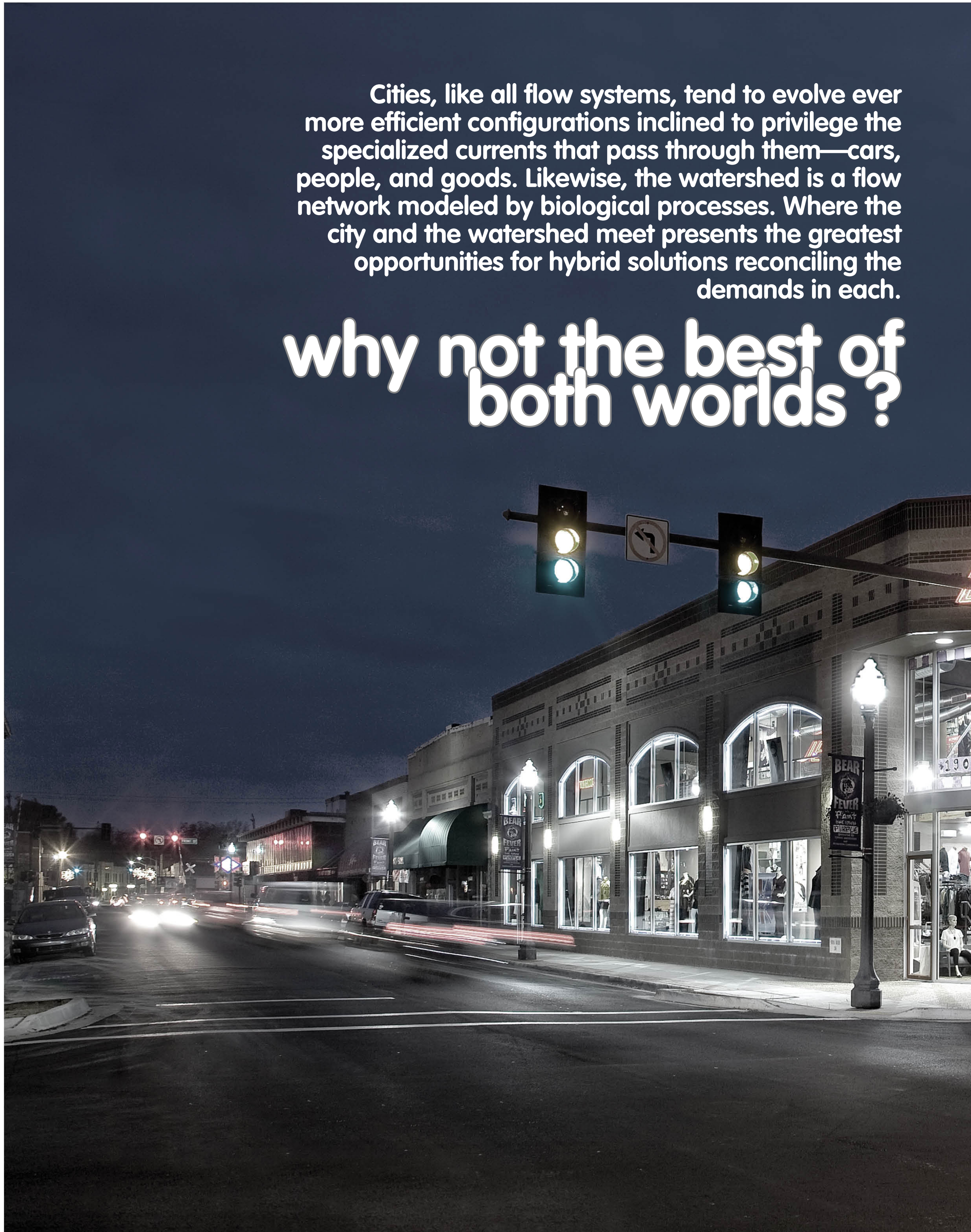
Mining within watershed threatens water quality due to erosion and pollutants

Loss of riparian edge causes direct nutrient and chemical input from fertilizers and pesticides

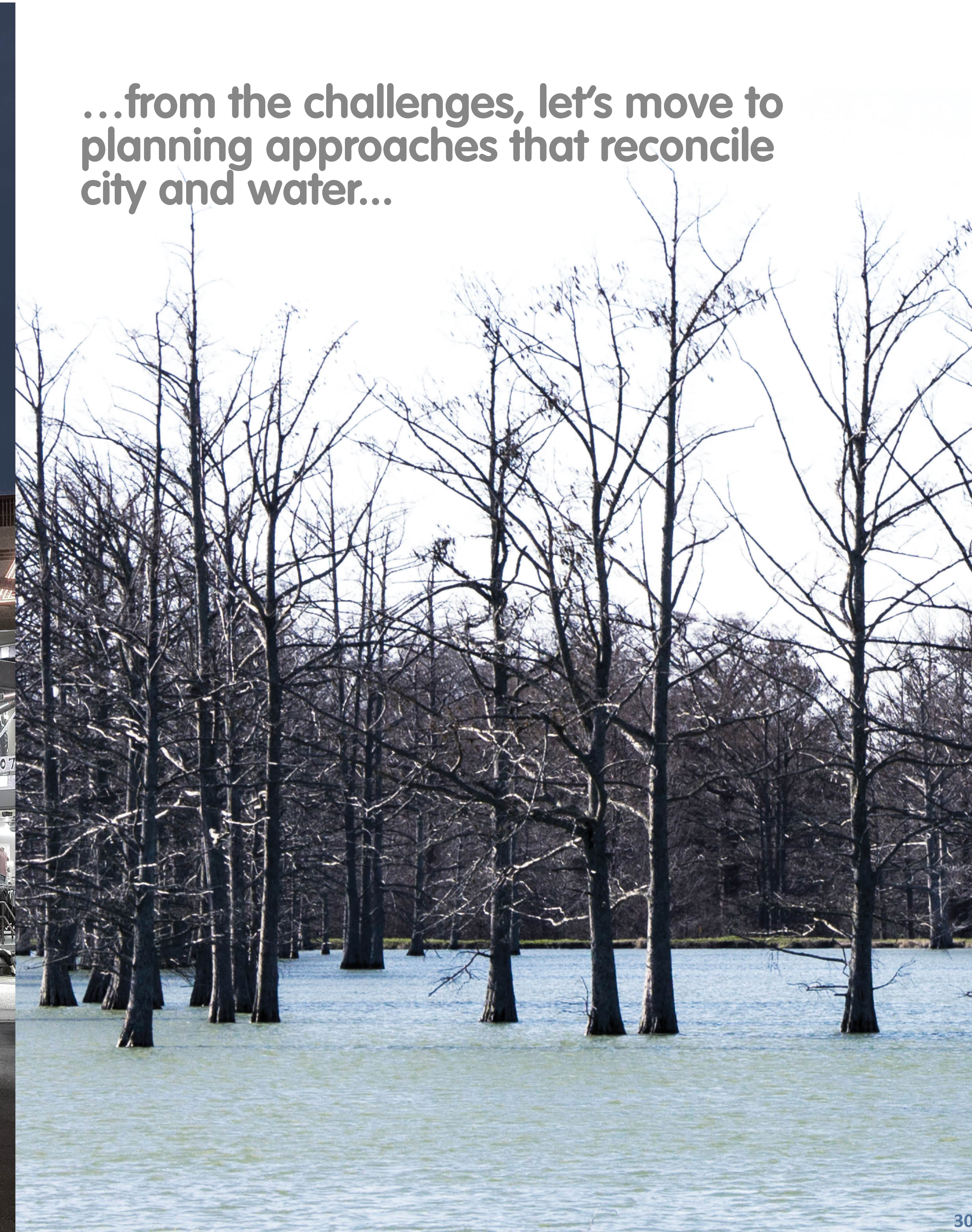
Loss of riparian vegetation results in sediments and pollutants directly entering the stream

Cities, like all flow systems, tend to evolve ever more efficient configurations inclined to privilege the specialized currents that pass through them—cars, people, and goods. Likewise, the watershed is a flow network modeled by biological processes. Where the city and the watershed meet presents the greatest opportunities for hybrid solutions reconciling the demands in each.

why not the best of both worlds ?

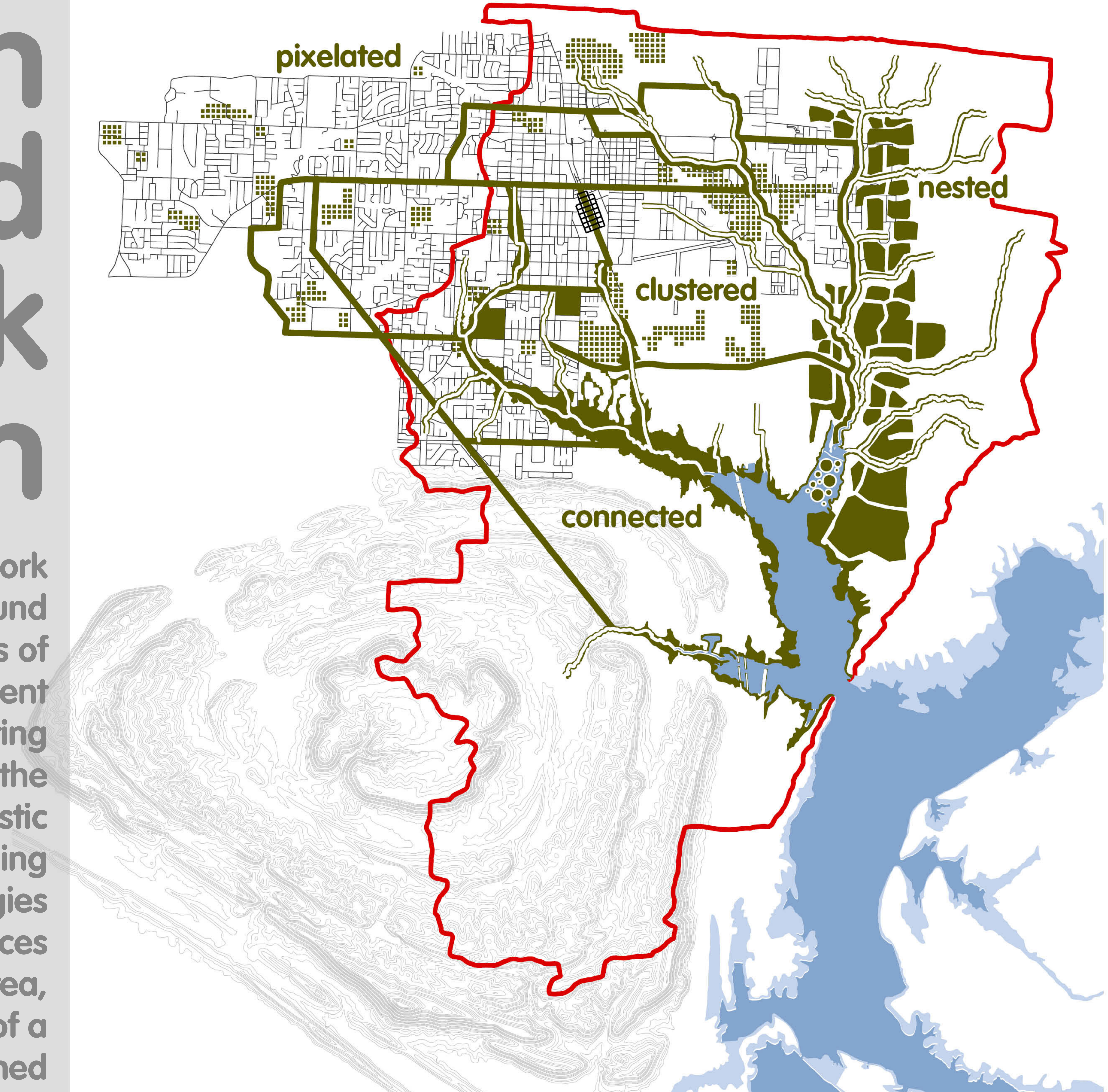


…from the challenges, let's move to planning approaches that reconcile city and water...



Urban Watershed Framework Plan

How can city form fix the watershed? Because the Framework Plan should not be prescriptive, the plan is structured around likely interface possibilities within each of the four levels of interaction between city and water—see Sponge City Gradient (in Executive Summary). The plan is modular, facilitating incremental implementation by various stakeholders across the sub-watershed, in the interest of eventually building a holistic framework. The challenge for stakeholders involves matching land use opportunities with the right Framework Plan strategies responsive to pixilated, nested, clustered, or connected interfaces between city and water. Every part of the urbanized area, including downtown, has a role to play in the creation of a green cityscape with good water quality and healthy watershed functioning.



cities are discrete,
whereas nature is continuous

Framework Plan: Adaptive Infrastructure

Lake Restoration 1
Enhancement of lake ecology requires tactical operations to normalize sediment and water flows at the edge, on the surface, and within the lake.

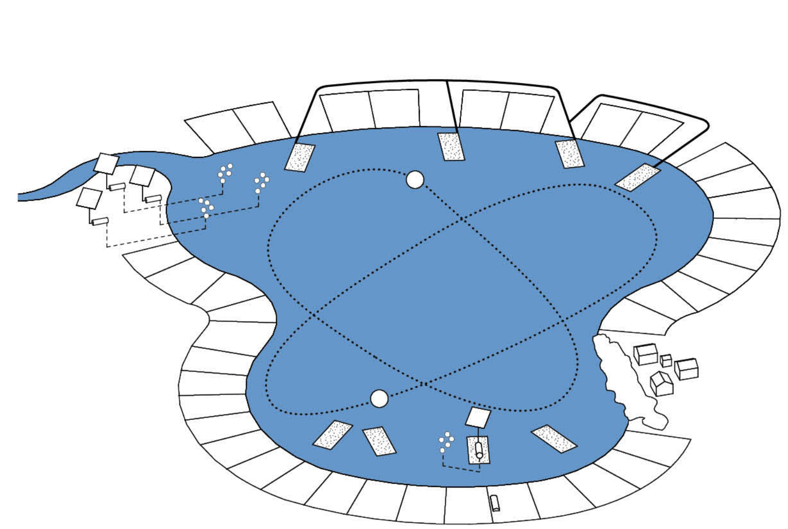
Green Streets and Parks 2
Streets and parks can be designed to deliver ecological services through alternative right-of-way configurations and landscape technologies embedded in street design. These strategies can be scaled to various types of public space.

Parking Gardens 3
Employing functional water treatment landscapes, parking lots can be designed to metabolize their own pollution generated by stormwater runoff and hydrocarbons from automobiles.

Urban Eco-Farm 4
As generators of nutrient overloads discharged to streams, farms can be designed to upcycle their outputs, eliminating the concept of waste in favor of higher economic returns and energy efficiencies.

Conservation Development 5
Conservation development is premised on clustered patterns of housing, infrastructure, and landscape to create unique neighborhoods of high vitality and interest, assembled from commonplace neighborhood components.

City Greenway 6
Incorporating both streams and street networks, greenway segments—or loops—form a third flow system delivering urban and ecological services scaled to neighborhoods.



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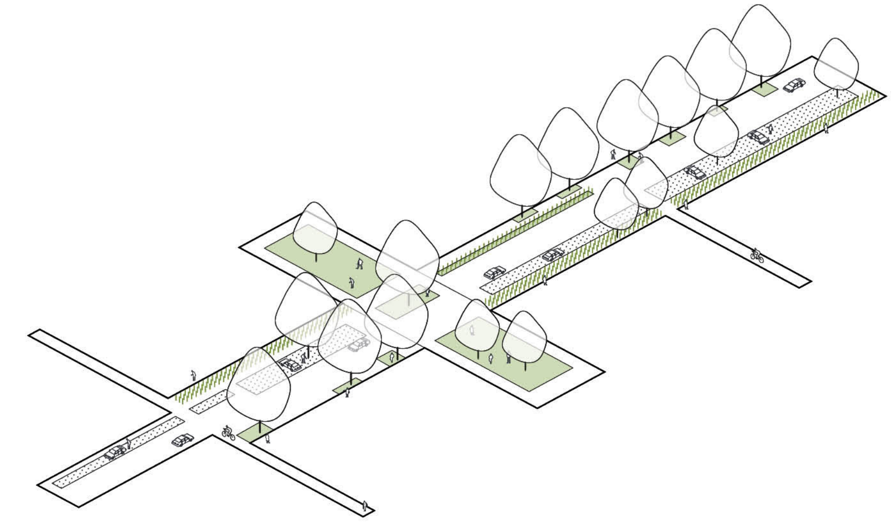

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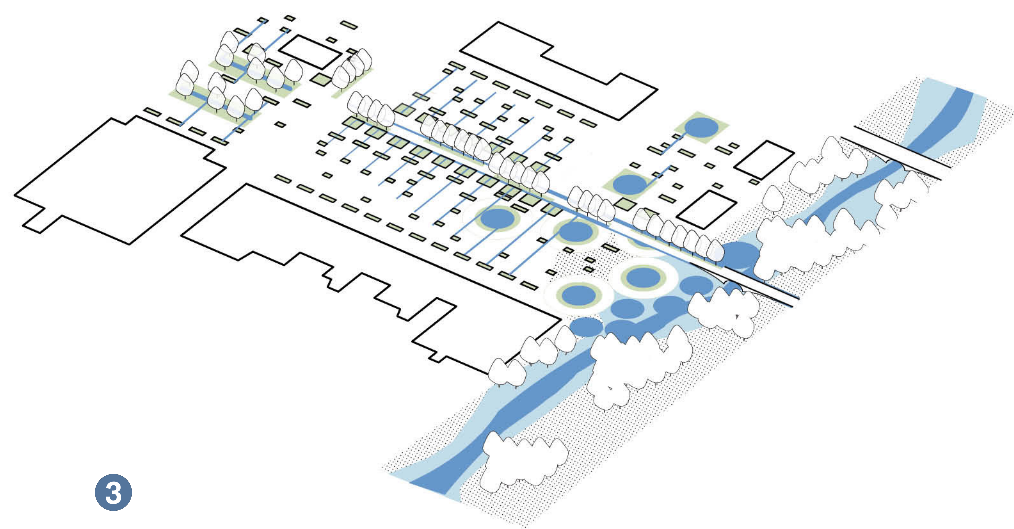

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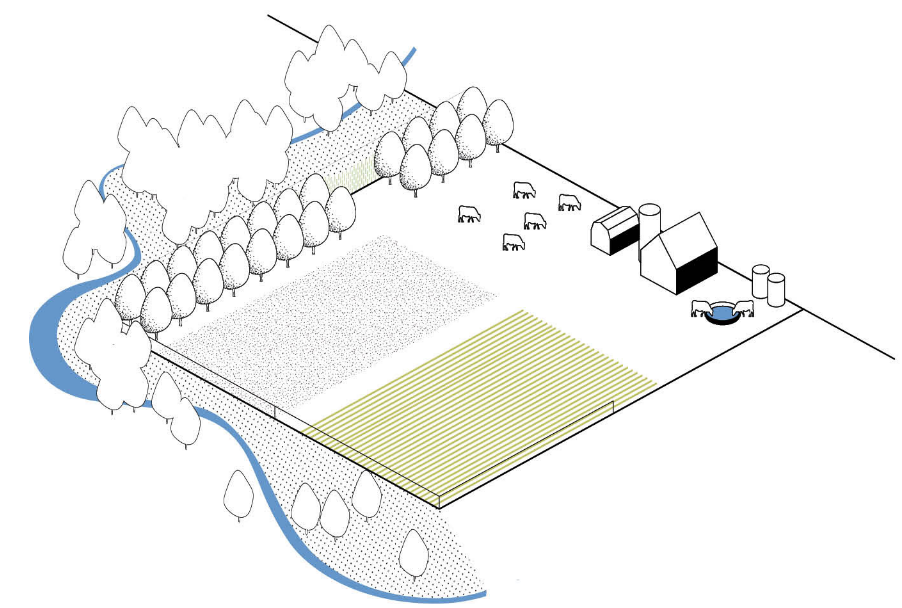

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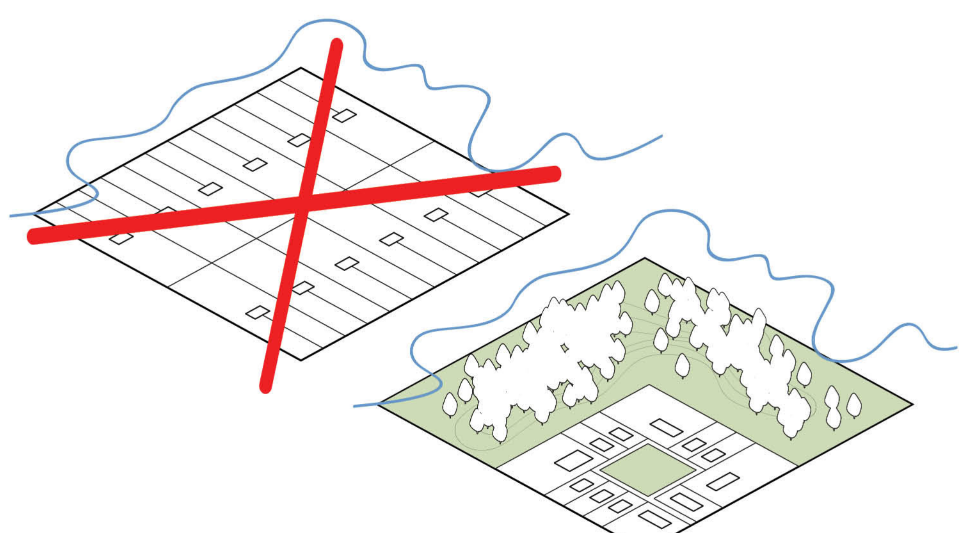

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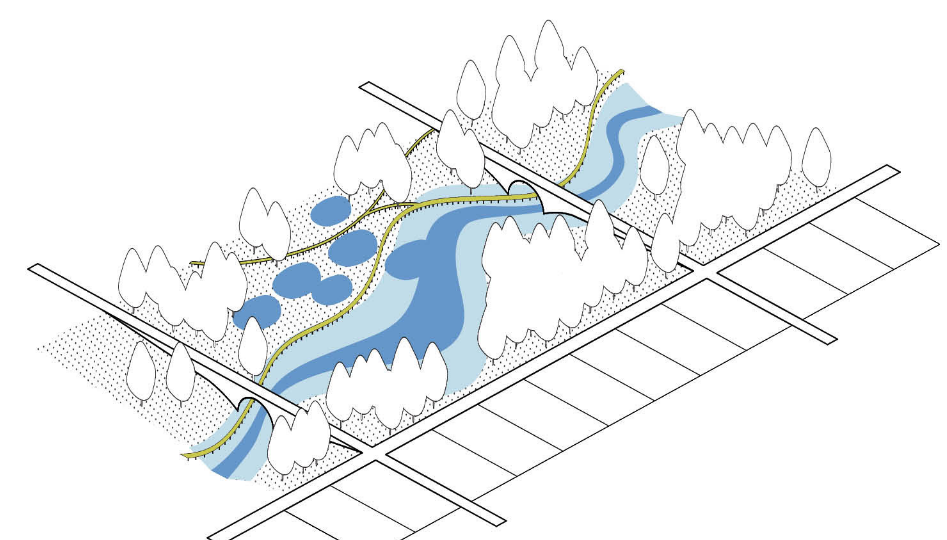

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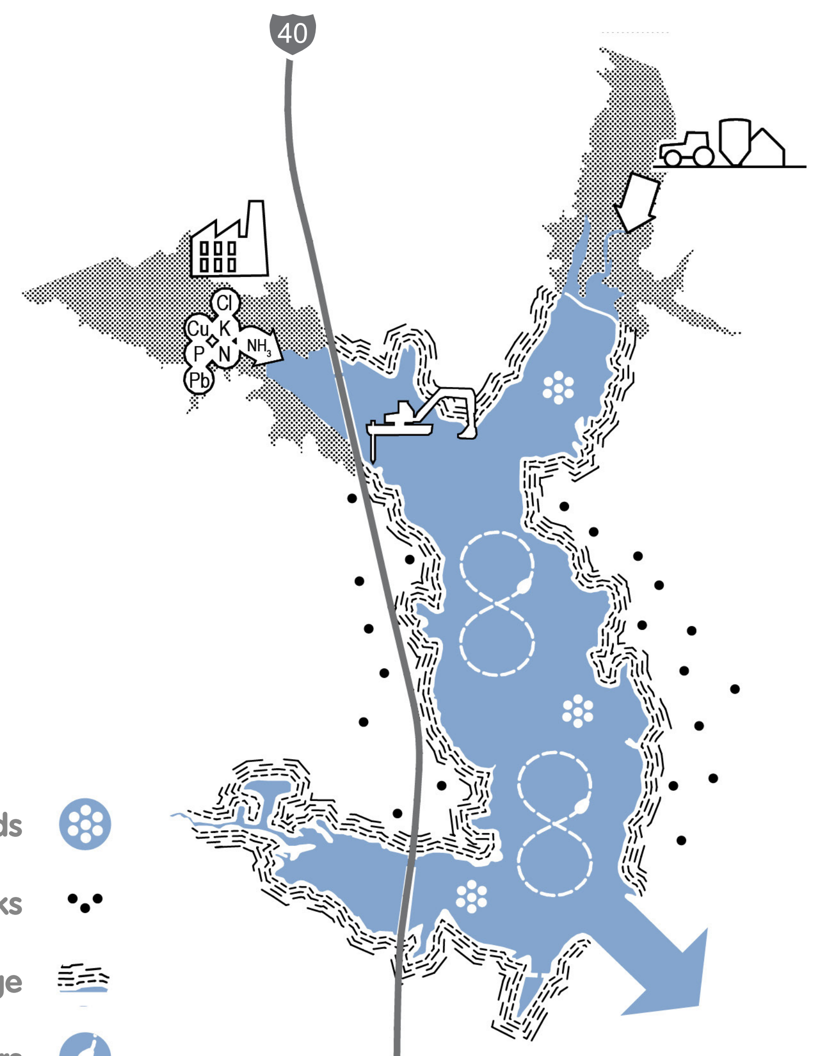
let's begin exploration of the plan by re-imagining lake conway

Lakes and reservoirs are quasi-closed energy systems requiring a continual influx of nutrients. However, Lake Conway has been excessively enriched with sediments and nutrients due to human activities and requires ecologically-based interventions to reclaim a more balanced relationship with its headwaters.

1 Lake Restoration



Floating Wetland Islands

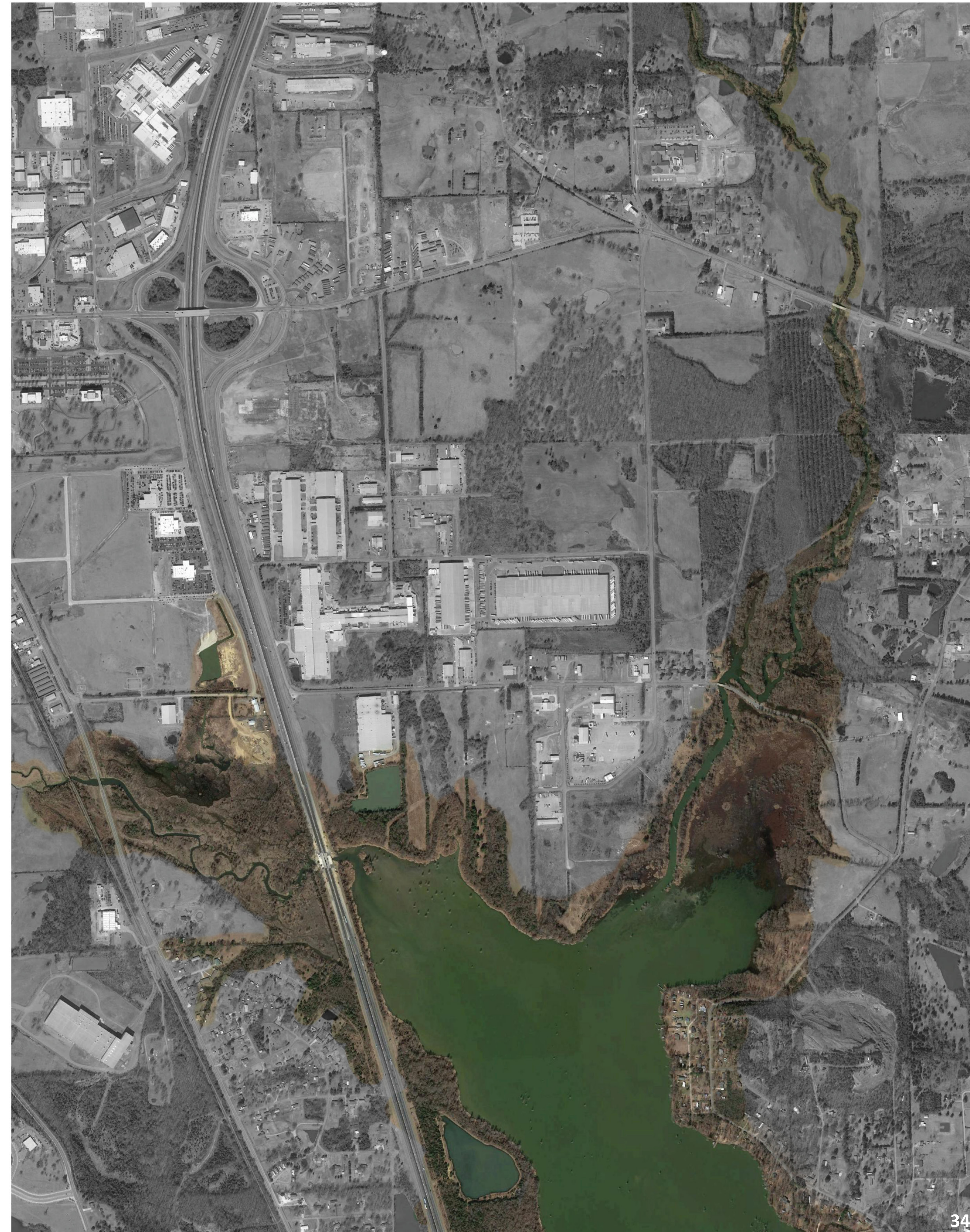
Retrofitted Septic Tanks

Revegetated Edge

Surface Aerators/Solar Harvesters

Dredging

Restored Wetlands



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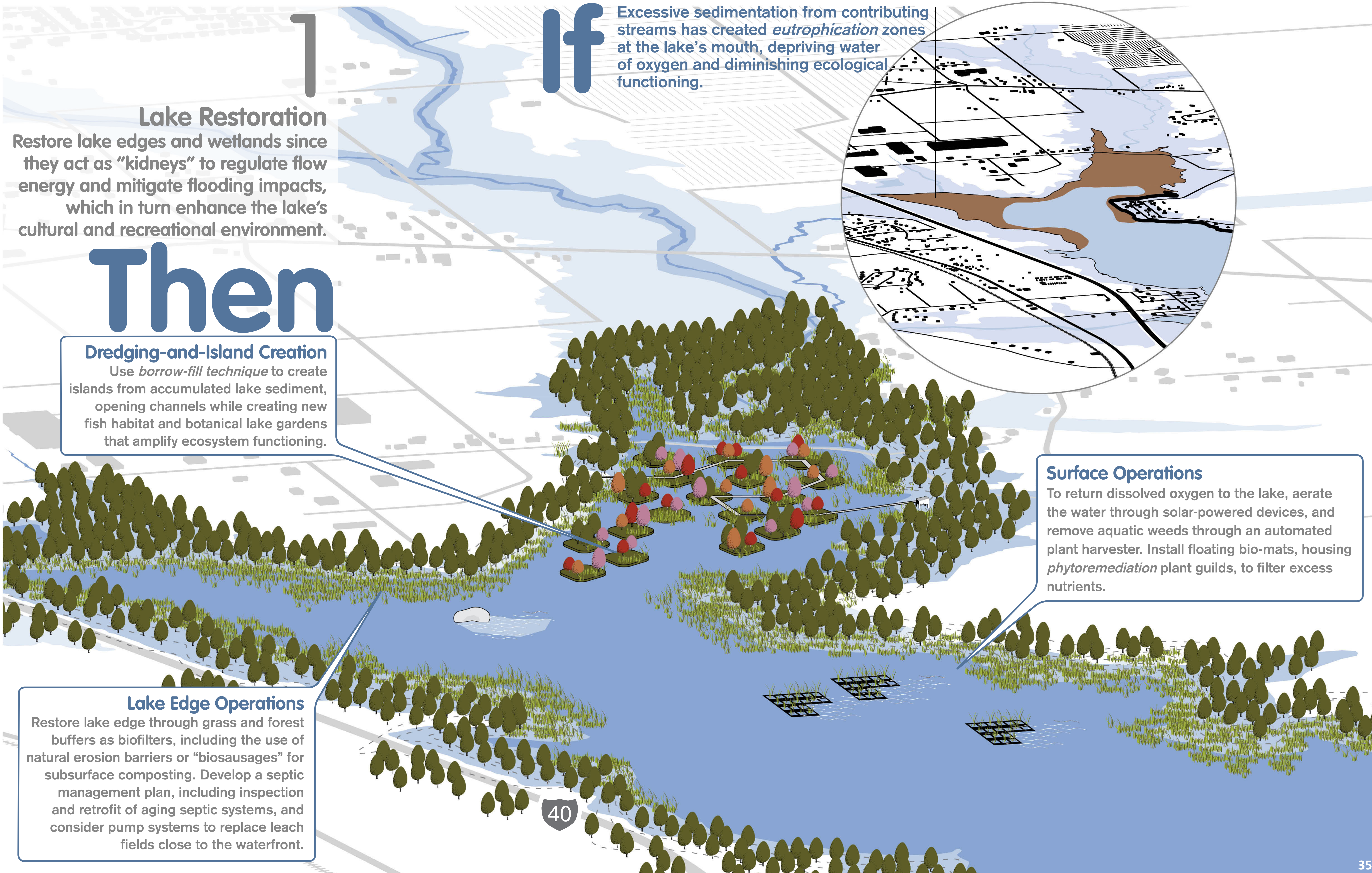
Lake Restoration

Restore lake edges and wetlands since they act as "kidneys" to regulate flow energy and mitigate flooding impacts, which in turn enhance the lake's cultural and recreational environment.

If

Excessive sedimentation from contributing streams has created *eutrophication* zones at the lake's mouth, depriving water of oxygen and diminishing ecological functioning.

Then



Dredging-and-Island Creation

Use *borrow-fill technique* to create islands from accumulated lake sediment, opening channels while creating new fish habitat and botanical lake gardens that amplify ecosystem functioning.

Surface Operations

To return dissolved oxygen to the lake, aerate the water through solar-powered devices, and remove aquatic weeds through an automated plant harvester. Install floating bio-mats, housing *phytoremediation* plant guilds, to filter excess nutrients.

Lake Edge Operations

Restore lake edge through grass and forest buffers as biofilters, including the use of natural erosion barriers or "biosausages" for subsurface composting. Develop a septic management plan, including inspection and retrofit of aging septic systems, and consider pump systems to replace leach fields close to the waterfront.

1

Lake Restoration

Restored Riparian Corridor 1
Improve riparian stream buffers to slow and filter stormwater runoff.

Dredging + Wetland Island Formations 2
Form islands from selective dredging and stockpiling lake bottom sediment.

Restored Wetland Habitat 3
Improve wetlands to filter, purify, and store water.

Retrofitted Septic Tanks 4
Incent remediation of aging septic systems.

Solar Weed Harvester Aquabot 5
Employ aquabots to remove excessive or invasive lake vegetation, "underwater lawn mowers."

Floating Bio-Mats 6
Use treatment facilities that provide aquatic, bird, and animal habitat with microbial communities that metabolize excess nutrients.

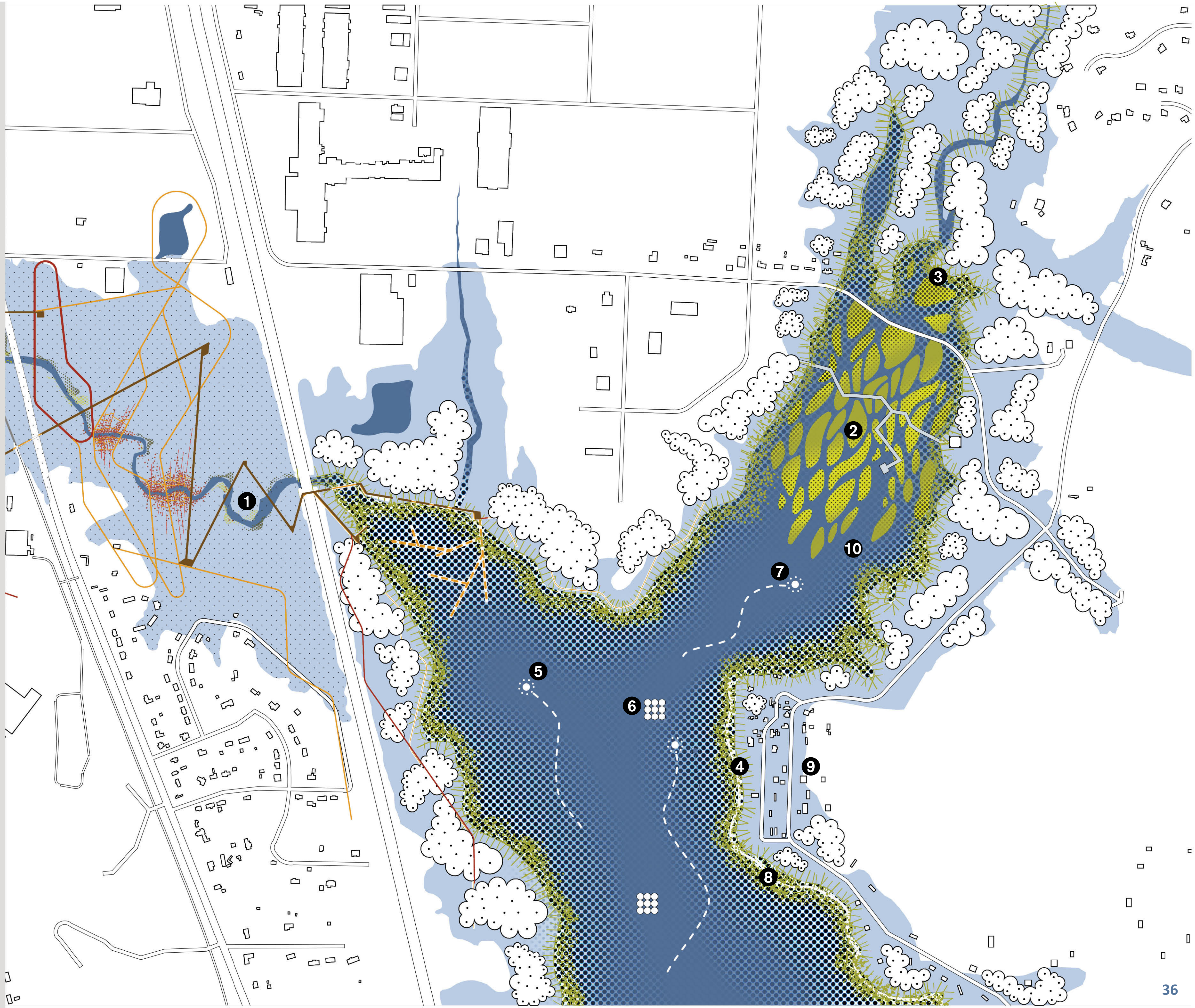
Solar Aeration Aquabot 7
Use aquabots that increase oxygenation in water, enhancing aquatic habitat.

Removal of Concrete Walls 8
Reestablish the natural stream bank and ecological functioning.

Community Waste Water Treatment Plant 9
Consider the role of small Community Centralized Cluster systems for collective septic services.

Native Mussels 10
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli, and to consume algae.

0 .25 .5 miles



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Lake Restoration Tools:

Solar Weed Harvester Aquabot

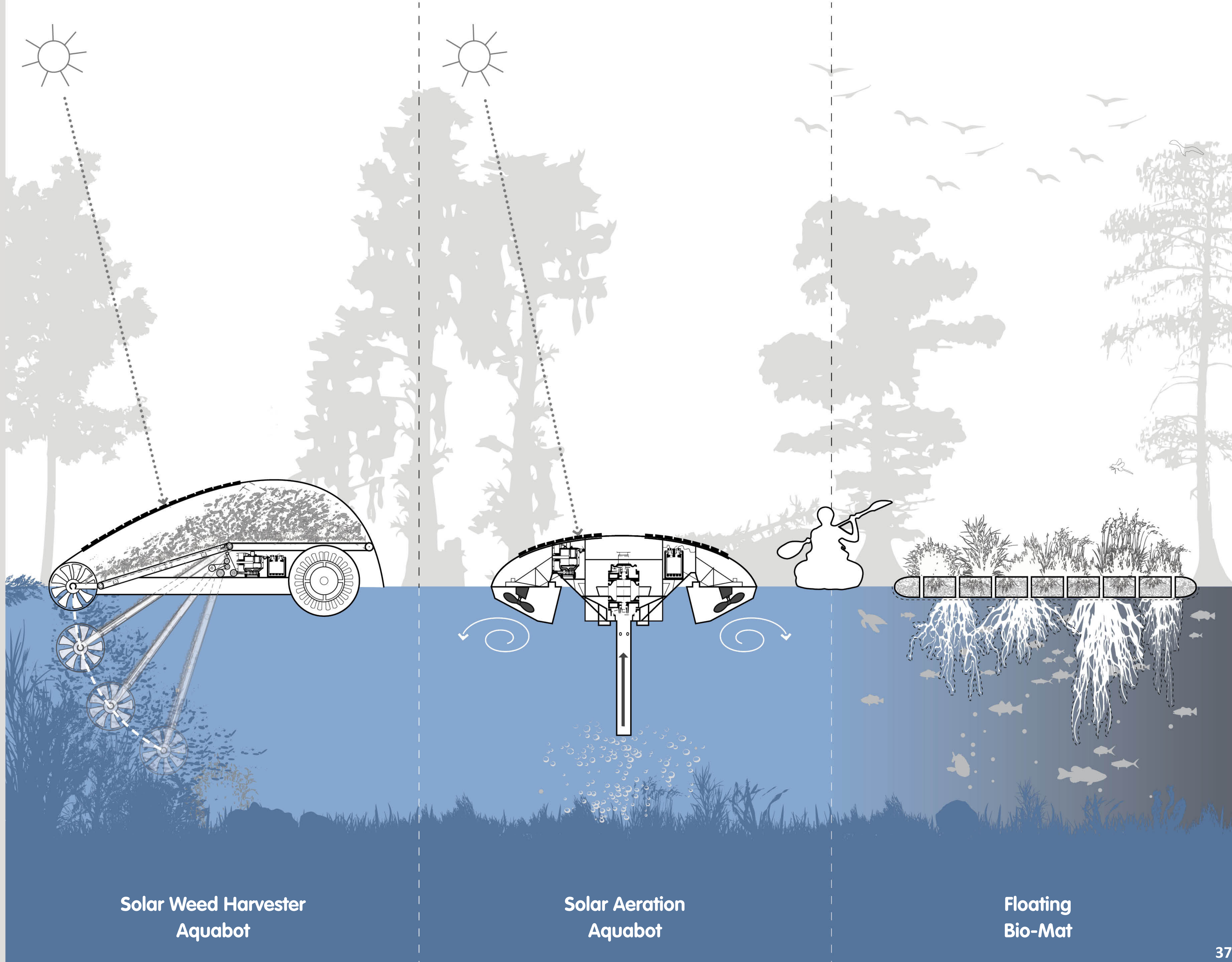
The harvester gathers floating debris and algae, while functioning as an underwater lawnmower uprooting, mulching, and transporting lake bottom vegetation for removal. This curbs the need for spraying herbicides within the lake. The self-automated stainless steel harvester floats like a boat and is propelled by a paddle wheel and solar powered engine with the capability of operating in as low as 12" of water.

Solar Aeration Aquabot

The "Solar Bee" is a solar powered aerator that mixes oxygen-rich water from the top of the lake with oxygen-depleted water from the bottom of the lake. A system of paddles both mixes water and propels the device around the lake. The Solar Bee also helps control lake odor.

Floating Bio-Mat

The mat is a hydroponic system that functions as a concentrated wetland habitat. It is composed of natural coir (coconut husk fiber) and a peat matrix planted with native wetland vegetation. Emergent vegetation serves as wildlife habitat for birds, insects, and amphibians while providing fish habitat supported by a rich layer of bio-film, and micro-organism colonies in association with plant roots below. Microbes and roots metabolize nutrients and chemical pollutants. These mats are suitable for phytoremediation application uses in streams, wetlands, and lake environments.



The 17 Ecosystem Services

Ecosystem services are the flow of energy, materials, and information from natural systems that support human life. The 2006 *Millennium Ecosystem Assessment* distinguishes four categories of ecosystem services—**provisioning, regulating, supporting,** and **cultural**. Supporting services underpin the services delivered in the other three categories. Since the quality of ecosystem services is tied to place and ecoregion functioning, it is imperative that urbanization processes ensure watershed integrity by enhancing ecosystem services.

Provisioning Services describe the material or energy production from ecosystems, including food, water, and other essential resources.

- food production
- raw material production
- water supply

Regulating Services describe the regulatory functions in maintaining healthy water, air, and soil as essential life support systems, including flood, climate, and disease control.

- atmosphere regulation
- climate regulation
- disturbance regulation
- water regulation
- erosion control
- species control
- waste treatment

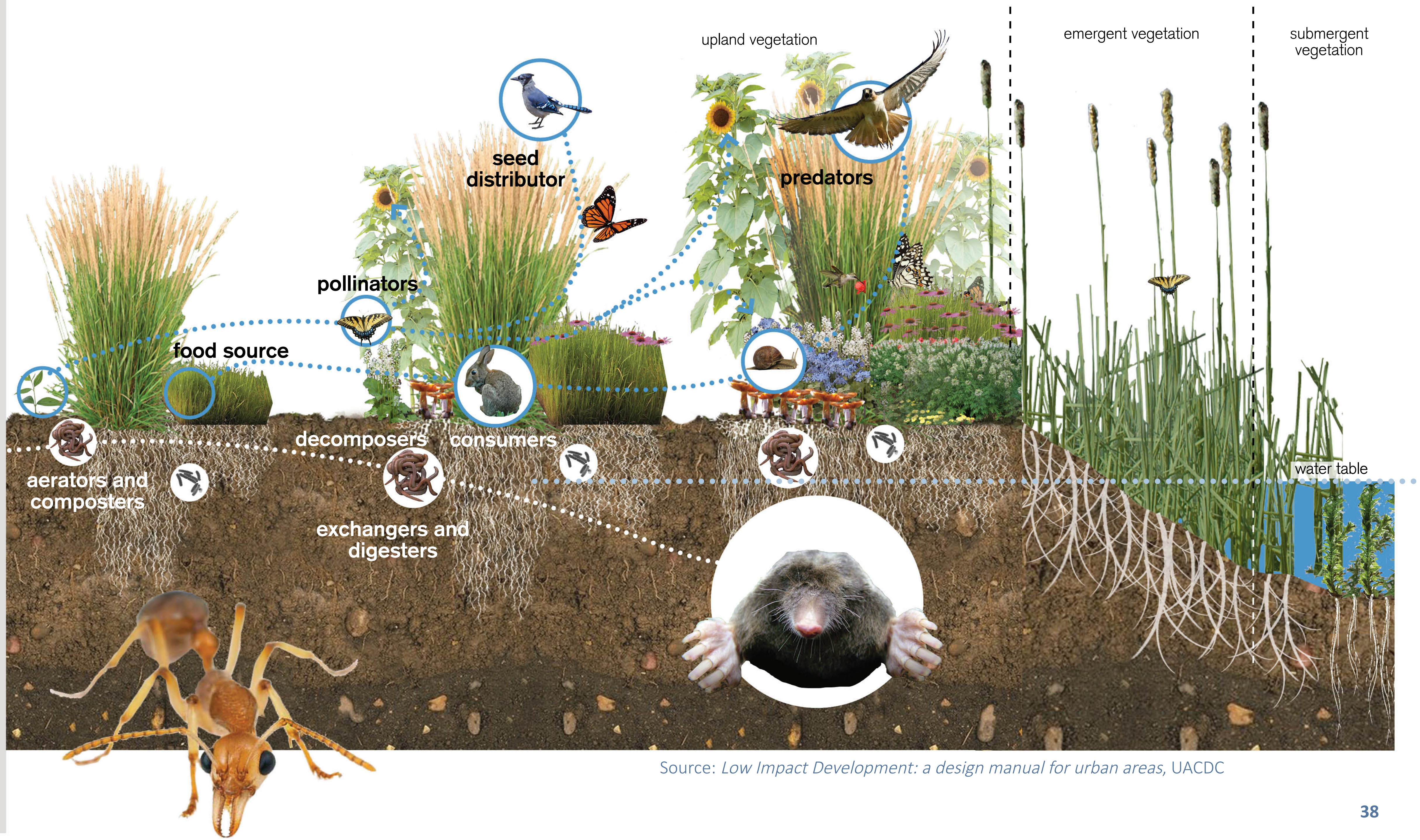
Supporting Services describe the functions necessary for the production of all other ecosystem services.

- refugia
- genetic resources
- pollination
- soil formation
- nutrient cycling

Cultural Services indicate a 'reference function' that supports human health, well being, and livability, as well as connection to place.

- recreation
- cultural enrichment

...a few thoughts on the formative role of ecosystem services in growing a city...



Source: *Low Impact Development: a design manual for urban areas,* UACDC

1

Lake Restoration: Island Creation

Lake Borrow-Fill Islands

are made from dredged nutrient-rich lake sediment to increase water clarity, providing a water quality **regulating service**, and a **supporting service** through addition of wildlife habitat and aquatic spawning areas. Reeds and grasses provide essential nesting areas.

Floating Bio-Mats

provide the **regulating services** of a wetland, including water treatment, as microbial communities concentrated in mat habitats—akin to reefs—metabolize chemicals and filter suspended solids.

Reintroduction of Endangered Mussels,

like the Rabbitsfoot Mussel, to clean water by metabolizing harmful bacteria—especially E. coli, an indicator of fecal contamination—a critical **regulating service,** while providing the **supporting service** of restoring endangered species.

Solar Aeration Aquabot

provides a water quality **regulating service** by balancing dissolved oxygen in low-flow water bodies, preventing build up of algae-dominant communities that eliminate aquatic life.

Solar Lake Vegetation Harvester

provides species control **regulating service** by removing algae, invasive or excessive *benthic* vegetation, curbing the need for spraying herbicides within the lake. Harvesting vegetation reduces excessive nutrient loads to improve water quality.

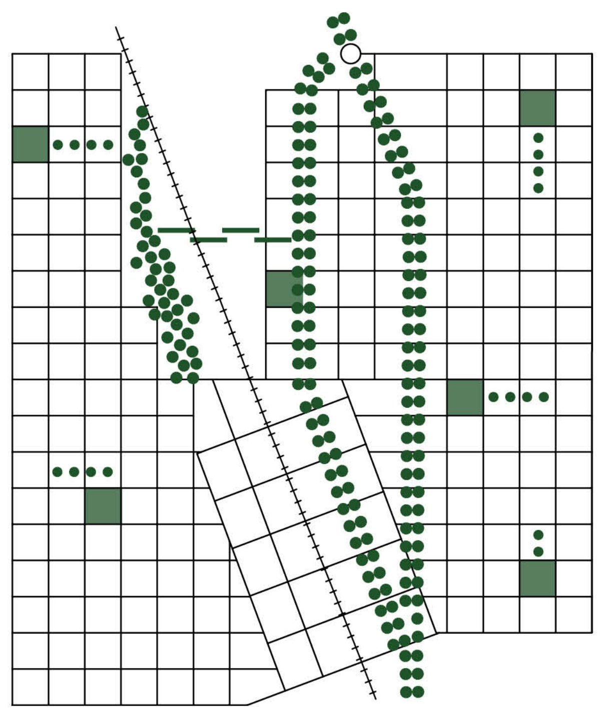
More cities are tasking urban infrastructure with regeneration of diminished ecosystems to support livable communities. Besides solving for urban water management problems like flooding, the collateral benefits of implementing the Framework Plan include greater livability, sustained economic development, improved community resilience to disruption and shocks, and exemplary beauty in the civic realm that creates enduring value and symbolism.

let's shift exploration of the plan to downtown—where ecology and economy intersect

downtown Conway

All public right-of-ways and open spaces should offer water management functions as part of their public utility. As in all "great streets", non-traffic services related to ecological and social functioning can be reclaimed to make great places.

2 Green Streets and Parks



Downtown Green Loop

Shared Green Street

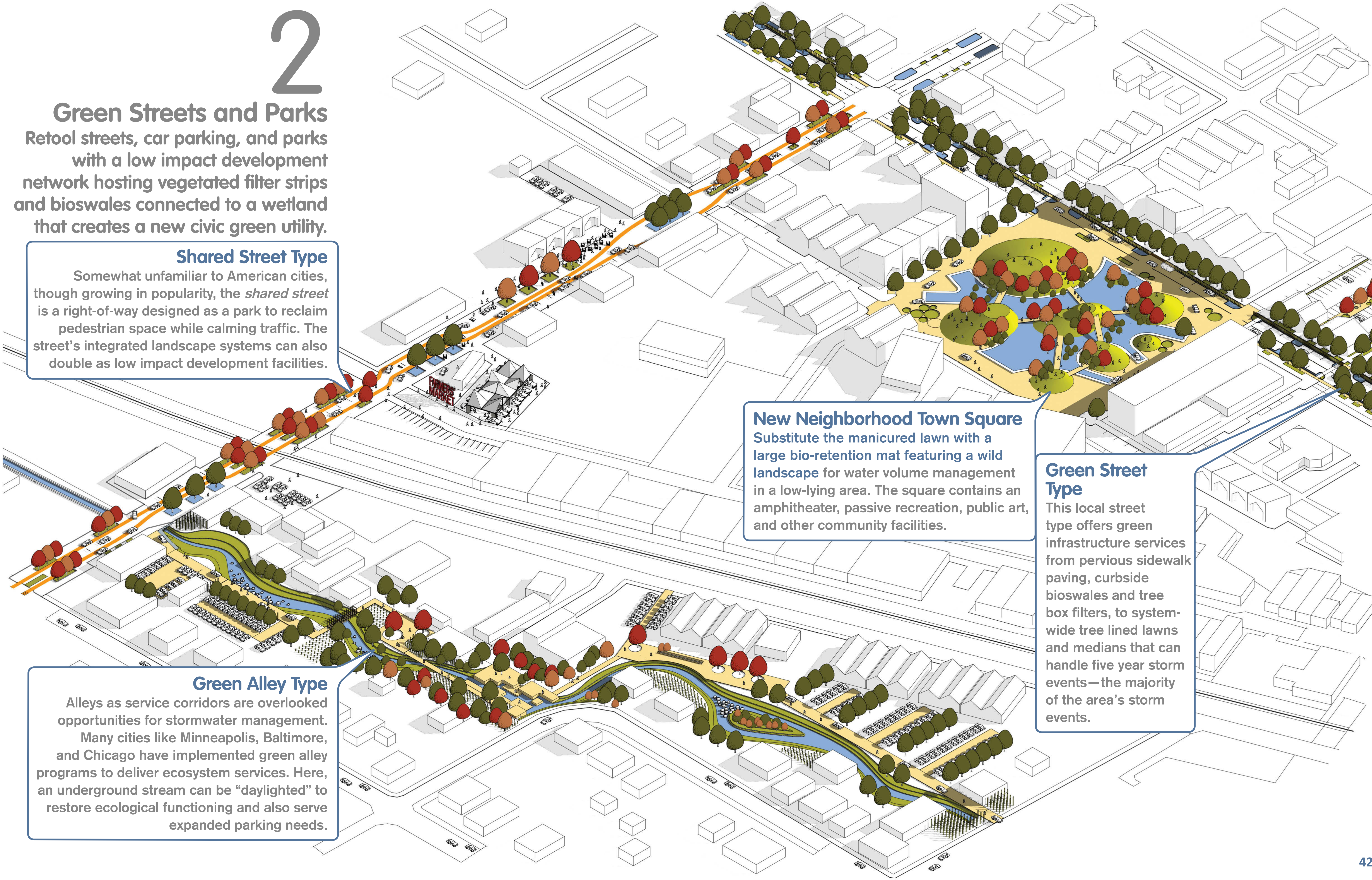
Green Alley

Neighborhood Parks

2

Green Streets and Parks

Retool streets, car parking, and parks with a low impact development network hosting vegetated filter strips and bioswales connected to a wetland that creates a new civic green utility.



Shared Street Type

Somewhat unfamiliar to American cities, though growing in popularity, the *shared street* is a right-of-way designed as a park to reclaim pedestrian space while calming traffic. The street's integrated landscape systems can also double as low impact development facilities.

New Neighborhood Town Square

Substitute the manicured lawn with a large bio-retention mat featuring a wild landscape for water volume management in a low-lying area. The square contains an amphitheater, passive recreation, public art, and other community facilities.

Green Street Type

This local street type offers green infrastructure services from pervious sidewalk paving, curbside bioswales and tree box filters, to system-wide tree lined lawns and medians that can handle five year storm events—the majority of the area's storm events.

Green Alley Type

Alleys as service corridors are overlooked opportunities for stormwater management. Many cities like Minneapolis, Baltimore, and Chicago have implemented green alley programs to deliver ecosystem services. Here, an underground stream can be "daylighted" to restore ecological functioning and also serve expanded parking needs.

2A

Green Streets and Parks: Markham Town Square

Wetland Town Square 1
Reformat the conventional town square to become both urban park and water treatment facility.

Rain Gardens 2
Use small bioswales designed to manage stormwater runoff by filtering sediment and pollutants.

Bio-Retention Mat 3
Incorporate a wetland landscape designed to manage stormwater runoff, mostly through retention.

Green Street 4
Build streets with low impact development facilities, to treat stormwater runoff, provide shade and habitat, and to purify air.

Evapotranspiring Tree Bosques 5
Employ groves of deep-rooting trees to uptake large amounts of water for transpiration.

Living Bridge 6
Use vegetated bridges with phytoremediating and flowering plants, allowing pedestrian access to mounds as well as providing ecosystem services.

Multi-programmatic Mounds (Pumping Water, Recreational, Habitat) 7
Design vegetated mounds as green spaces for recreational activities while absorbing and transpiring stormwater runoff through tree bosques.

0 60′ 120′

2A

Green Streets and Parks: Markham Town Square

Phreatophytic Bosques

are water-loving, deep-rooted trees (e.g., Cottonwoods, Poplars, Willows, etc.) that provide flow **regulating services** by pumping, storing, and evapotranspiring groundwater where a high water table limits runoff retention. An acre of these trees can pump more than a million gallons of water annually.

Underground Filtration Basins

are rock-filled trenches with bio-films beneath porous pavement that filter sediment and infiltrate stormwater runoff providing water **regulating services** in streets.

2A
Green Streets and Parks: Markham Town Square

Town Square as a Rain Terrain
Rain terrains are green infrastructure based on holding water versus *riparian corridors* based on drainage. Rain terrains prevent uncontrolled flooding in urbanized areas by managing overflow, and attenuating peak flows to streams that cause downstream flooding after rainfall.

Bio-Retention Mat
holds floodwater during large scale rain events providing a **regulating service** as well as retaining civic functions despite flood events.

2A

Green Streets and Parks: Markham Town Square

Reedy Plant Guilds
tolerate inundation, thrive in hydric soils, and are ideal for erosion and water flow control in providing **regulating services**, while offering **supporting services** through land-water nutrient cycling and refugia provisioning.

Living Bridge
akin to a "living wall", supports a vegetated wire mesh of pollinating plant guilds that offer **supporting services**, and **provisioning services** if edible plant guilds are used.

2A

Green Streets and Parks: Markham Town Square

Infiltration Mounds

filled with moss-lined rock and/or structural soil with high porosity provide **regulating services** through stormwater runoff infiltration, treatment, and storage in a flood-prone area of the city with a high water table.

2B

Green Streets and Parks: Shared Street Type

Rain Gardens 1
Incorporate small bioswales designed to manage stormwater runoff by filtering sediment and pollutants.

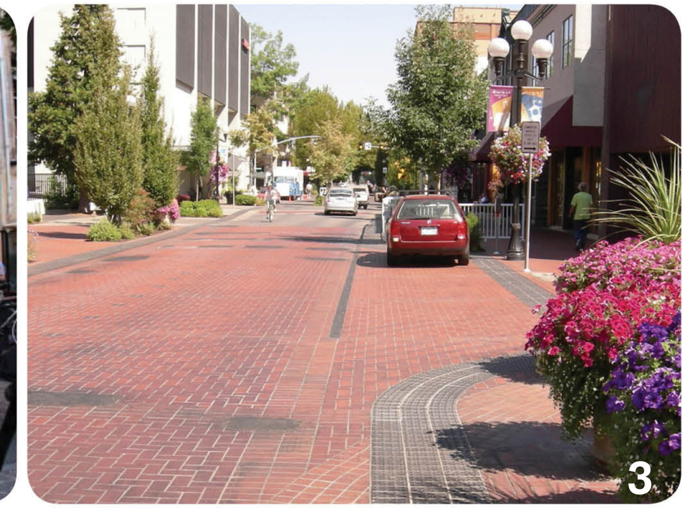
Pervious Paving 2
Design pavement to allow water infiltration for groundwater recharge.

Evapotranspiring Tree Bosques 3
Use groves of deep-rooting trees to uptake large amounts of water for transpiration. Trees mitigate heat island effect and lower ambient summer temperatures.

1 Fayetteville, AR
2 Paris, France
3 Eugene, OR
4 Amsterdam, Netherlands
5 Tokyo, Japan

Streets as economic enhancers

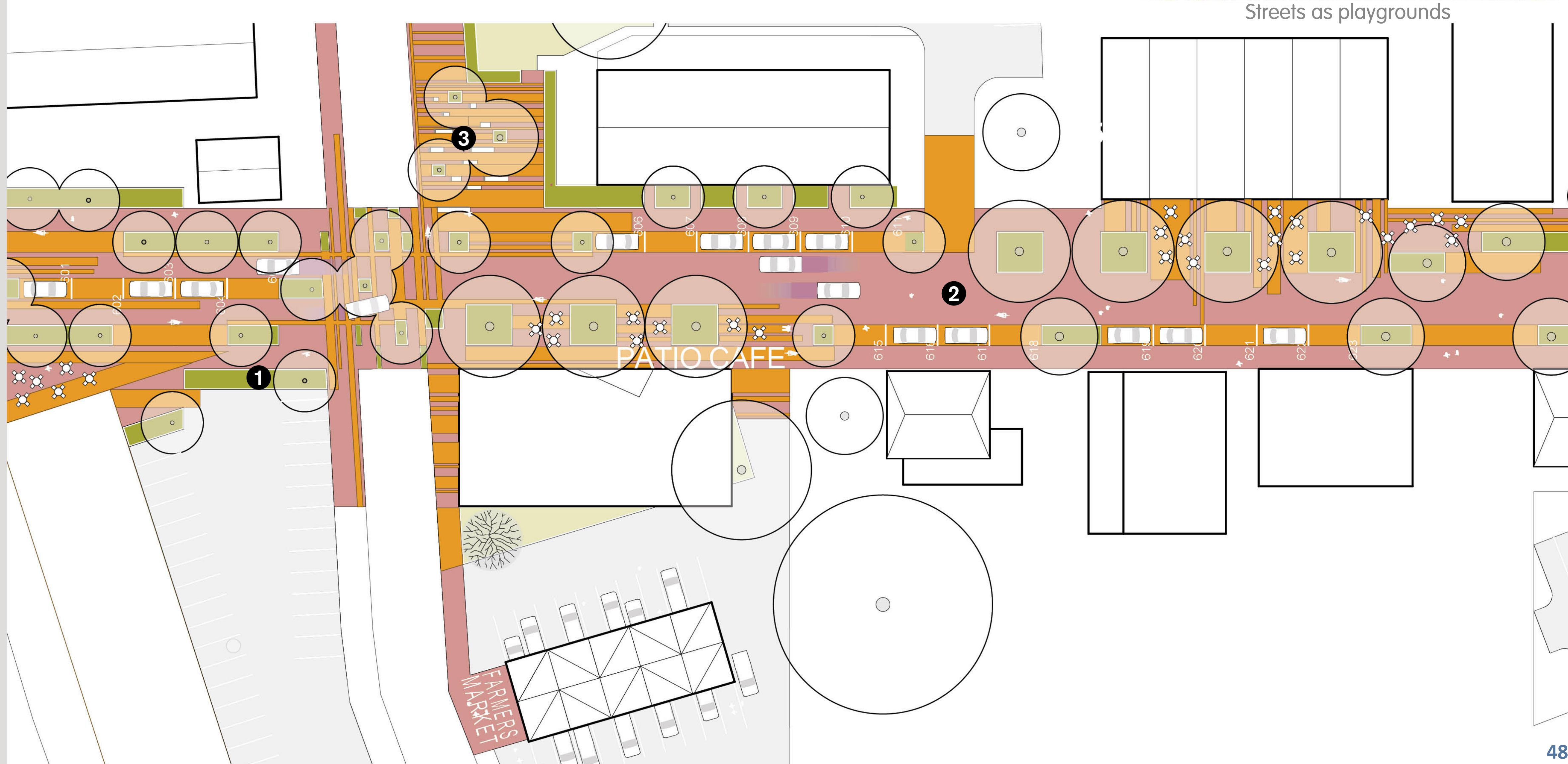
Streets as places for hanging out



Streets as ecological assets

Streets as multi-modal facilities

Streets as playgrounds



0 60' 120'

2C

Green Streets and Parks: Green Alley Type

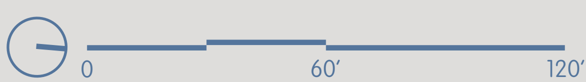
Restore Stream Sinuosity 1
When feasible, reclaim the stream's riffle-pool-glide natural algorithm.

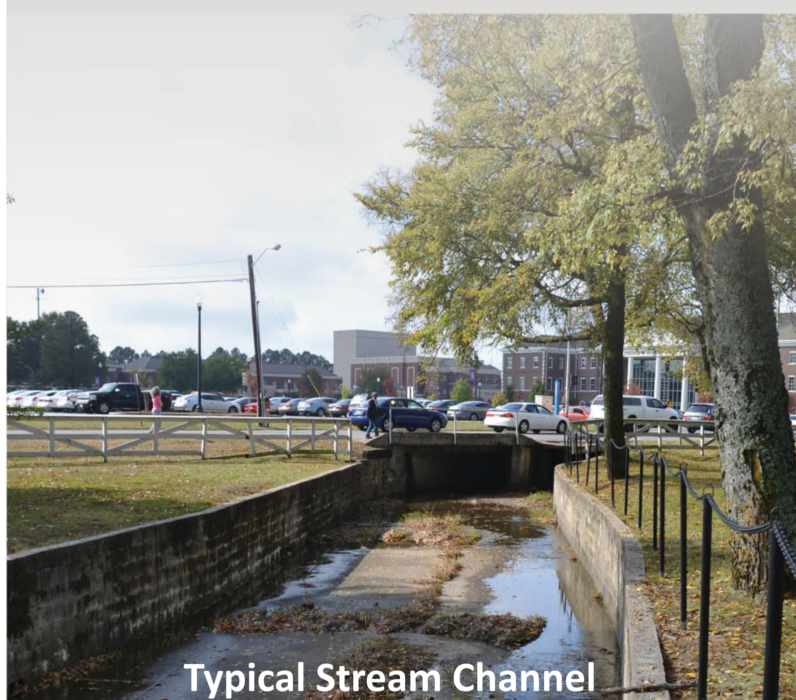
Daylighting/Deconcretizing Stream 2
Uncover piped streams and remove conveyance structures to restore natural stream sinuosity and riparian vegetation.

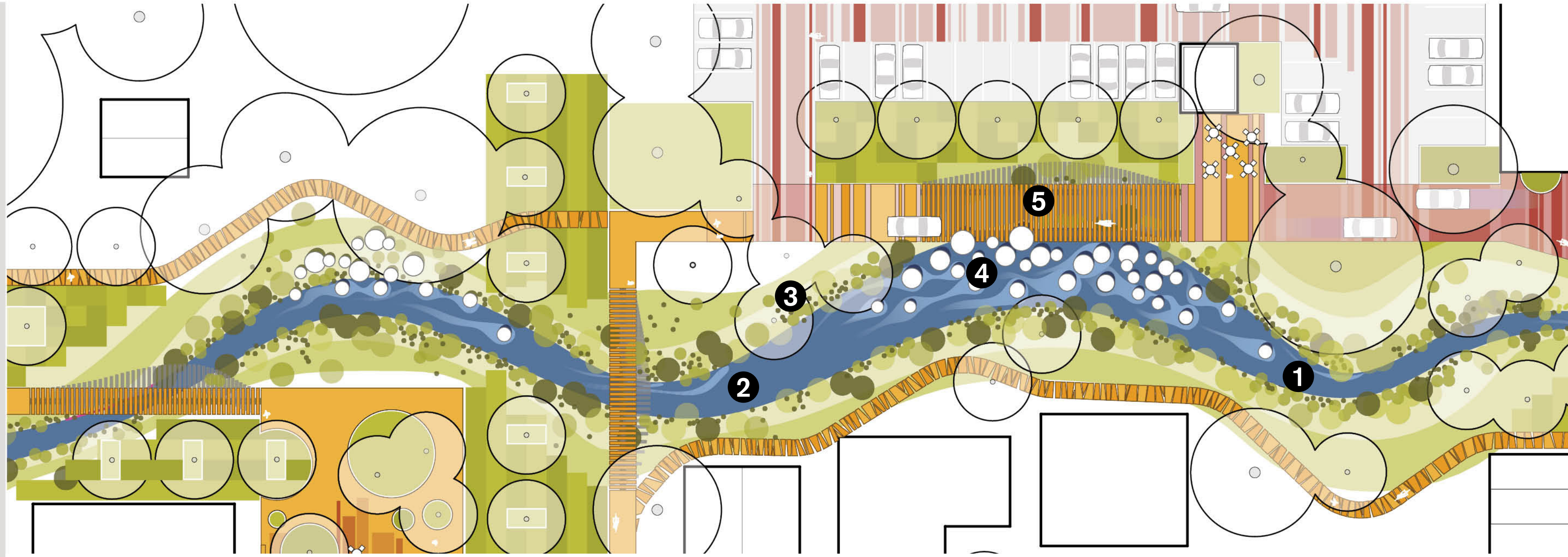
Evapotranspiring Tree Bosques 3
Use groves of deep-rooting trees to uptake large amounts of water for transpiration and ground water management.

Sediment Traps 4
Deploy a system of porous spheres that also support a boardwalk designed to trap sediment.

Filtration Boardwalk 5
Equip boardwalk with undercarriage filter to trap sediment while serving as a platform for navigating wetland areas.

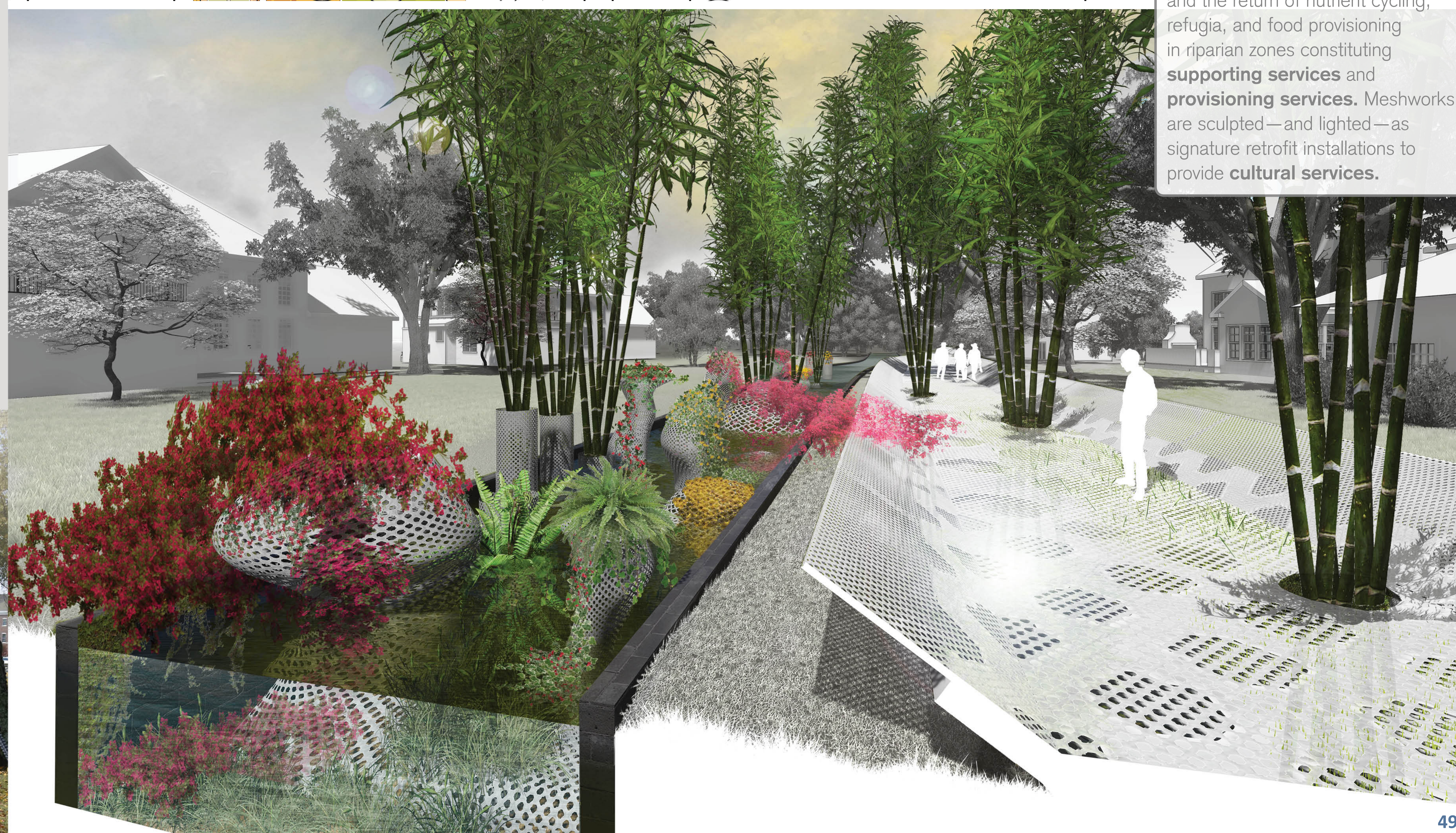






Channel Retrofit Gardens

introduce biologically active zones into urban streams that have undergone hard-engineered drainage solutions. The gardens comprise submergent and emergent plant guilds whose growth is controlled through structural meshes akin to espaliers. Cellular meshworks provide flow attenuation and restoration of sinuosity in flow patterns important for water **regulating services.** Plant guilds support microbial communities in root zones for water treatment, and the return of nutrient cycling, refugia, and food provisioning in riparian zones constituting **supporting services** and **provisioning services.** Meshworks are sculpted—and lighted—as signature retrofit installations to provide **cultural services.**



The conventional parking lot is made entirely from impervious surfacing and fails to deliver ecological services. Large lots like this are primary sources of polluted stormwater runoff leading to urban stream syndrome. Since the lot is oversized and only fully used during the holiday shopping season why not also make it a garden?

Students love parking in the garden at UCA. This demonstration parking garden was developed under the sponsorship of Arkansas Natural Resource Commission's Nonpoint Source Pollution Program—the first project under this Framework Plan. Parking stalls are made from pervious paving with gravel basins as sediment filters that slow, soak, and spread water to adjacent vegetated treatment swales. This lot never floods and it is an appealing visual amenity.

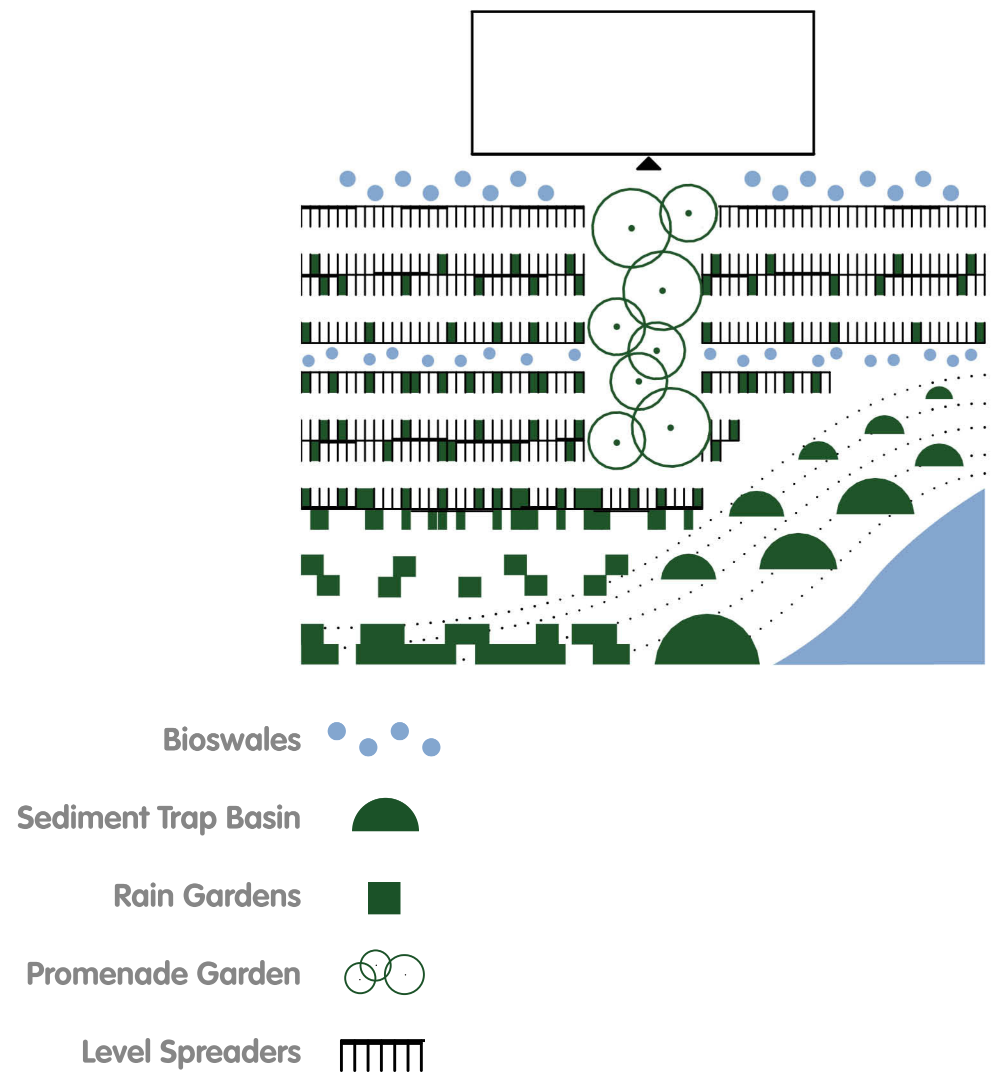
the plan's third tool parks the car in its own treatment facility

University of Central Arkansas Green Parking Lot

3

Why not park the car in its own treatment facility?
Parking lots can be easily designed as productive landscapes to remediate water pollution and manage urban runoff on site.

Parking Garden

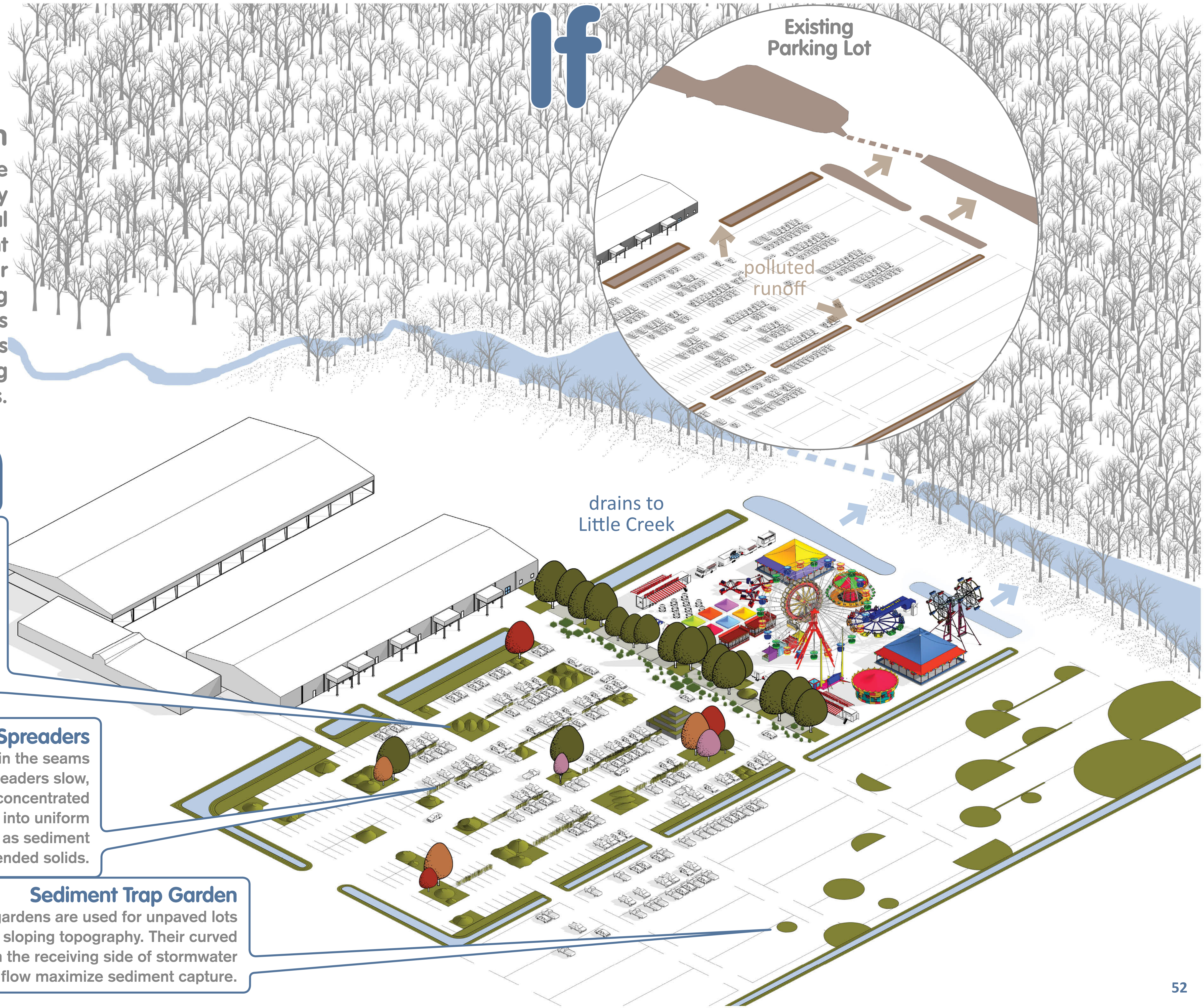


3

Parking Garden

How might the "park" in [park]ing be foregrounded? Consider the Conway Expo Center and Fairgrounds' chip seal and unpaved parking lot, equivalent in area to eight football fields, similar in scale to other commercial parking facilities in Conway. Construct lots as gardens using a vocabulary of elements that manage water flows while creating enjoyable places.

If



Then

Habitat Mounds and Rain Gardens

Habitat mounds function as flow diverters, attenuating stormwater runoff flows and eventually capturing some runoff for evapotranspiration. Mounds provide wildlife habitat. Rain gardens on the receiving side of the mounds intercept, treat, and infiltrate urban runoff.

Level Spreaders

Tear the asphalt and plant a garden in the seams separating parking rows. Level spreaders slow, spread, and soak by converting concentrated urban runoff from large surface areas into uniform sheet flow while also functioning as sediment filters to trap suspended solids.

Sediment Trap Garden

These gardens are used for unpaved lots with sloping topography. Their curved edges on the receiving side of stormwater flow maximize sediment capture.

3

Parking Garden

Bioswale 1
Incorporate vegetated channels designed for treatment and conveyance of stormwater runoff.

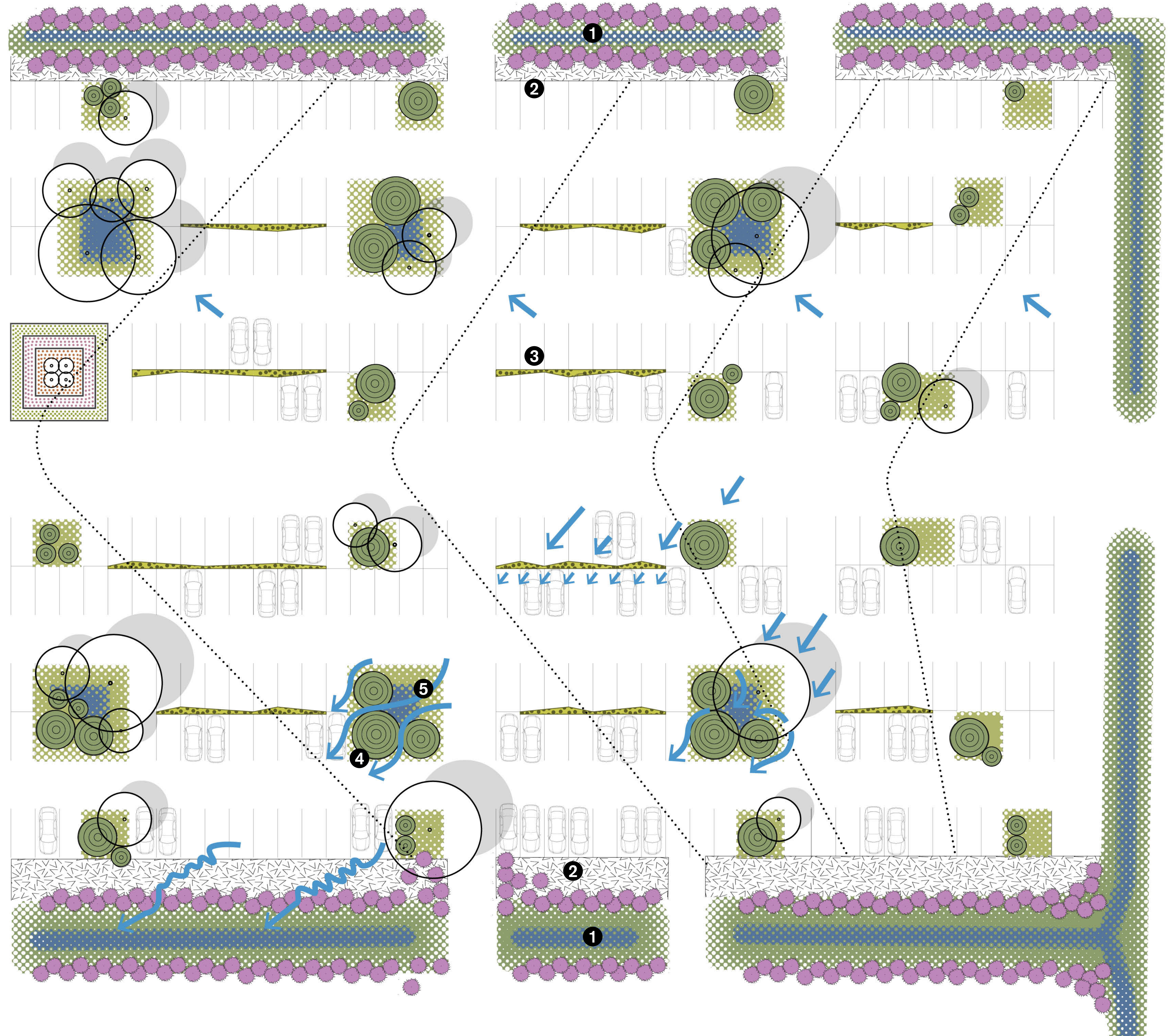
Sediment Filter 2
Align edge of bioswales with basins that capture suspended solids in stormwater runoff.

Level Spreaders 3
Distribute vegetated sediment trenches throughout lot to transform erosive energy of turbulent stormwater runoff into uniform sheet flow.

Habitat Mounds 4
Distribute vegetative mounds throughout lot to attenuate stormwater runoff through absorption and evapotranspiration while providing wildlife habitat.

Rain Gardens 5
Encircle habitat mounds with shallow vegetated depressions to treat stormwater runoff.

0 55' 110'



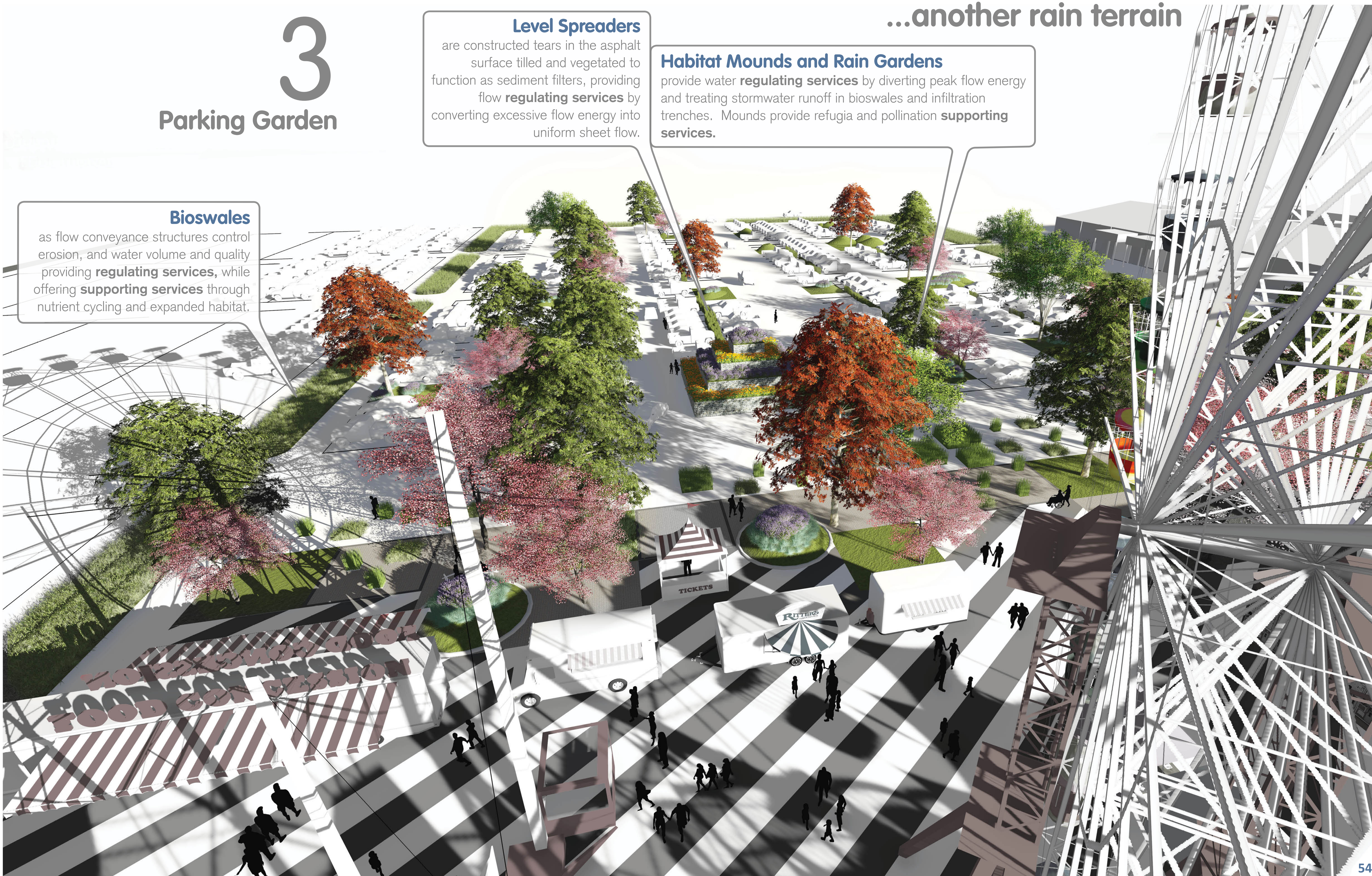
3
Parking Garden

...another rain terrain

Level Spreaders
are constructed tears in the asphalt surface tilled and vegetated to function as sediment filters, providing flow **regulating services** by converting excessive flow energy into uniform sheet flow.

Habitat Mounds and Rain Gardens
provide water **regulating services** by diverting peak flow energy and treating stormwater runoff in bioswales and infiltration trenches. Mounds provide refugia and pollination **supporting services.**

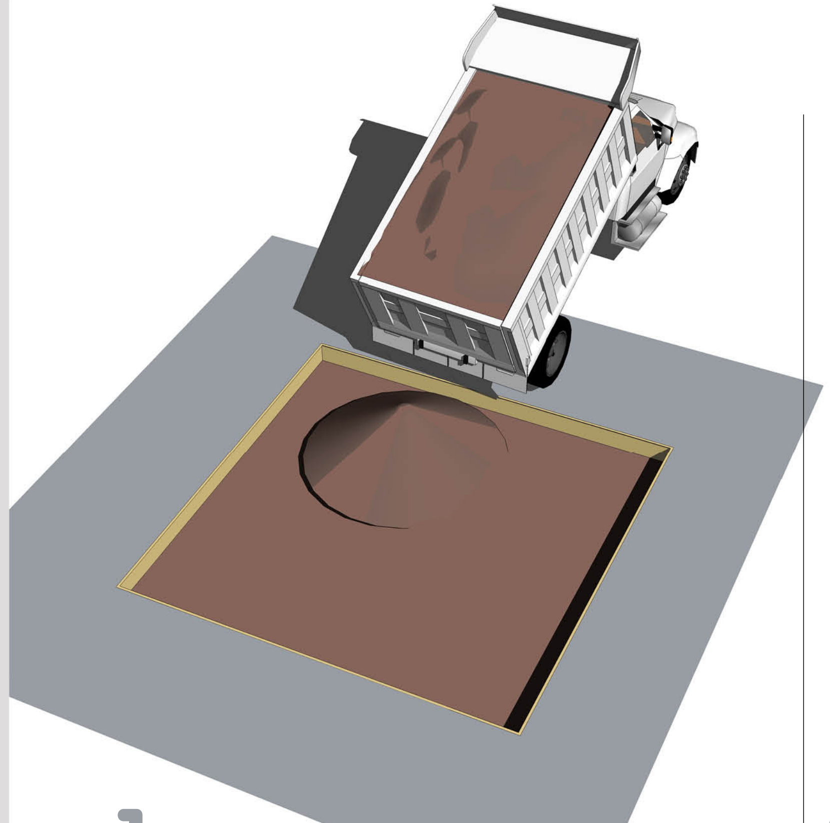
Bioswales
as flow conveyance structures control erosion, and water volume and quality providing **regulating services,** while offering **supporting services** through nutrient cycling and expanded habitat.



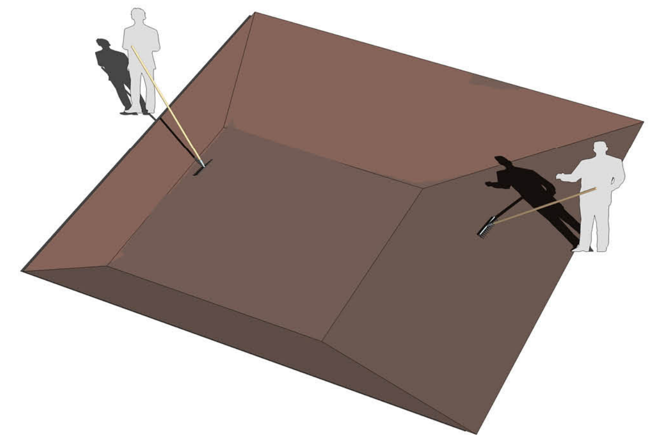
3

Parking Garden Tools: Habitat Mounds and Rain Gardens

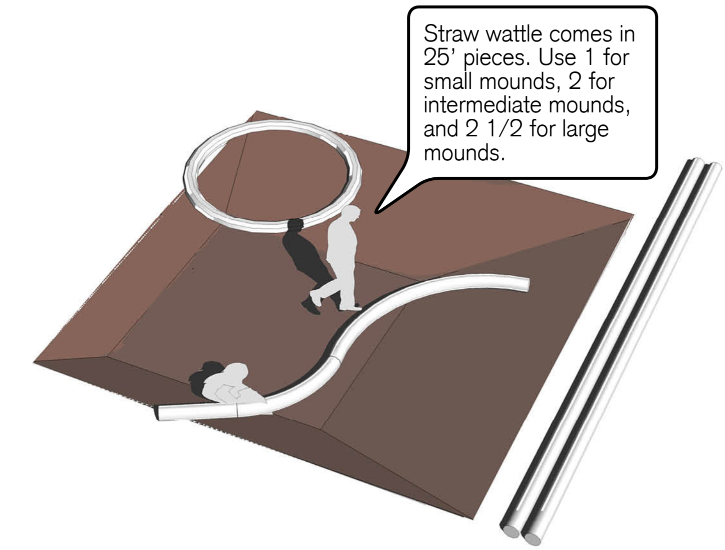
Ecological-based LID management technologies are designed with permissive tolerances based on in-house road crew construction standards—what we call "Bobcat Artists". Mound sizes are based on dump truck load sizes and shaped with a bulldozer. Gardens are seeded and armored for erosion control per highway landscaping standards …no fuss.



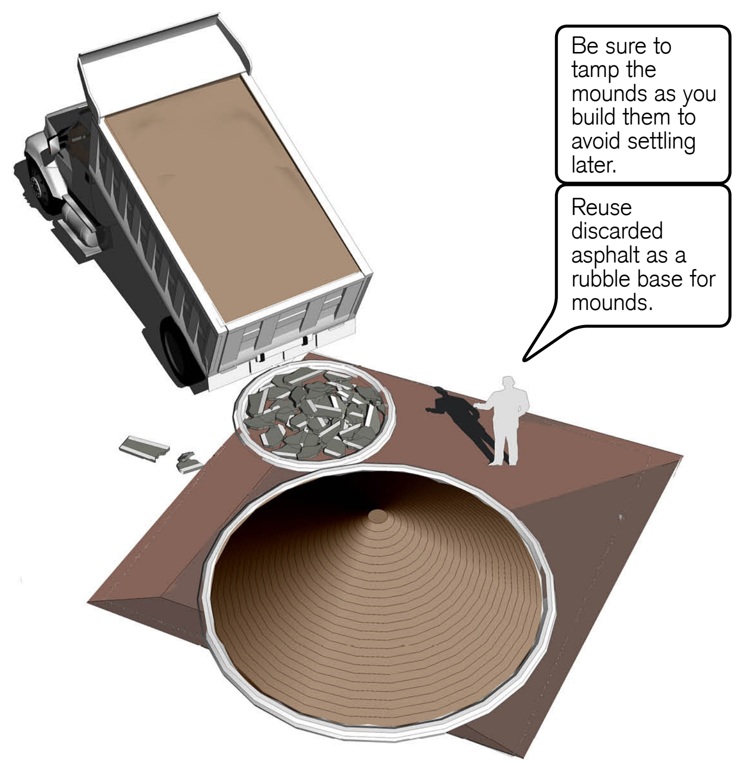
1 fill rain garden area with soil



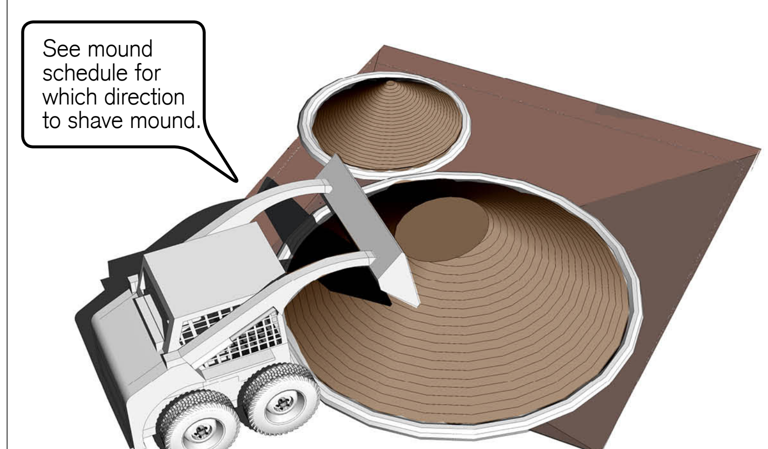
2 grade soil to create slight depression



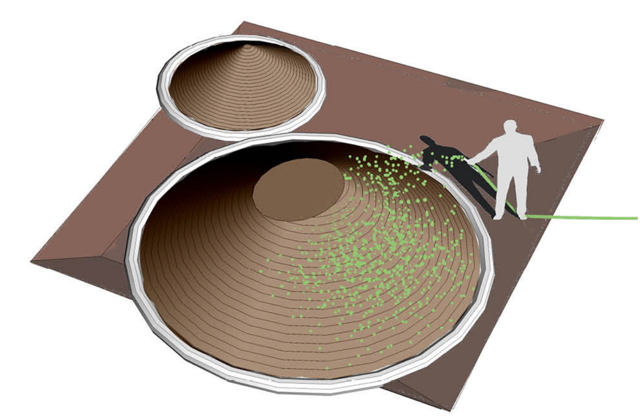
3 construct mound edges with straw wattle



4 use asphalt rubble and finish with soil



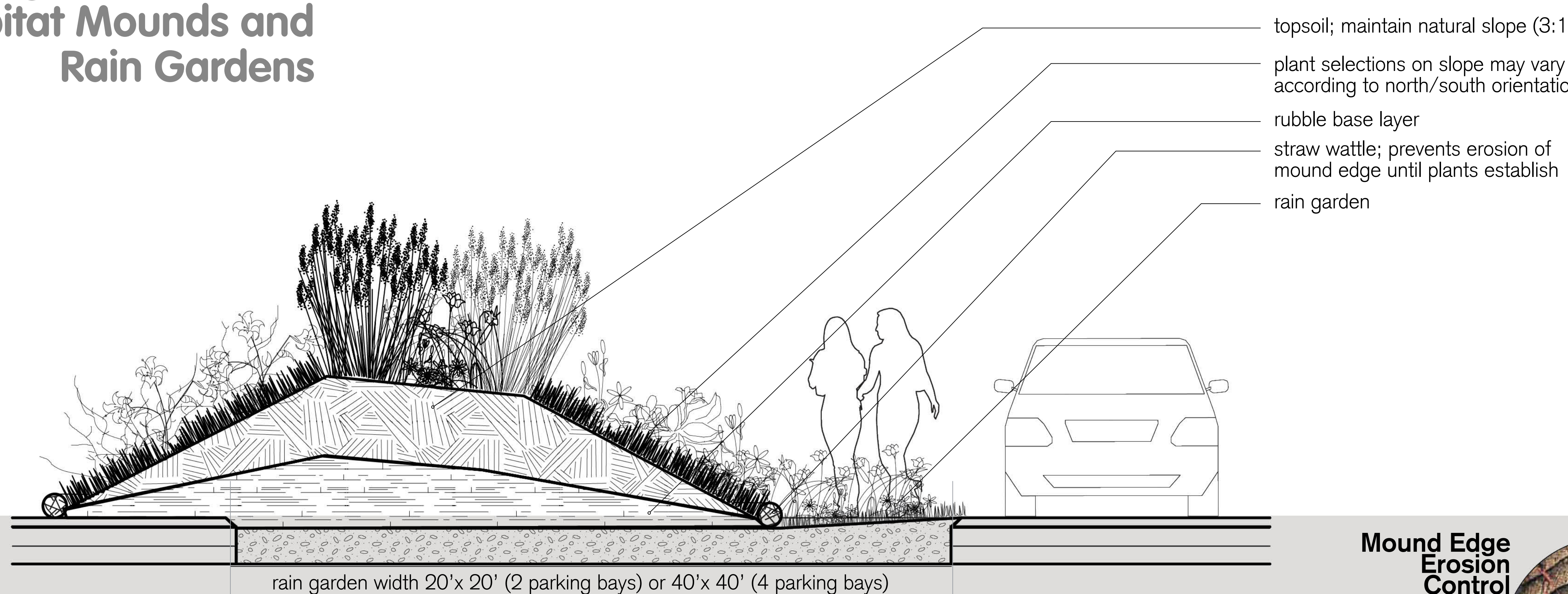
5 sculpt mounds (Bobcat Artist Required)

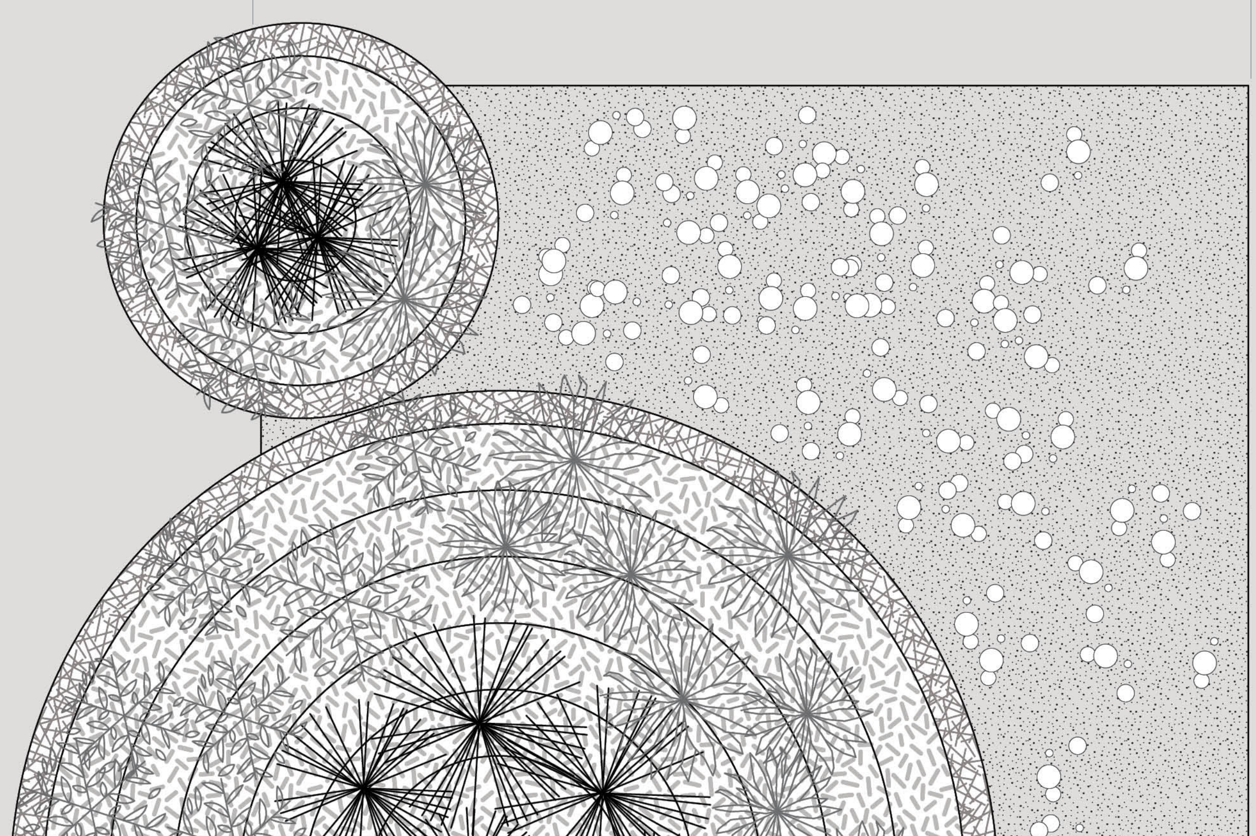


6 hydroseed mounds and plant rain garden

3

Parking Garden Tools: Habitat Mounds and Rain Gardens





A rain garden is a shallow depression used to treat stormwater runoff. A habitat mound attenuates runoff and evapotranspirates stormwater while providing wildlife habitat refuge.

Grassed Mound Top

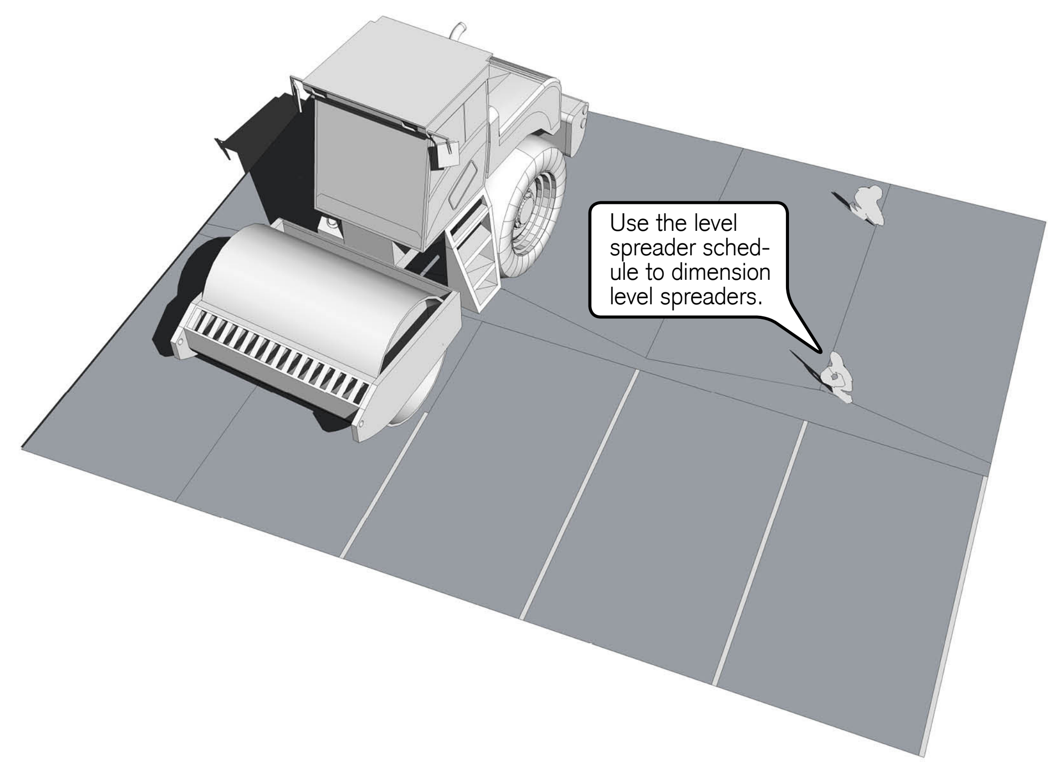
Mound Edge Erosion Control

Rain Garden Plants

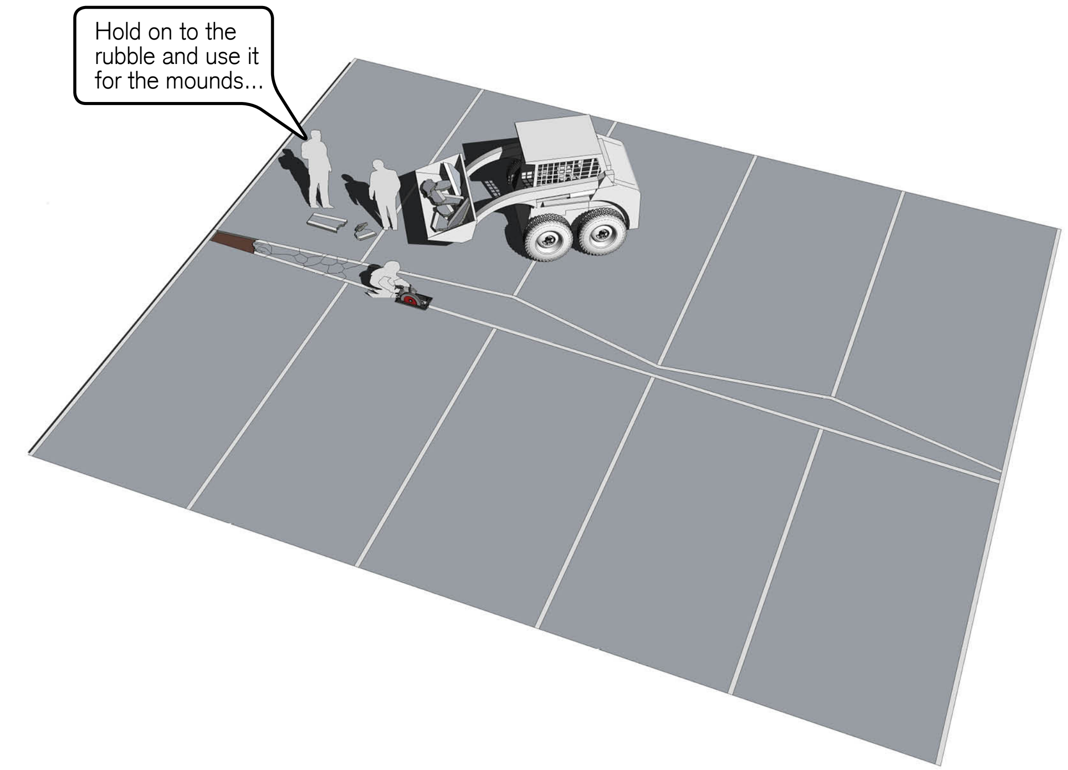
Mound Construction

3
Parking Garden Tools: Level Spreaders

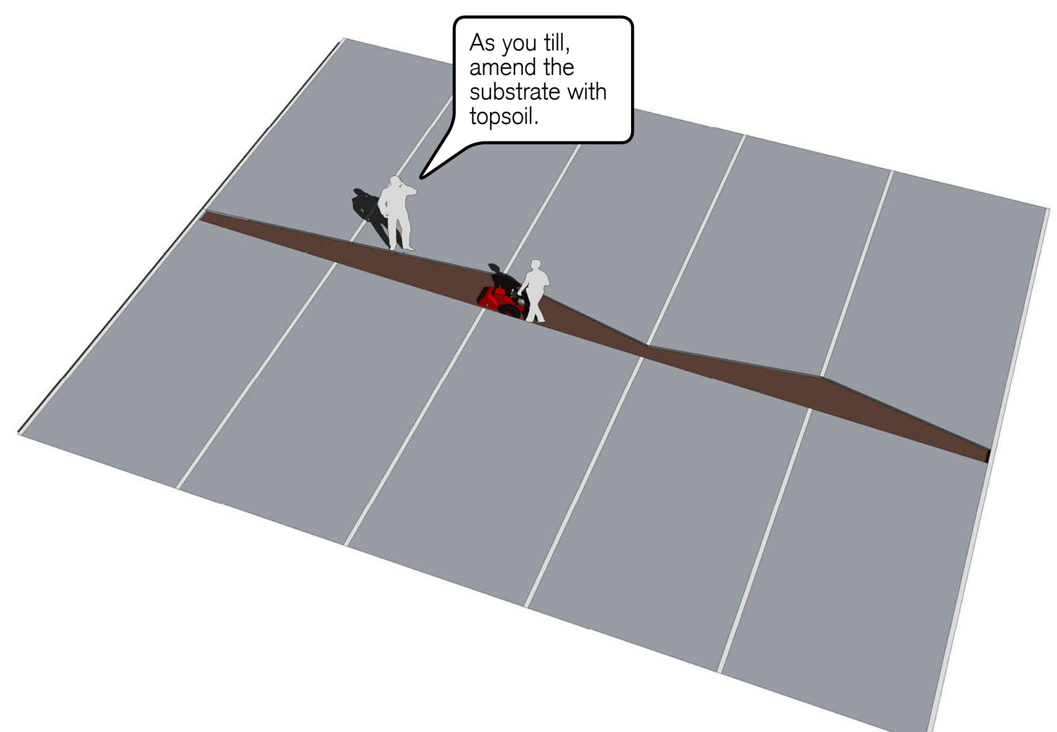
These flow diverters and sedimentation trenches mimic the process of cracking in paved surfaces. However, in tearing the asphalt surface to promote plant growth, the soil is tilled to amend compacted substrate for infiltration and planted with reedy plant stock…a miniature garden.



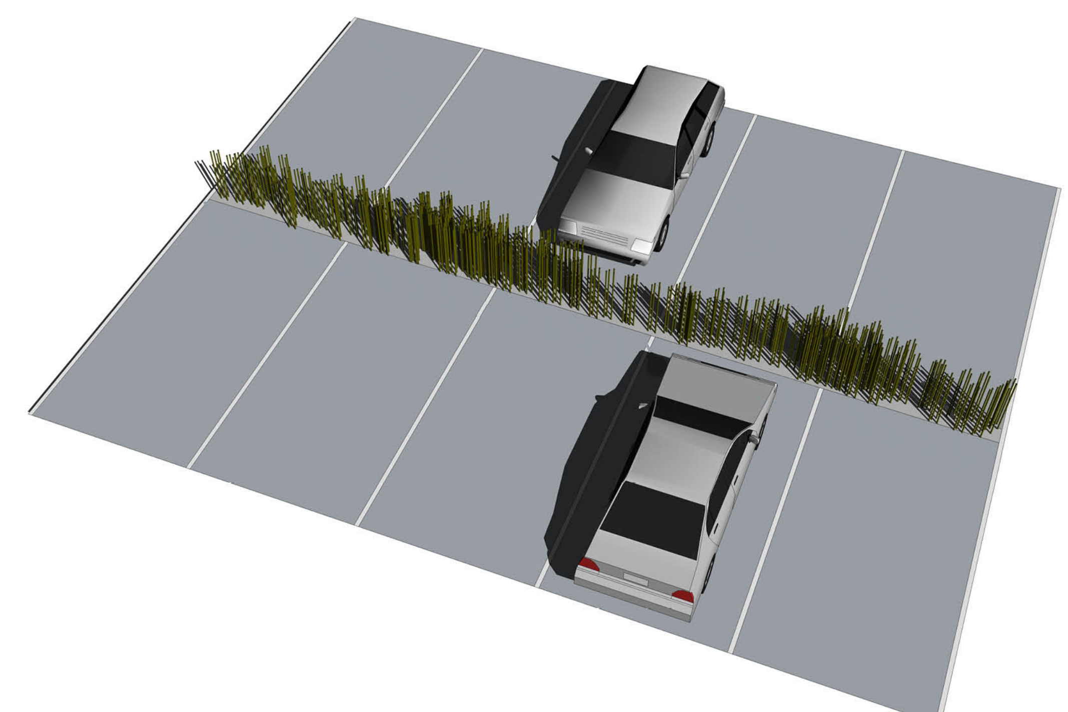
1 measure and paint parking lot



2 saw and remove asphalt



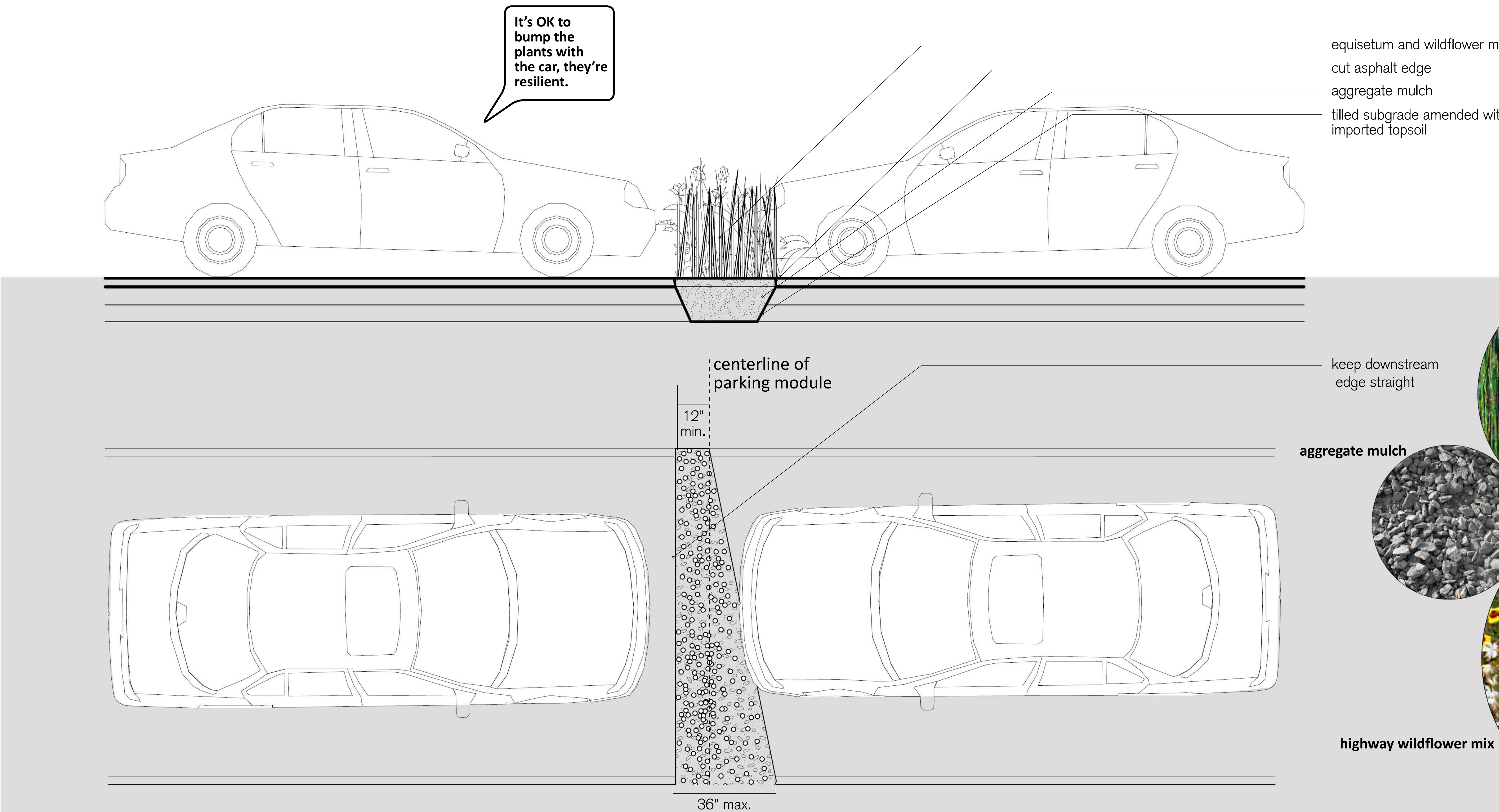
3 till and amend compacted substrate

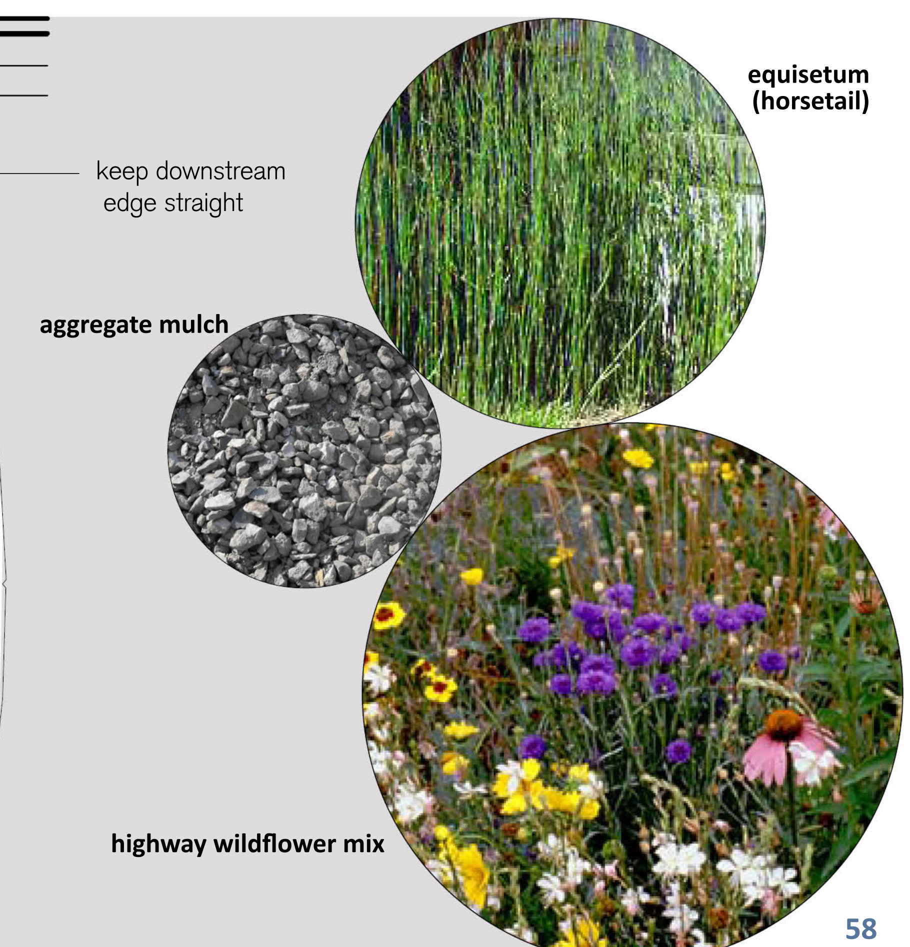


4 plant and fill with aggregate mulch

3

Parking Garden Tools: Level Spreaders





3
Parking Garden

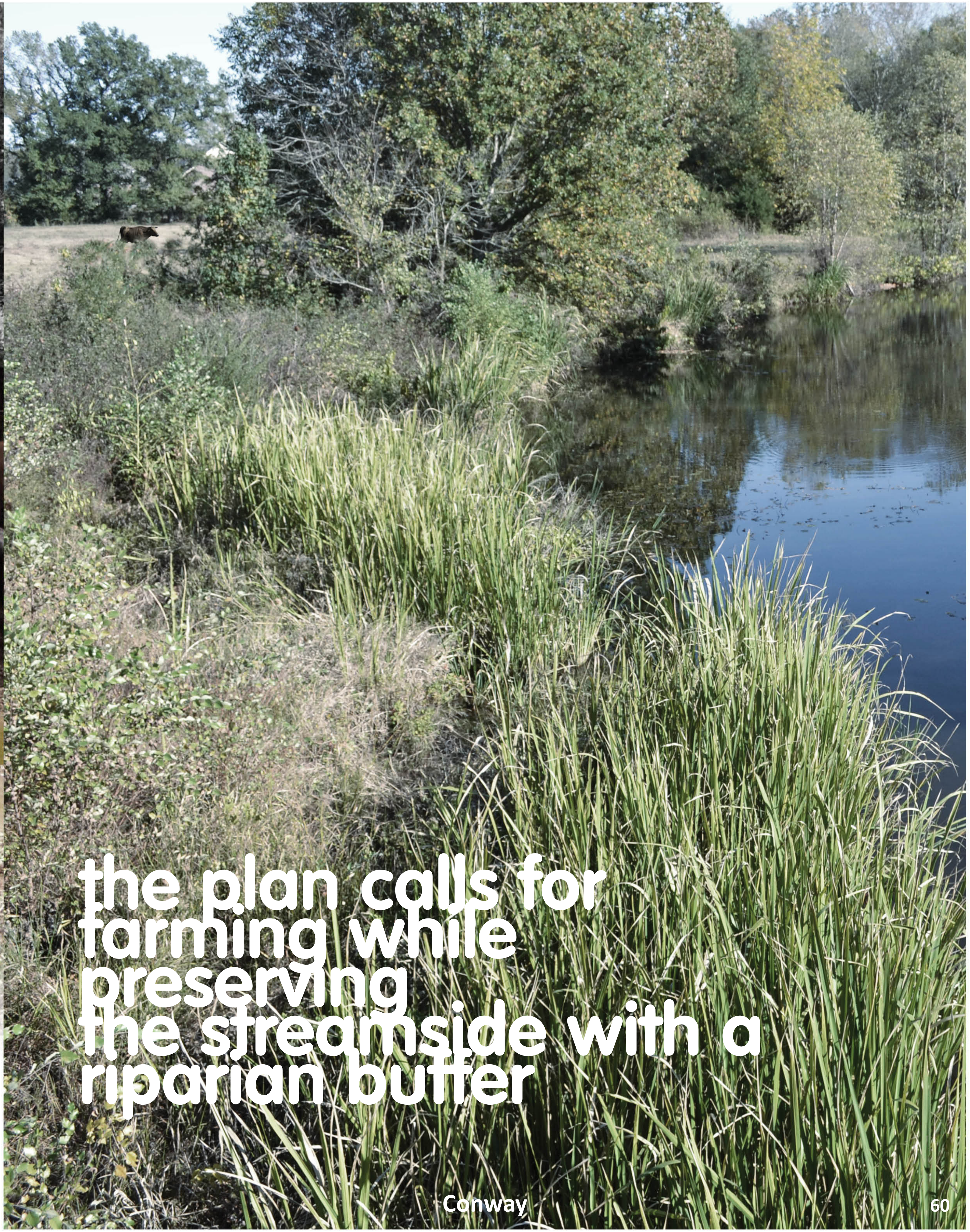
Expo Promenade

is a tree-lined sediment filter providing water quality and atmospheric **regulating services**, and **supporting services** through porous paving and structural soils that optimize urban tree health. Each tree can intercept and absorb up to 700 gallons of rainfall annually.

Living Wall Ziggurat

is a gabion wall that supports a vegetated mesh of pollinating plant guilds that offer **supporting services**, and **provisioning services** if edible plant guilds are used. It is also a wayfinding landmark in a large lot providing **cultural services**.

Studies have shown a 30-95% reduction in pollutants when agricultural runoff passes through streamside buffers.

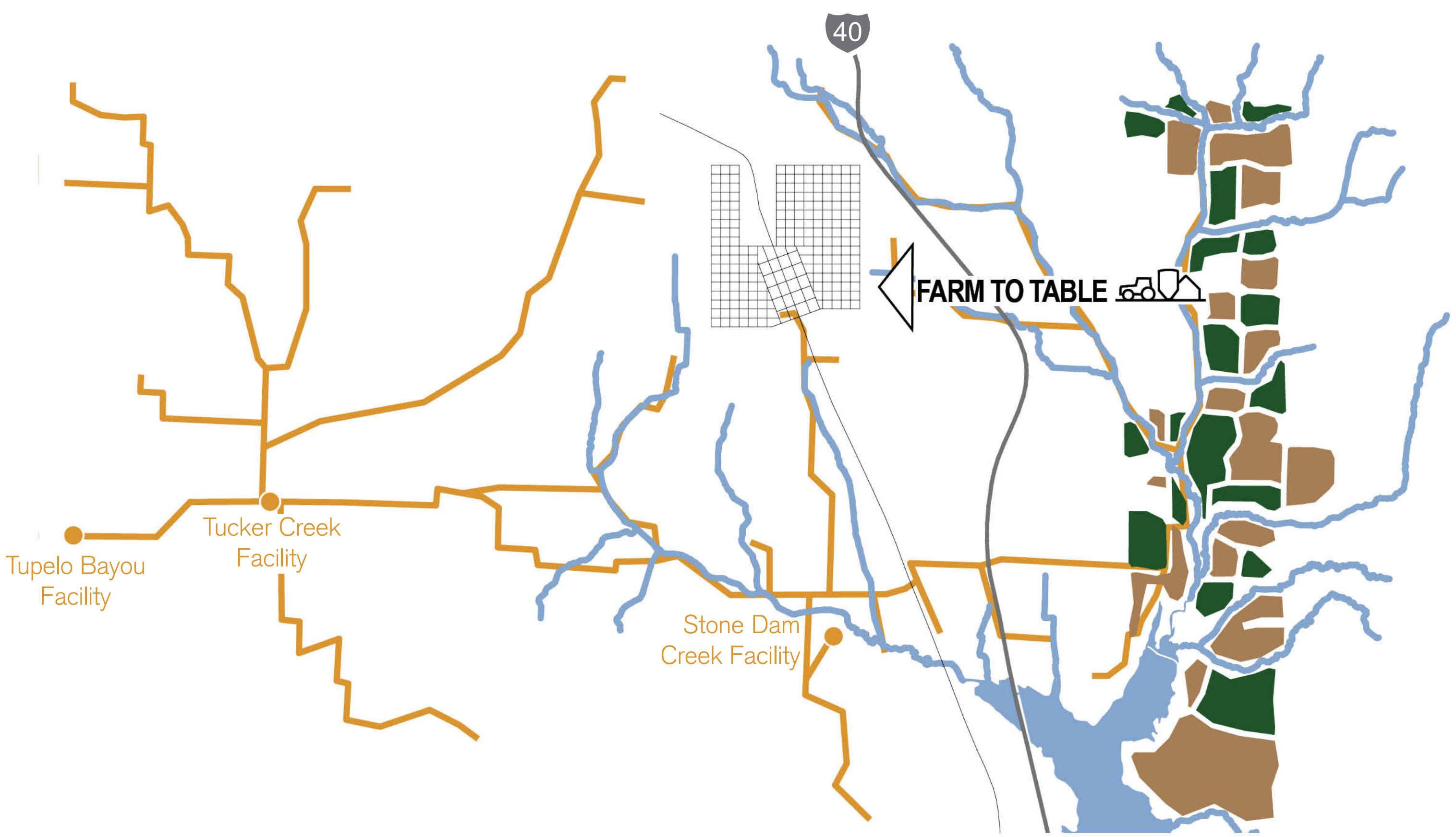


the plan calls for farming while preserving the streamside with a riparian buffer

Farms are essentially energy systems comprised of several growing models between the natural and the industrial. Arrange natural growing systems closest to riparian corridors as buffers to mitigate impacts from industrial outputs (pesticides, herbicides, nutrient concentrations).

4

Urban Eco-Farm



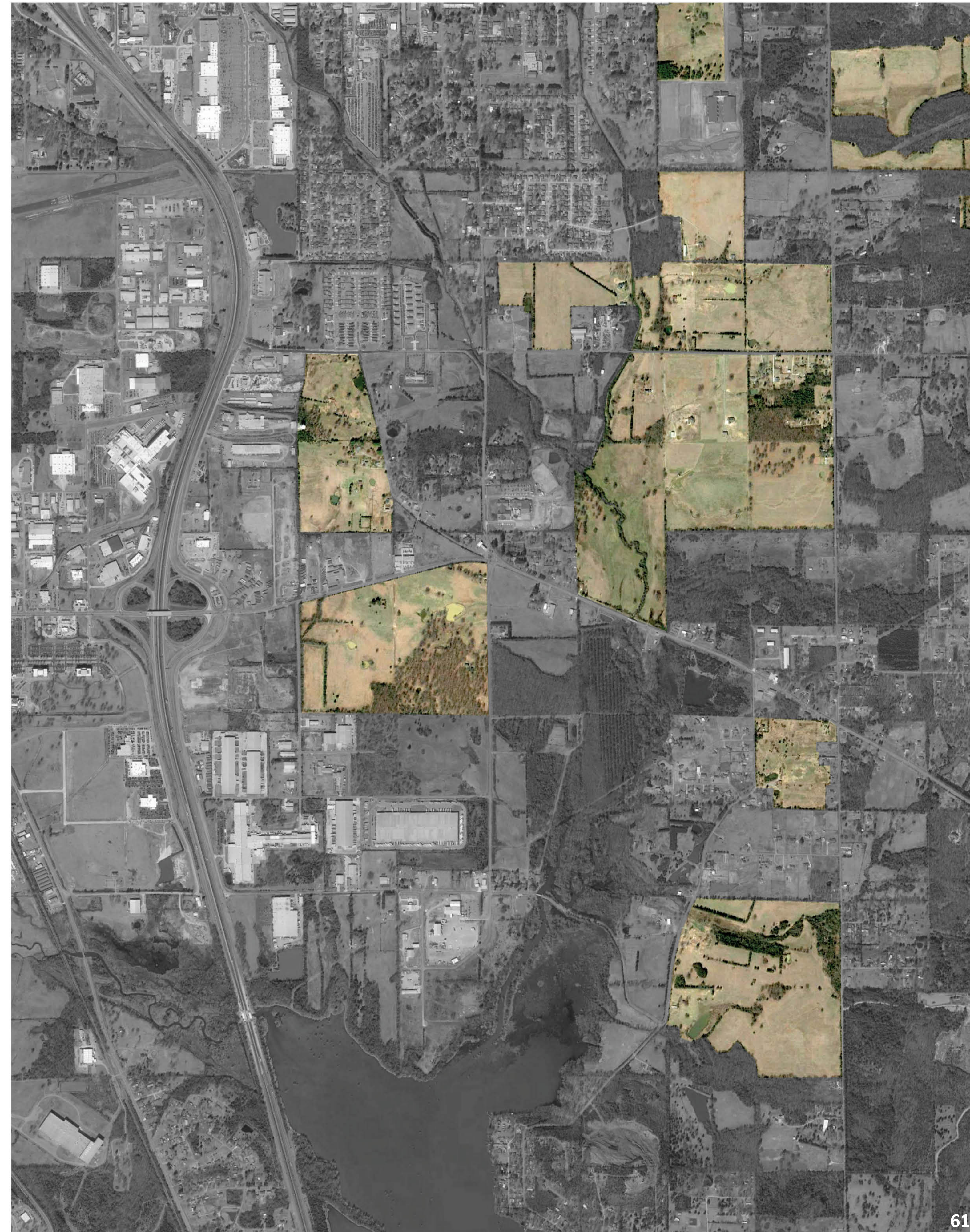
Pasture Mosaic

Crop Mosaic

City Sewer Trunks indicating area of future growth

Water Treatment Locations

Downtown Conway

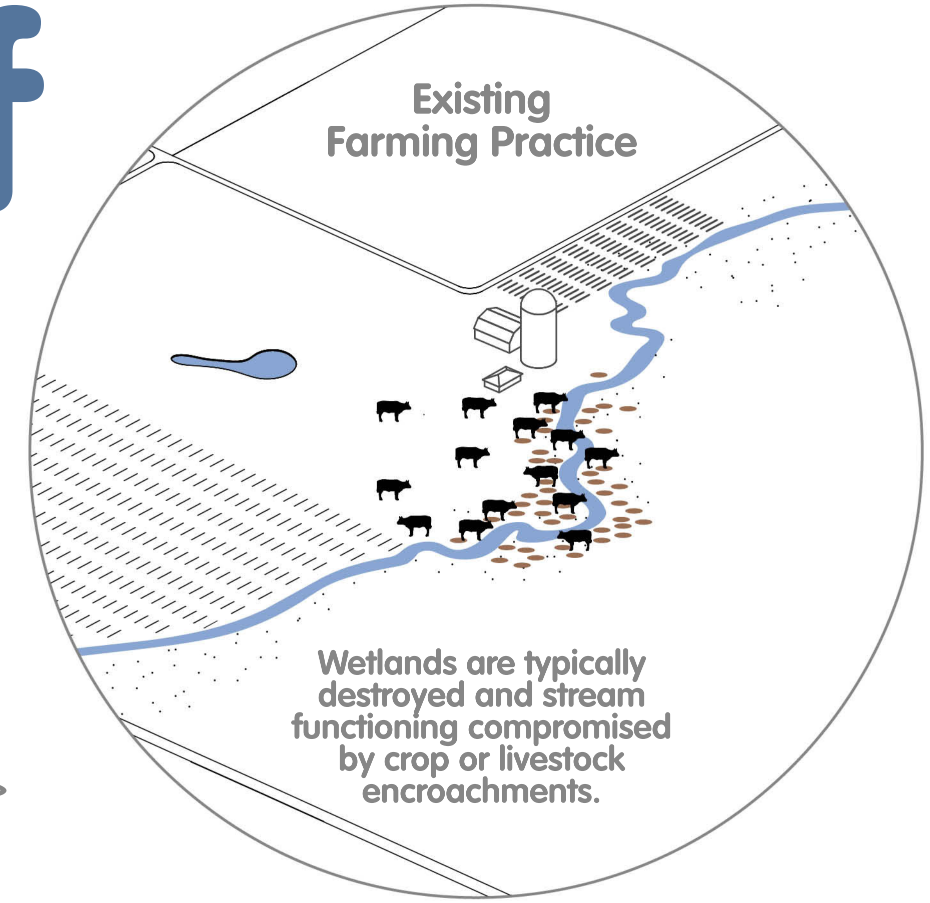


4

Urban Eco-Farm

Imagine a new paradigm for the farm as an urban asset—"farm to table"—providing locally-sourced food and increased economic returns while minimizing production and transportation cost. Such farms are popping up all over American cities and have an astounding rate of financial return.

If



Then

Adopt Eco-Farming Techniques

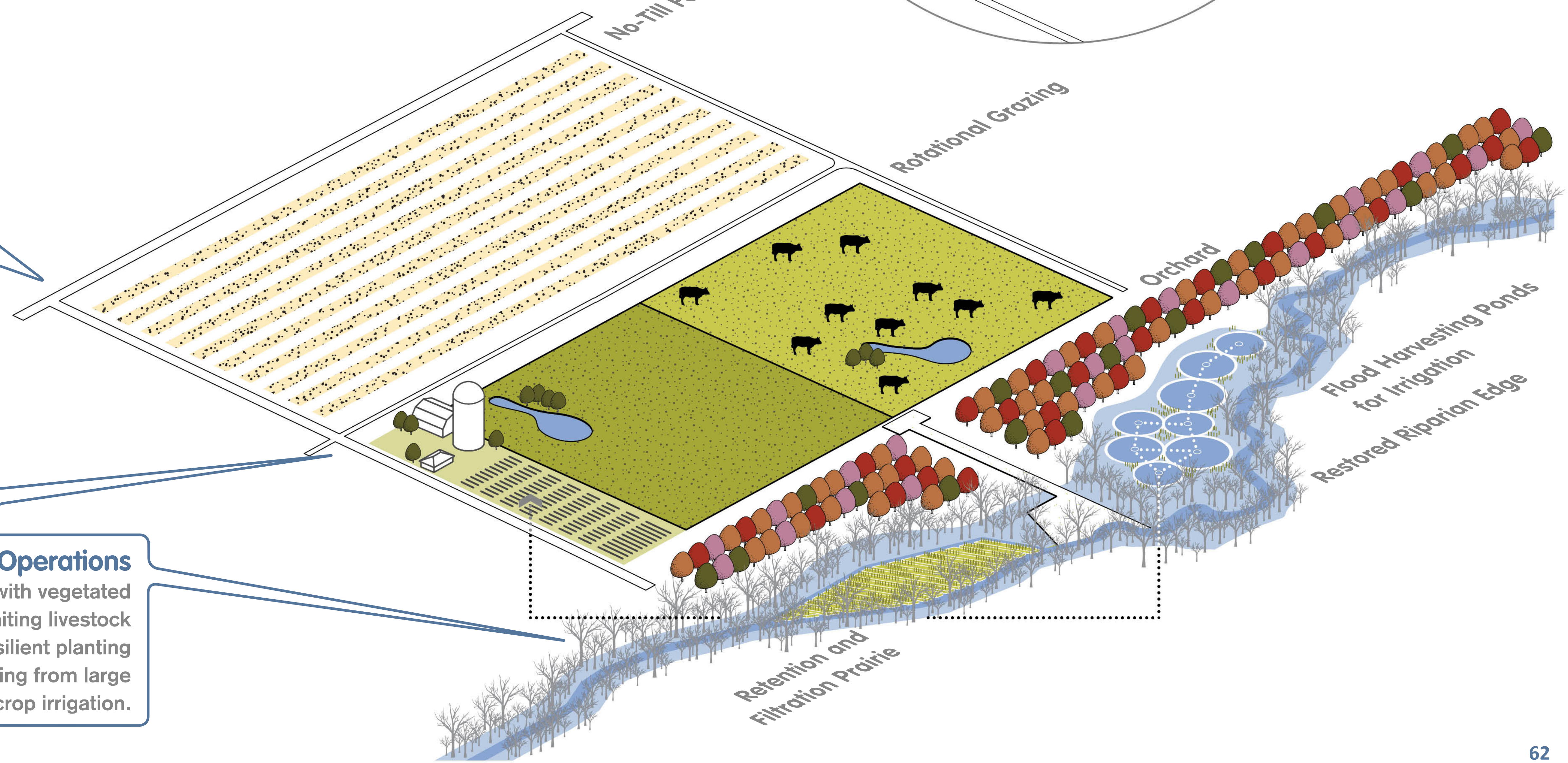
Restore healthy soil structure through no-till farming, crop and grazing rotation, and cover crop recharge during the off-season. Best barnyard practices include better manure management through practices such as deep litter farming/composting, and manure sharing.

Laminate Farming Operations

Arrange farming operations in response to stream and floodplain proximity: natural farming techniques near the stream; more intensive growing techniques located within the interior.

Restore Stream Operations

Restore riparian corridors with vegetated stream buffers while limiting livestock access. Consider a flood-resilient planting scheme and water harvesting from large rain events for crop irrigation.



4

Urban Eco-Farm

Riparian Buffer 1
Consider requiring a stream buffer to slow and filter stormwater runoff, and to protect stream integrity.

Wastewater Treatment Wetland 2
Include a bio-treatment facility for livestock waste including pre-treatment and post-treatment polishing ponds if livestock access streamside.

Rotational Grazing 3
Adapt seasonal migration of grazing livestock to allow regeneration of pastures.

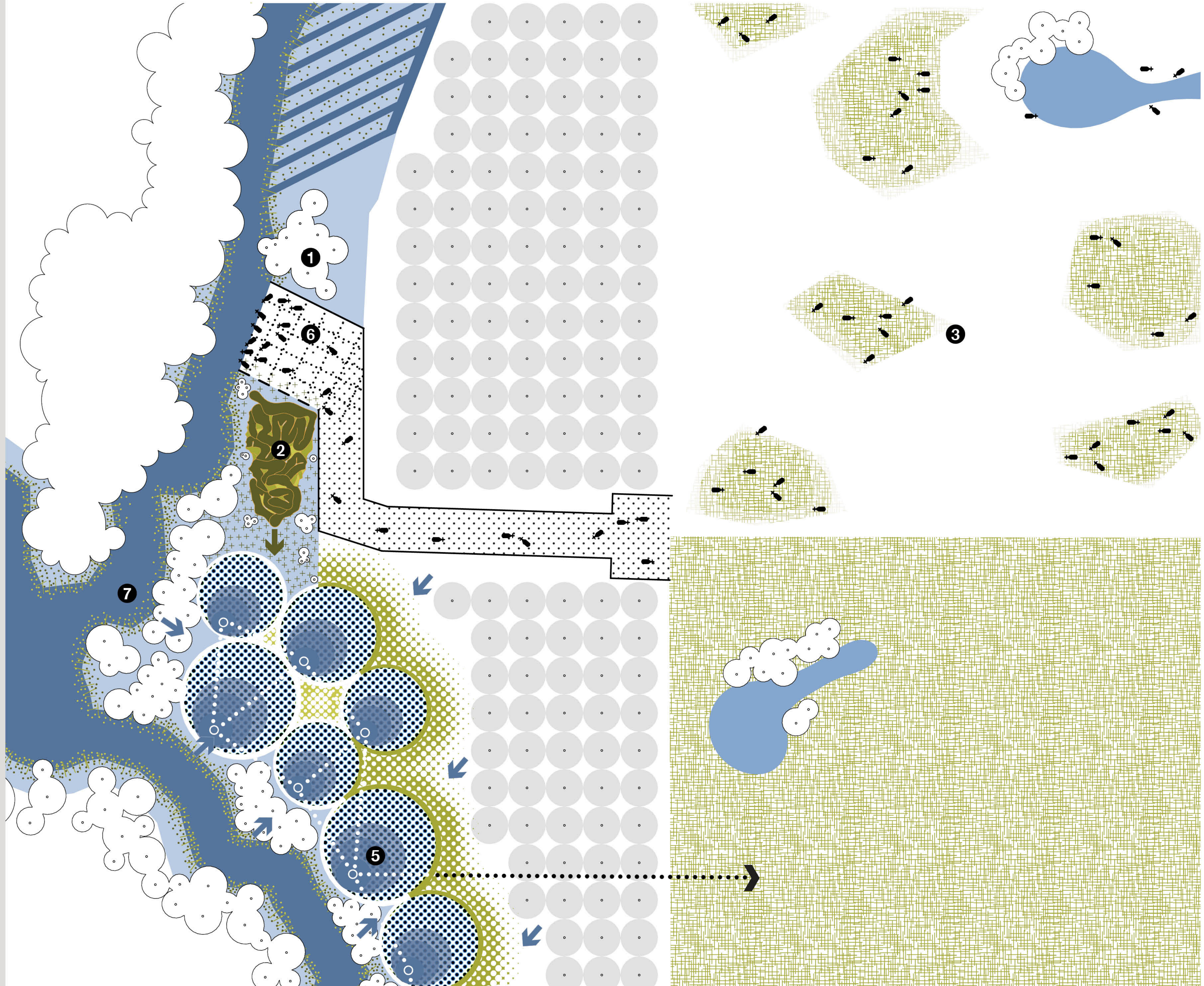
No-Till Farming 4
Consider this growing technique that does not disturb soil, increasing water and nutrient retention. It is effective in preventing soil erosion and in building high-quality soil.

Flood Harvesting Ponds 5
Consider using floodplain wetlands that harvest floodwater for farm irrigation while treating stormwater runoff from agricultural operations.

Livestock Streamside Control 6
Use paddocks that limit livestock's destruction of streamsides and buffers. Streamside substrates redirect runoff to a wastewater treatment wetland, and facilitate manure upcycling for compost applications that increase soil health.

Native Mussels 7
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli.

0 250' 500'



4 Urban Eco-Farm

Restored Riparian Buffer

provides **regulation services** by stabilizing stream banks, reducing erosion, and intercepting pollutant discharges into the stream. Vegetated edges support stream temperatures critical for land-water enzymatic exchange and maintain genetic resources in **supporting services.**

Rotational Grazing

balances food provisioning for livestock with the landscape's **provisioning service** capacity and ability of pasture soil to metabolize nutrient-rich animal waste toward healthy soil formation, a **supporting service.**

No-Till Farming

provides important **supporting services** by maintaining nutrient-rich biotic communities and moisture in soil structure, while preventing erosion, an important **regulating service,** and optimizing food and fiber production in **provisioning services.**

Soft/Hard Fruit Orchard

offers high-value perennial food production in a **provisioning service** that also stabilizes nutrient cycling and long-term soil formation in **supporting services** with beneficial **regulating service** impacts on riparian corridors.

Flood Harvesting Ponds

provide disturbance and water **regulating services** through storage and harvest of floodwater during peak rainfall for future irrigation, a water **provisioning service.** Wetland vegetation provides highly productive refugia and soil communities, and is a critical source of genetic material and food foraging in **supporting** and **provisioning services.**

Optimal ecosystem functioning entails physical connectivity among landscapes—the very feature cities erase. Where the city and the watershed meet presents the greatest opportunities for hybrid solutions. New types of public spaces should appear.

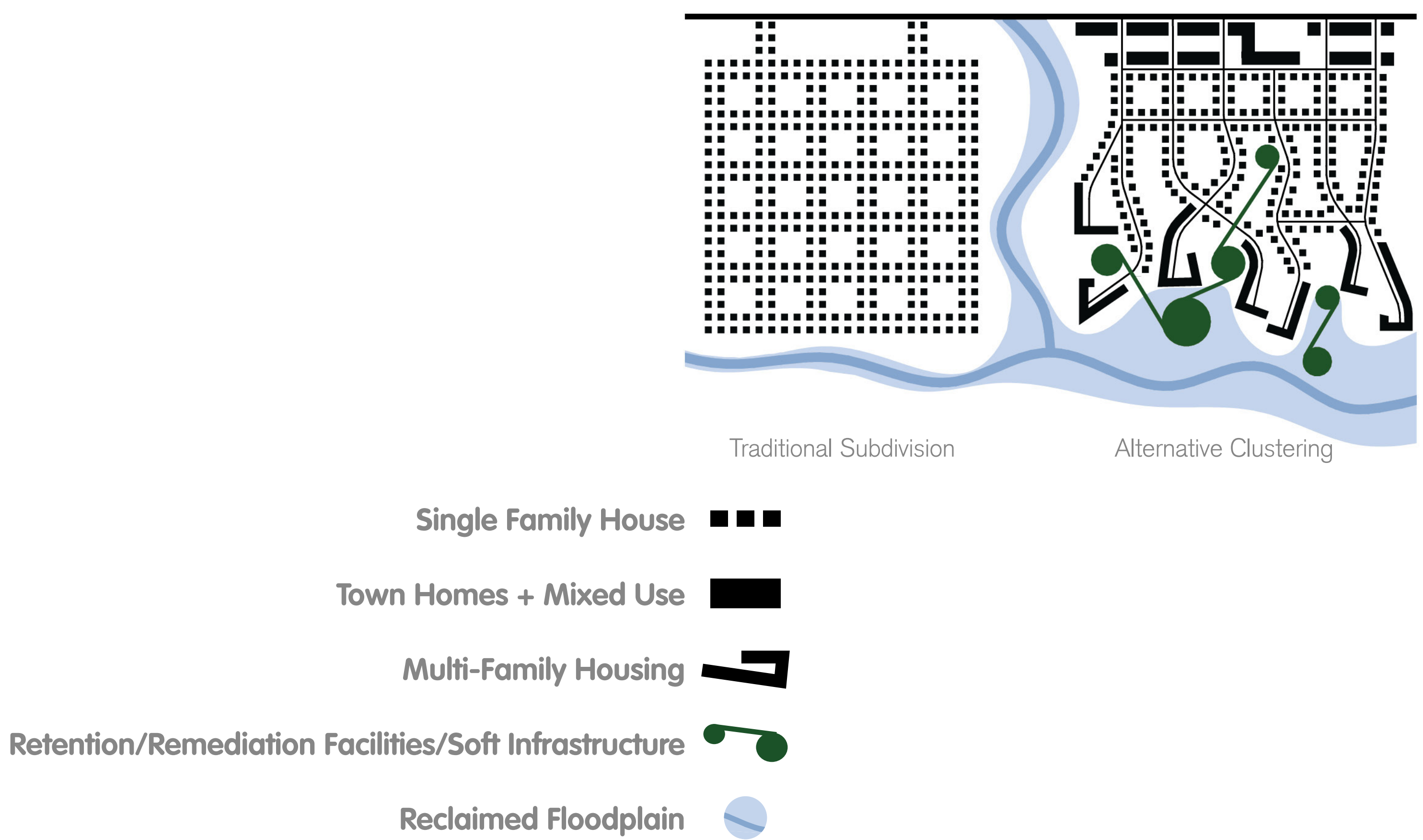
the plan's fifth tool: riparian corridor as housing frontage since biking is the new golf

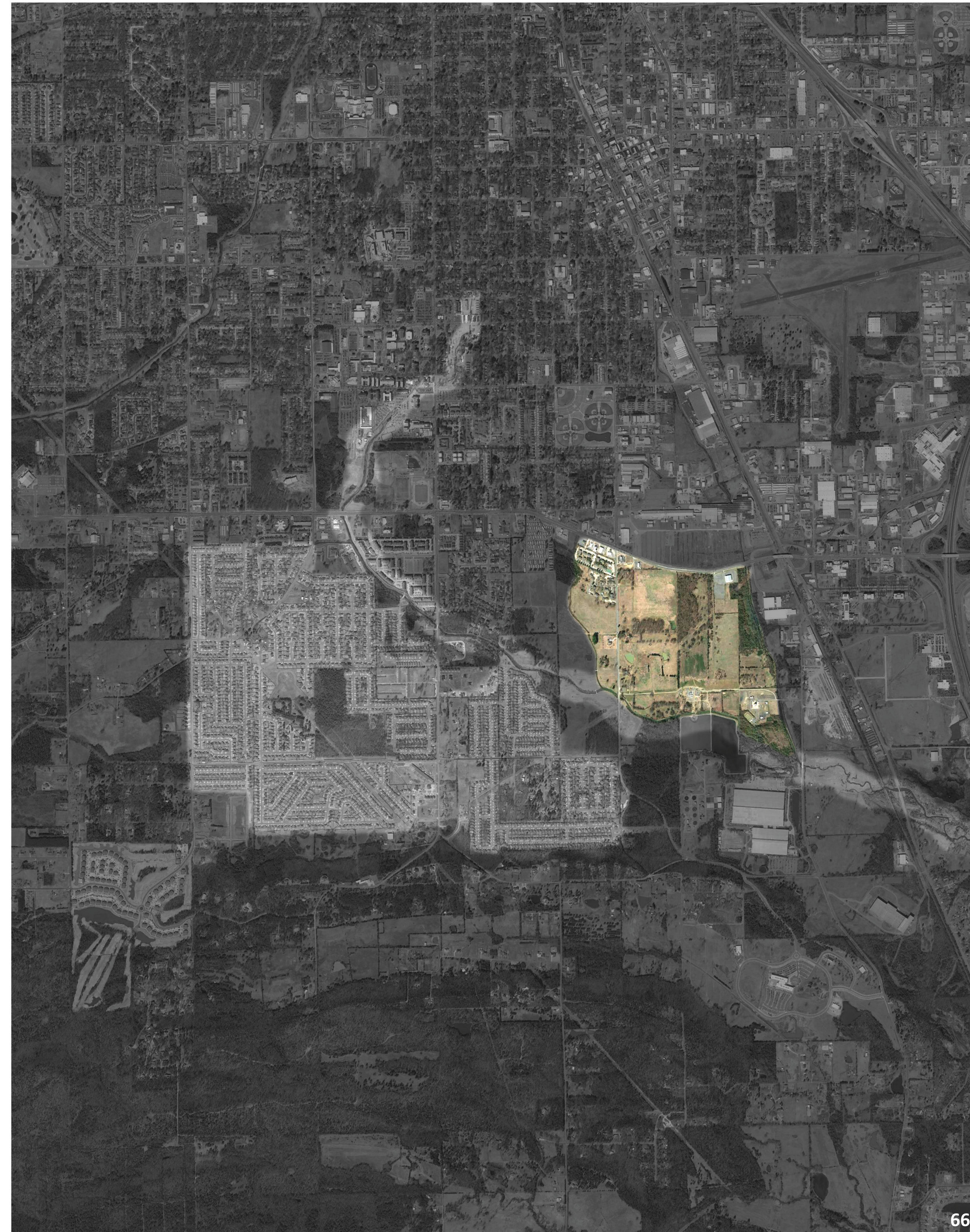
Conway

5

Cluster impervious surfaces in residential development (roofs, drives, and streets) to preserve landscape for on-site water management. Such real estate products always enjoy a higher premium than conventional development.

Conservation Development





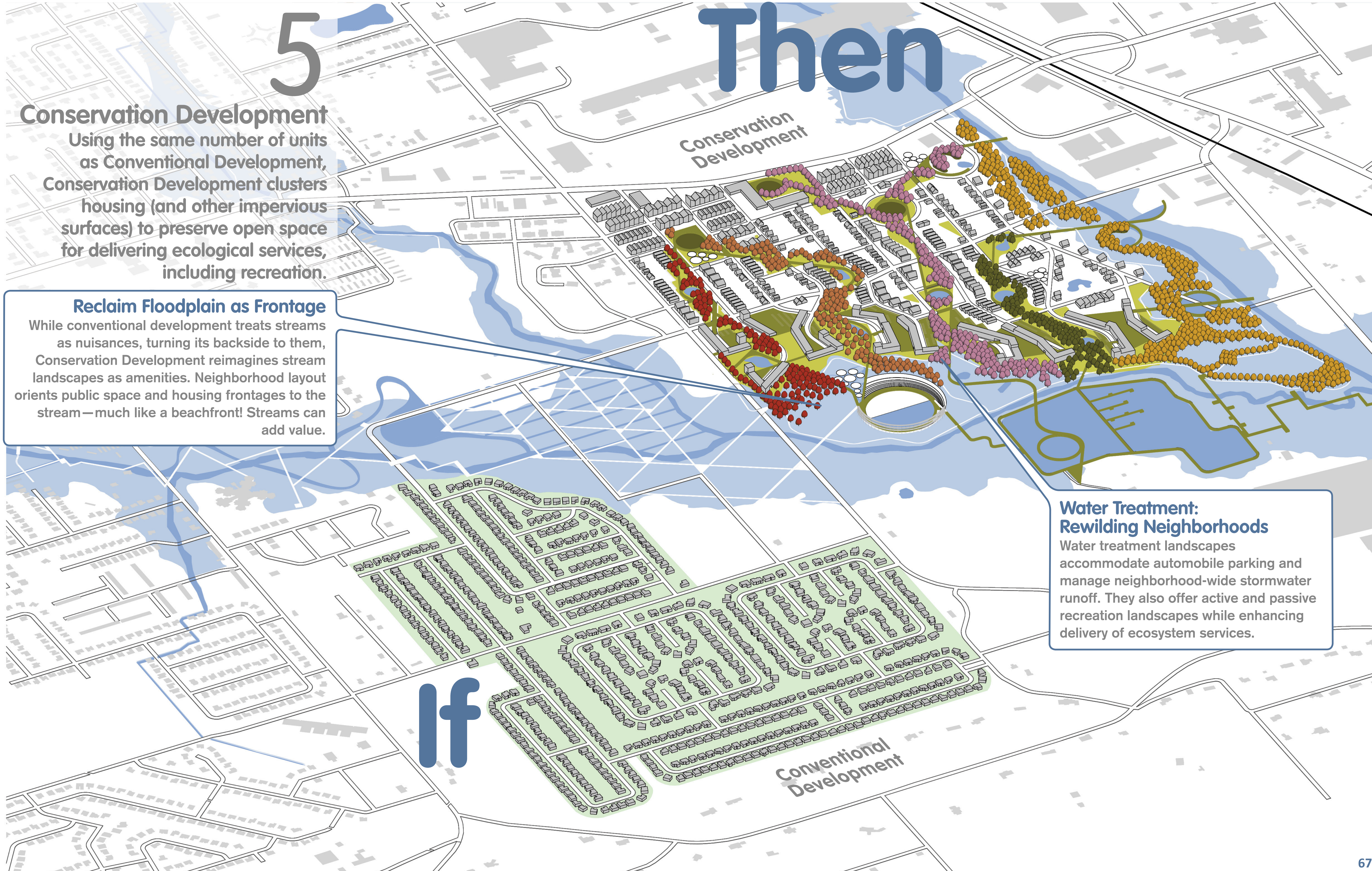
5

Conservation Development

Using the same number of units as Conventional Development, Conservation Development clusters housing (and other impervious surfaces) to preserve open space for delivering ecological services, including recreation.

Reclaim Floodplain as Frontage

While conventional development treats streams as nuisances, turning its backside to them, Conservation Development reimagines stream landscapes as amenities. Neighborhood layout orients public space and housing frontages to the stream—much like a beachfront! Streams can add value.



Water Treatment: Rewilding Neighborhoods

Water treatment landscapes accommodate automobile parking and manage neighborhood-wide stormwater runoff. They also offer active and passive recreation landscapes while enhancing delivery of ecosystem services.

5

Conservation Development

Restored Riparian Corridor 1
Improve riparian stream buffer to optimize stream protection and create a neighborhood amenity.

Water Retention Ponds 2
Develop a pond system to capture and treat stormwater runoff.

Filtration Meadow 3
Consider using meadows in disturbance regulation to absorb floodwaters and filter sediment.

Neighborhood Drifts 4
Employ clustered landscapes that combine parking and recreation with stormwater management and wildlife habitat.

Retention Meadow (wet/dry) 5
Improve riparian corridor with a wet meadow for stormwater management.

Waterfront Recreational Amenities 6
Reclaim the floodplain's intrinsic suitabilities for recreation.

Parking Gardens 7
Incorporate parking facilities in neighborhood drifts incorporating low impact development techniques to manage stormwater runoff.

Native Mussels 8
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli.

0 600' 1200'

5

Conservation Development

Vegetated Riparian Bank

combines **regulating** and **cultural services** by capitalizing on the intrinsic aesthetics of the floodplain as residential frontage, protecting riparian functioning while increasing property values.

City Greenway

protects the riparian landscape as a continuous ecosystem for optimum recreational and watershed functioning that provide **provisioning** and **cultural services,** including continuous wildlife corridors and sustained genetic diversity in **supporting services.**

Neighborhood Drifts

combine linear remediation landscapes for auto parking, providing water and disturbance **regulating services,** with wildlife corridors and extensive habitat as **supporting services.**

Floodplain Terraces

reconstruct wetland plant communities at the decommissioned waste water treatment plant providing water and disturbance **regulating services,** while offering **cultural services** through recreational amenities.

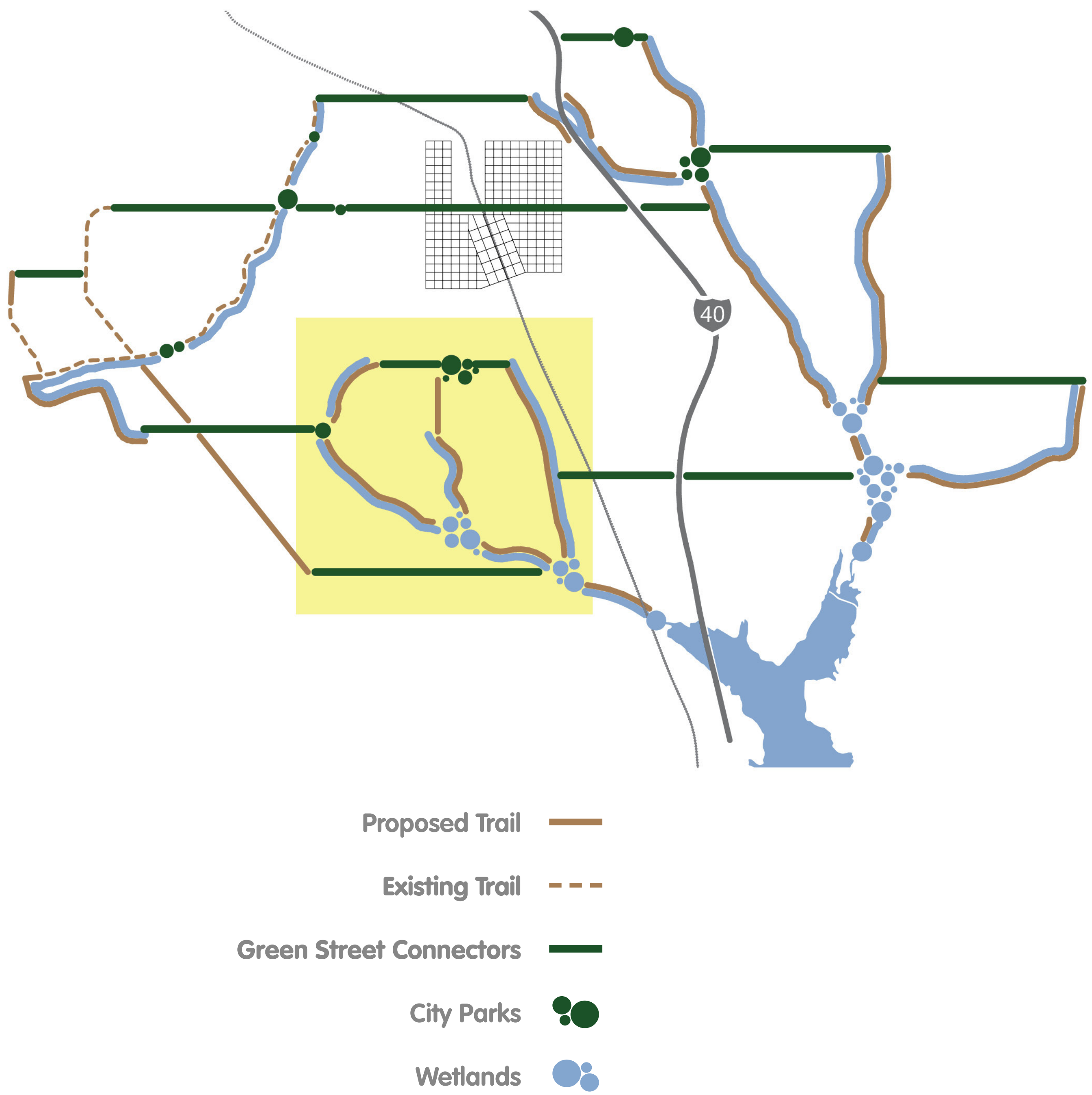
For the city to work like a sponge, greenways can readily employ Low Impact Development techniques, riparian corridor improvements, and green infrastructure. These tools slow, soak, and spread urban runoff through landscape systems, given their intrinsic capacity for biologic treatment and metabolization of contaminants…and they can be inspiring cityscapes.

conway has great bones for developing a prized greenway system

Conway

Build an alternative pedestrian and bicycle transportation network through green right-of-way improvements to riparian corridors and streets that enhance water management. Create the network from micro-loops for ease of implementation and use.

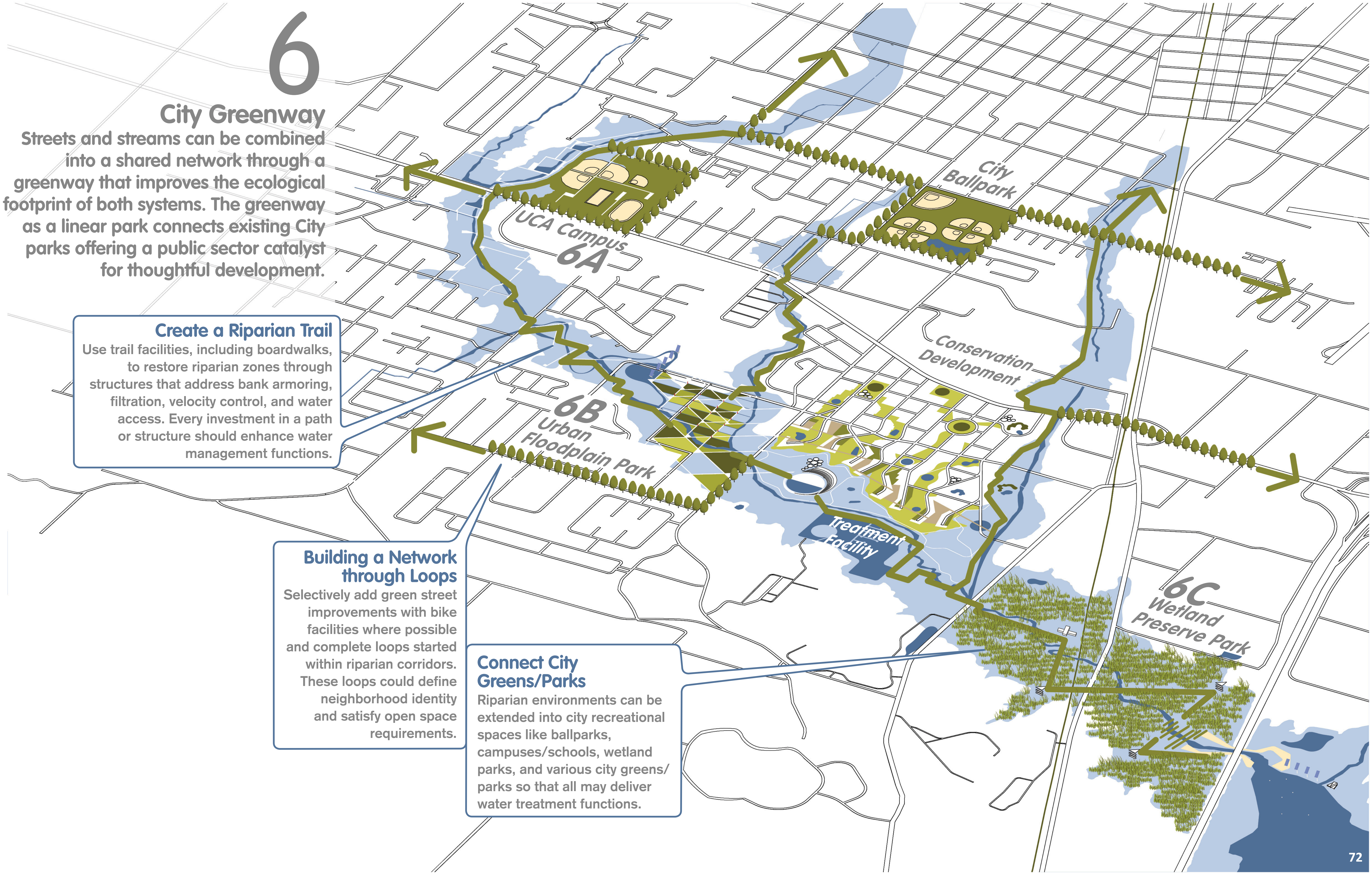
6 City Greenway



6

City Greenway

Streets and streams can be combined into a shared network through a greenway that improves the ecological footprint of both systems. The greenway as a linear park connects existing City parks offering a public sector catalyst for thoughtful development.



Create a Riparian Trail

Use trail facilities, including boardwalks, to restore riparian zones through structures that address bank armoring, filtration, velocity control, and water access. Every investment in a path or structure should enhance water management functions.

Building a Network through Loops

Selectively add green street improvements with bike facilities where possible and complete loops started within riparian corridors. These loops could define neighborhood identity and satisfy open space requirements.

Connect City Greens/Parks

Riparian environments can be extended into city recreational spaces like ballparks, campuses/schools, wetland parks, and various city greens/ parks so that all may deliver water treatment functions.

6A

City Greenway: UCA Campus

Restored Riparian Corridor 1
Employ corridor improvements in tandem with transportation facilities for pedestrians and cyclists.

Living Wall 2
Retrofit concrete walls on riparian edge with a vertical garden in lieu of removing walls (typical).

Cooling Water Bosques 3
Locate tree clusters near a water body to regulate stream temperature.

Parking Gardens 4
Retrofit parking facilities with low impact development technologies to manage stormwater runoff.

Bridges with Flow Control 5
Equip bridges with functions in their undercarriage to dissipate flow energy during flood events.

Natural Bank Armoring 6
Remove the concrete edge and restore the stream's natural sinuosity, banks, and vegetation.

Native Mussels 7
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli.

0 600' 1200'

6A

City Greenway: UCA Campus

Urban Floodplain Meadow

provides **regulating services** by reducing water velocity and spreading flood waters in a wet meadow while controlling erosion and facilitating sedimentation. The wetland environment delivers a full range of hydrological services amidst recreational amenities as a **cultural service.**

Boardwalk Check Dams

provide water flow **regulating services** by slowing, spreading, and storing stormwater runoff in retention ponds where sedimentation and groundwater recharge is facilitated. Boardwalk filters sediment as it flows though structure.

6B

City Greenway: Urban Floodplain Park

Restored Riparian Corridor 1
Restore thalweg sinuosity, bankfull, vegetated banks, and floodplain for full ecological functioning.

Retention Ponds 2
Capture and store stormwater runoff in wetland habitat as a trail amenity.

Solar Aeration Aquabot 3
Deploy aquabots that increase oxygenation in water, enhancing aquatic habitat.

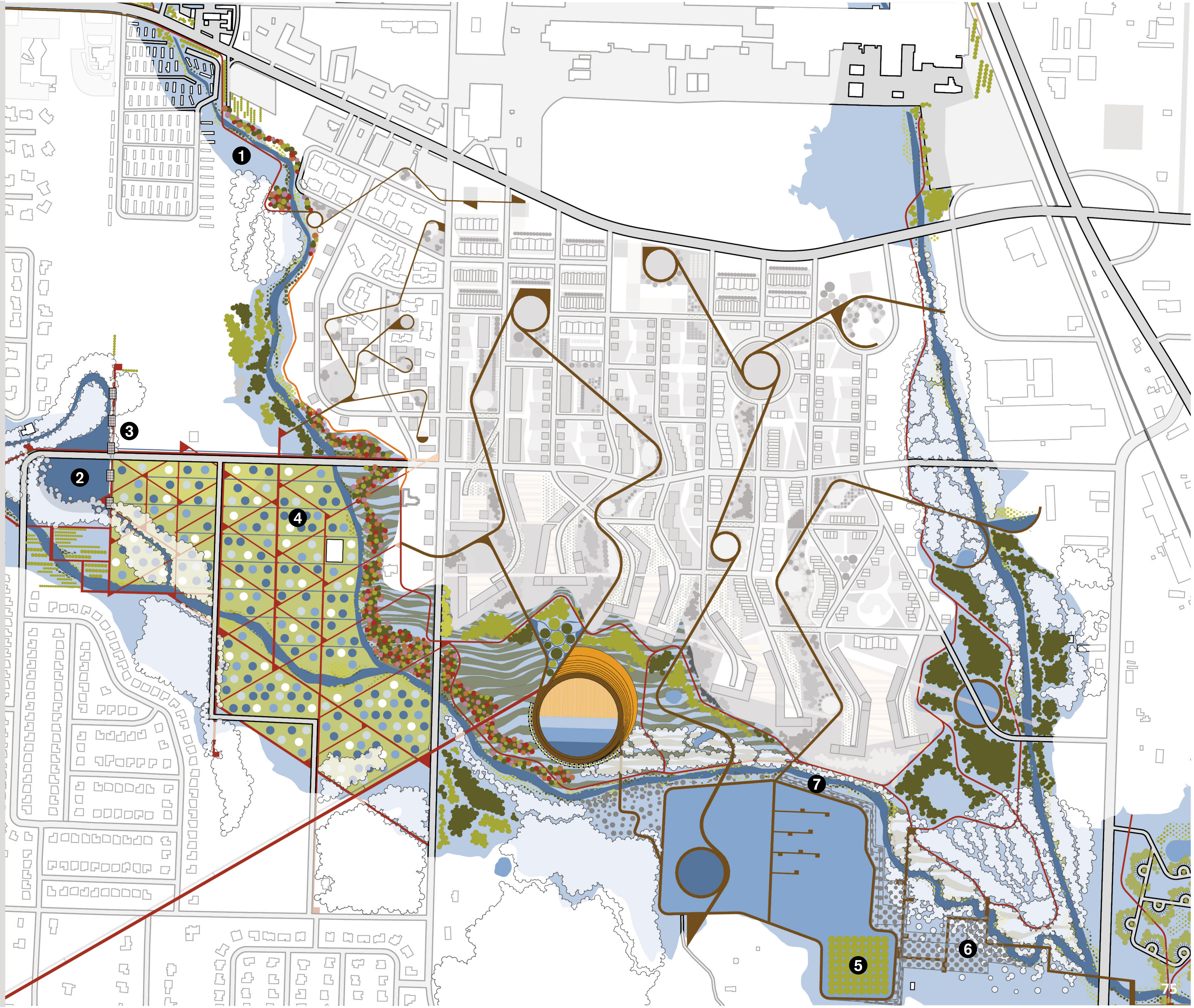
Pollination Grid 4
Cultivate a wetland meadow to provide food and habitat to attract pollinators back to the city.

Bald Cypress Bosque 5
Install bald cypress groves in flood-prone areas to provide air and water purification services.

Oxygenating Riffles 6
Restore streambed sinuosity and texturing to increase oxygenation in water, enhancing aquatic habitat.

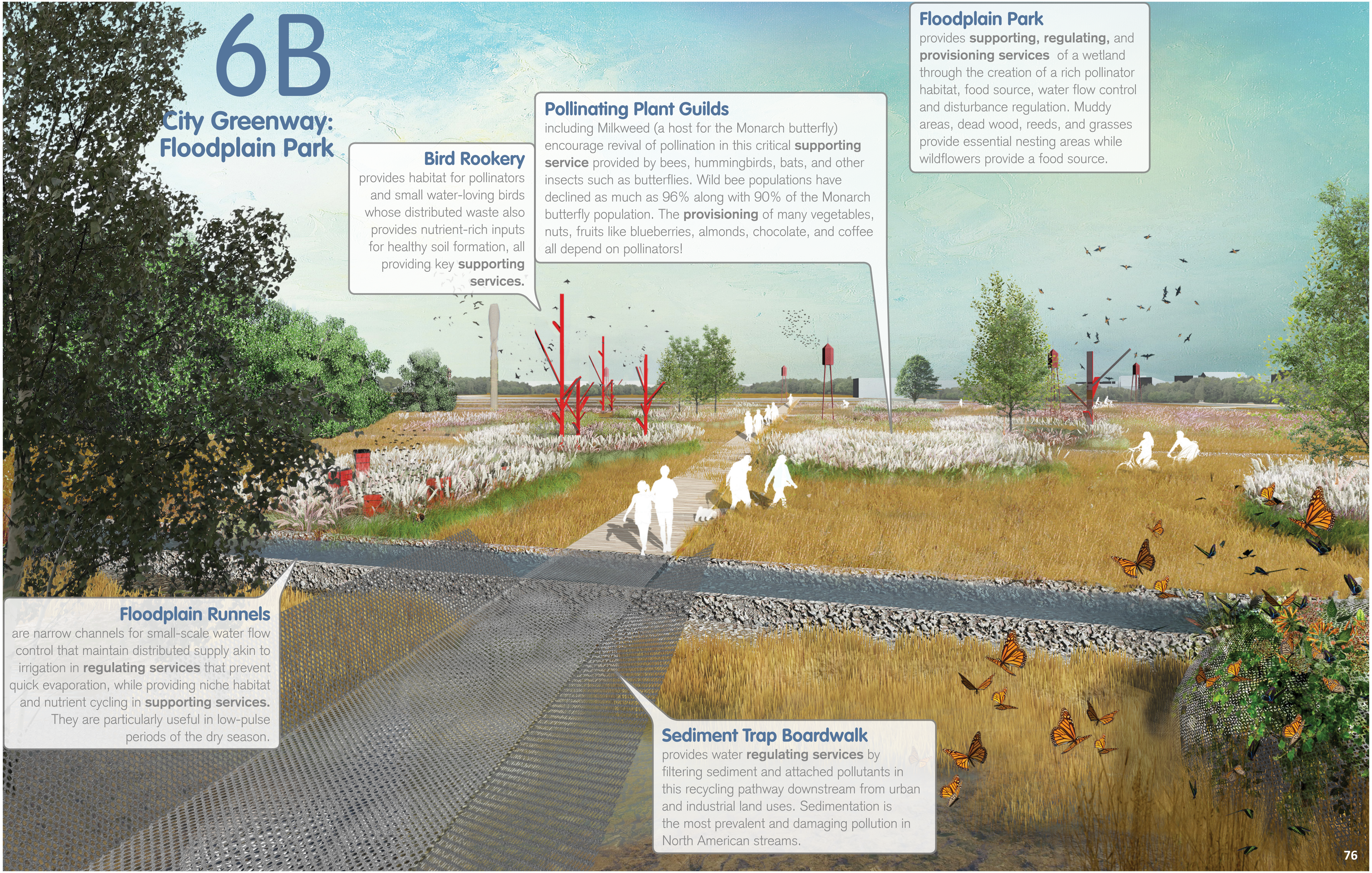
Native Mussels 7
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli.

0 600′ 1200′



6B

City Greenway: Floodplain Park



Floodplain Park

provides **supporting, regulating,** and **provisioning services** of a wetland through the creation of a rich pollinator habitat, food source, water flow control and disturbance regulation. Muddy areas, dead wood, reeds, and grasses provide essential nesting areas while wildflowers provide a food source.

Pollinating Plant Guilds

including Milkweed (a host for the Monarch butterfly) encourage revival of pollination in this critical **supporting service** provided by bees, hummingbirds, bats, and other insects such as butterflies. Wild bee populations have declined as much as 96% along with 90% of the Monarch butterfly population. The **provisioning** of many vegetables, nuts, fruits like blueberries, almonds, chocolate, and coffee all depend on pollinators!

Bird Rookery

provides habitat for pollinators and small water-loving birds whose distributed waste also provides nutrient-rich inputs for healthy soil formation, all providing key **supporting services.**

Floodplain Runnels

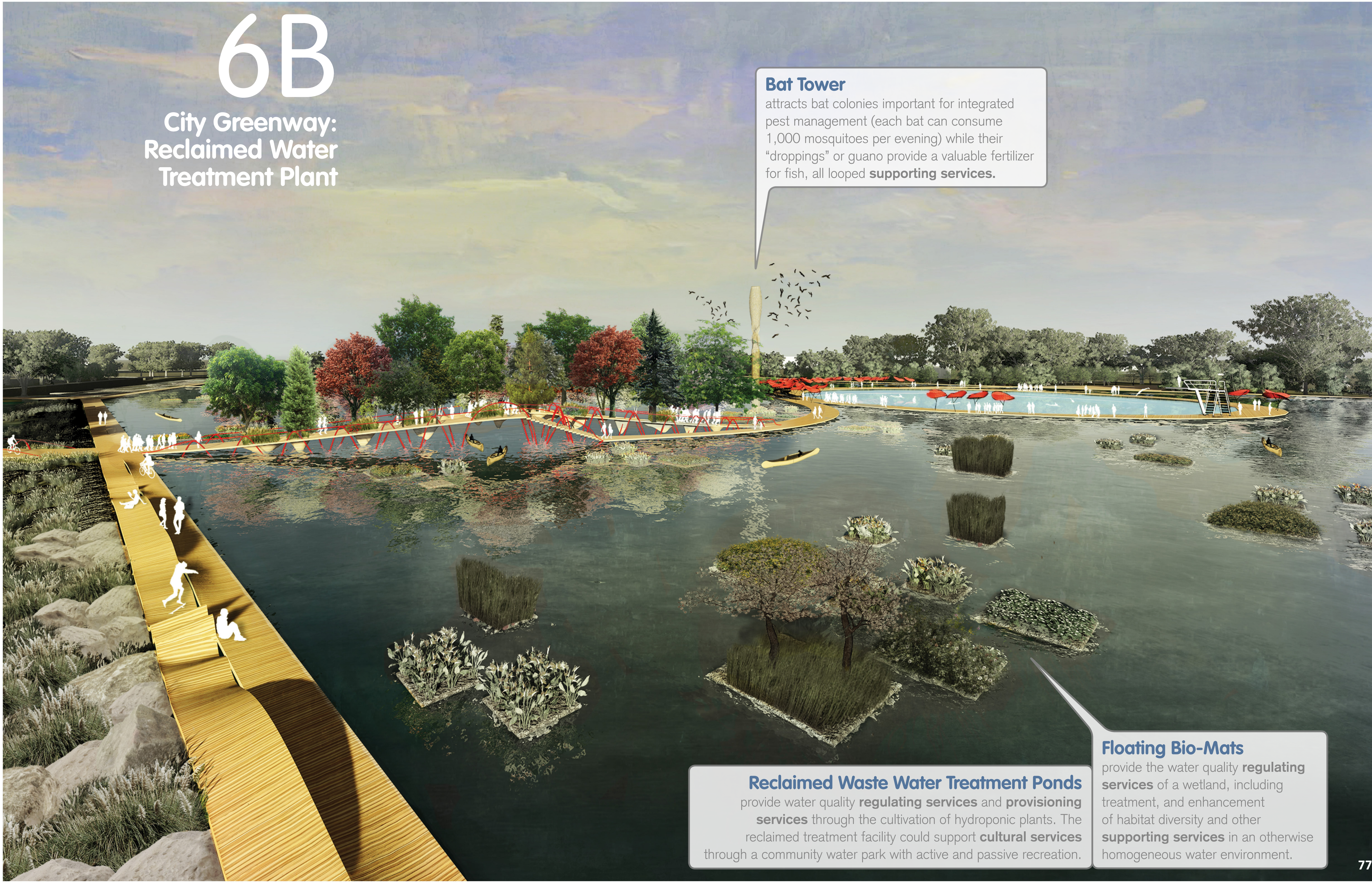
are narrow channels for small-scale water flow control that maintain distributed supply akin to irrigation in **regulating services** that prevent quick evaporation, while providing niche habitat and nutrient cycling in **supporting services.** They are particularly useful in low-pulse periods of the dry season.

Sediment Trap Boardwalk

provides water **regulating services** by filtering sediment and attached pollutants in this recycling pathway downstream from urban and industrial land uses. Sedimentation is the most prevalent and damaging pollution in North American streams.

6B

City Greenway: Reclaimed Water Treatment Plant



6C

City Greenway: Wetland Preserve

Wetland Restoration 1
Restore hydrological functioning and ecological functioning of floodplains.

Bald Cypress Bosque 2
Install bald cypress groves in flood-prone areas to provide air and water purification services.

Red Twig Dogwood Filtration Marsh 3
Install this naturalized wetland woody species used to purify water by filtering sediment and nutrients.

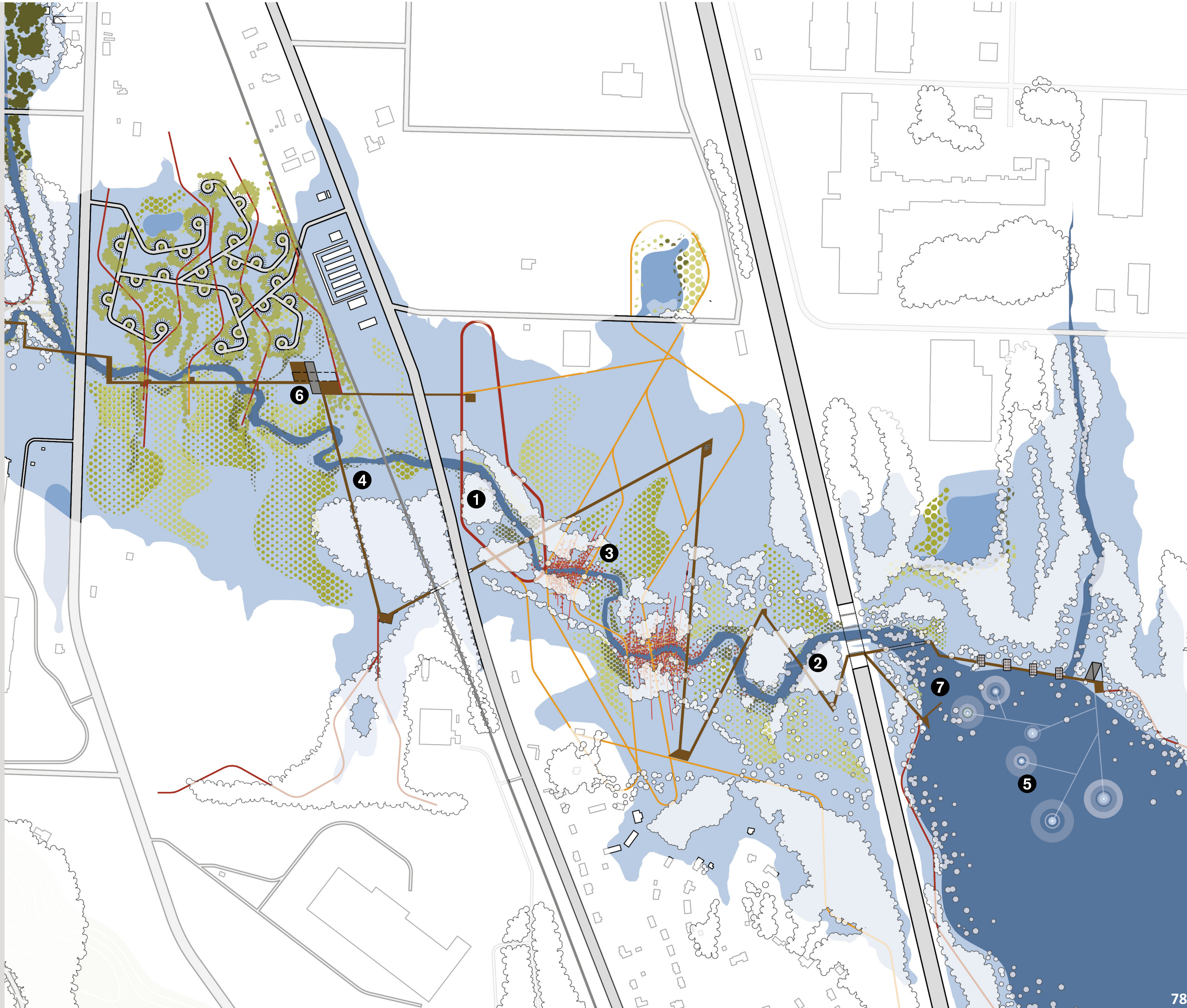
Filtration Boardwalk 4
Equip boardwalks with an undercarriage that filters water and traps sediment while serving as a platform for navigating wetland areas.

Solar Aeration Aquabot 5
Deploy aquabots that increase oxygenation in water, enhancing aquatic habitat.

Recreational/Educational Facilities 6
Develop a lake head system of viewing towers, boardwalks, and trails.

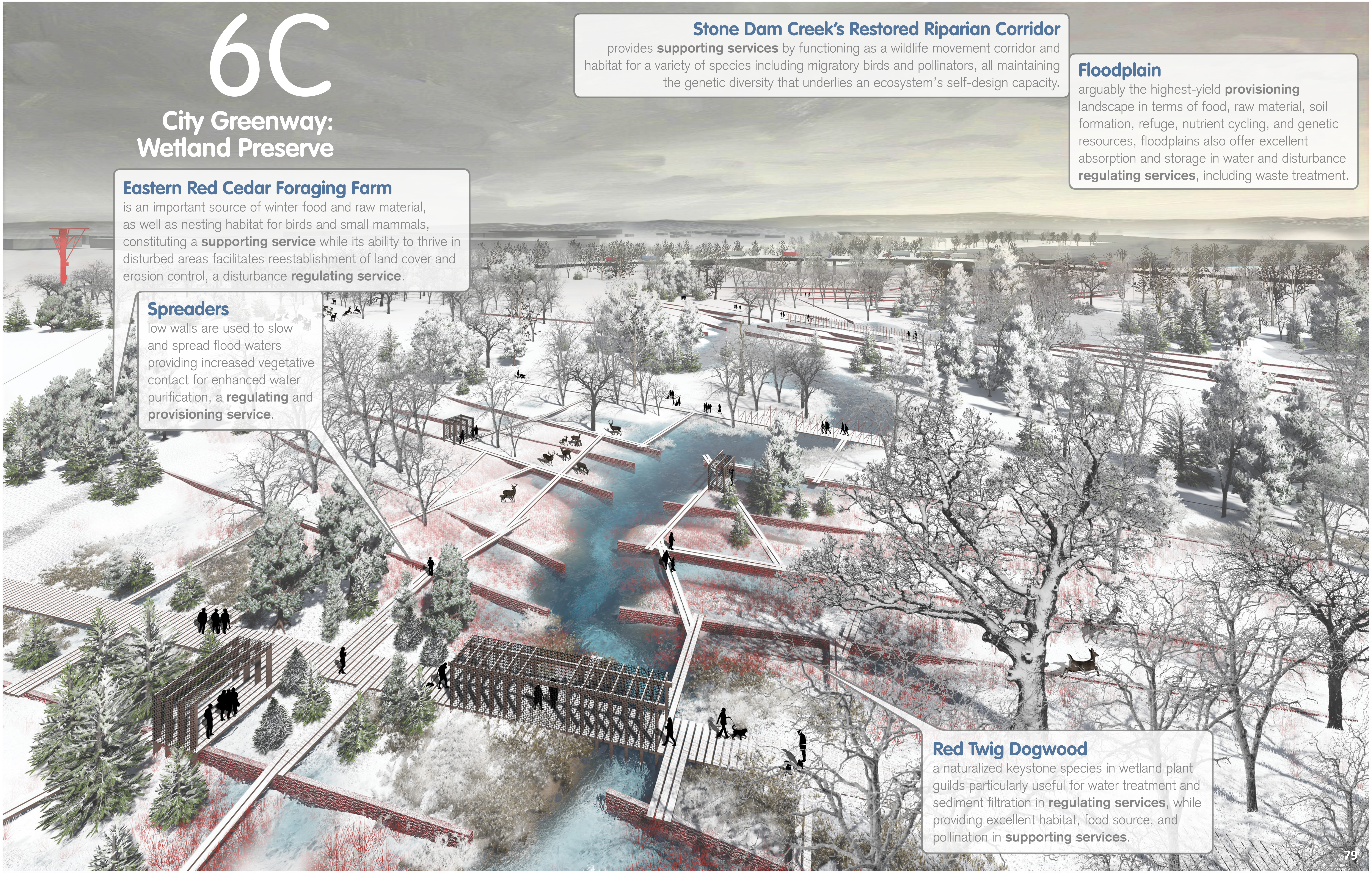
Native Mussels 7
Introduce these endangered nutrient filters into water bodies to reduce harmful bacteria, especially E. coli.

0 600′ 1200′



6C

City Greenway: Wetland Preserve



Why not make Conway a national model for a reconciliation landscape between city and water ?

Ecological Design Principles

1 Ecosystem structure and functions are determined by forcing functions of the system.
2 Energy inputs to the ecosystems and available storage of matter are limited.
3 Ecosystems are open and dissipative systems.
4 Attention to a limited number of factors is most strategic in preventing pollution or restoring ecosystems.
5 Ecosystems have some homeostatic capability that results in smoothing out and depressing the effects of strongly variable inputs.
6 Match recycling pathways to the rates of ecosystems to reduce the effect of pollution.
7 Design for pulsing systems wherever possible.
8 Ecosystems are self-designing systems.
9 Processes of ecosystems have characteristic time and space scales that should be accounted for in environmental management.
10 Biodiversity should be championed to maintain an ecosystem's self-design capacity.
11 Ecotones, or transitions zones, are as important for ecosystems as membranes are for cells.
12 Coupling between ecosystems should be utilized wherever possible.
13 The components of an ecosystem are interconnected, interrelated, and form a network, implying that direct as well as indirect effects of ecosystem development need to be considered.
14 An ecosystem has a history of development.
15 Ecosystems and species are most vulnerable at their geographic edges.
16 Ecosystems are hierarchical systems and are part of a larger landscape.
17 Physical and biological processes are interactive. It is important to understand both physical and biological interactions and to interpret them properly.
18 Ecotechnology requires a holistic approach that integrates all interacting parts and processes as far as possible.
19 Information in ecosystems is stored in structures.

Source: Mitsch and Jorgensen, *Ecological Engineering and Ecosystem Restoration*, 2004

Glossary

303(d) list of impaired water bodies
Under section 303(d) of the Clean Water Act, states, territories and authorized tribes are required to submit lists of impaired waters. These water bodies are too polluted or otherwise degraded to meet designated water quality standards. The law requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters.

adaptive management
Iterative process of decision making based on learning and interaction with feedback to improve management outcomes of resources.

bankfull
Composite stream channel consisting of the thalweg belt (baseflow) with water at least part of the year, and the full channel just before flooding. Bankfull formation is determined by the interaction among sediment discharge, sediment particle size, stream flow, and stream slope.

benthic
The ecological zone at the bottom of a water body such as a lake or ocean, including the sediment surface layer housing invertebrate communities.

bioremediation
Treatment processes that improve water quality by utilizing phytoremediation or microbial processes that metabolize contaminants in stormwater runoff.

borrow-fill technique
A borrow is an area where soil, gravel, or sand has been dug for use as fill at another location—in this case, lake sediment has been dredged to create islands—an ancient wetland farming technique.

ecosystem services
Resources and processes that are supplied by healthy natural ecosystems and serve all living organisms. The 17 ecological services are: atmosphere regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, species control, refugia, food production, raw material production, genetic resources, recreation, and cultural enrichment.

ecotone
A transitional zone between two adjacent but different plant communities where a high level of niche biogeochemical changes occur.

emergent vegetation
Vegetation that is rooted below the mean water level but extends above the water level.

eutrophication
A natural aging process in lakes characterized by reduced dissolved oxygen levels in water due to concentrations of nutrients that stimulate excessive plant growth such as algae, eventually altering water quality regime and reducing aquatic life.

evapotranspiration
The process by which water is transferred from the Earth to the atmosphere through the combined efforts of transpiration from plants and evaporation from water bodies.

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

first flush
Initial pulse of stormwater runoff that captures stationary pollutants, resulting in higher levels of concentrated pollution than that which occurs during the rest of the storm event.

floodplain
Areas adjacent to a stream or river that experience periodic flooding where floodwaters accumulate and dissipate their energy. The floodplain includes the floodway, which carries significant volumes of flood water, and the flood fringe, the area covered by the flood.

flow attenuation
Dissipation of peak stormwater runoff flows and volume following rain events.

green infrastructure
Infrastructure that incorporates soft engineering to deliver ecosystem services such as stormwater management, food production, improved air quality, healthy soils, and atmospheric regulation. Going beyond the simple minimalization of ecological harm, green infrastructure aims to be regenerative, providing an ecological framework for enhancing community livability.

greenway
A corridor of public open space used for recreation and pedestrian and bicycle traffic often located along water bodies.

hard engineering
Conventional civil engineering systems reliant on mechanical abiotic structures for infrastructural purposes.

Hydrological Unit Code (HUC)
Nationwide geographic classification characterizing either the drainage area of a river or the combined drainage areas of a series of rivers. Hydrologic units are classified into four levels: regions, sub-regions, accounting units, and cataloging units—the latter also known as watersheds.

hydric soil
Relating to soils that are formed under conditions of saturation, flooding, or ponding long enough to develop anaerobic conditions in the subsurface layers.

hydrocarbons
Class of organic chemical compounds that are the principal ingredients of petroleum, lubricants, and natural gas as well as raw materials for the production of plastic, rubber, solvents, and industrial chemicals.

impervious surface
A material unable to transmit fluids through its surface.

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

Leaf Area Index (LAI)
Characterization of plant canopy density based on one-sided green leaf area per unit ground surface area in broadleaf canopies, and selected needle surface area per unit ground surface area for conifers. LAI impacts stormwater functioning in addition to other plant functions.

Low Impact Development (LID)
LID is an ecologically-based stormwater management approach using landscape architecture 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.

nonpoint source pollution
Surface level pollutants generated by diffused human activities concentrated and transported by stormwater runoff.

phytoremediation
Mitigation of contaminated soil, water, or air using the microbial processes in plants to contain, degrade, or eliminate pollutants.

rain terrain
In wet areas, landscapes and green infrastructure designed to hold water for disturbance regulation, versus riparian corridors whose properties are based on drainage and channeled flow. Here, rain does not flow, but rather overflows, expressing the complex behavior in spreading and soaking.

resilient
Of or relating to the capacity of a system, in this case urban areas to retain social and ecological functioning in the course of being exposed to disruptions, shocks, or black swan events.

riffle-pool-glide
Algorithm of alternating shallow and deep areas in the stream baseflow (thalweg). A function of stream sinuosity and sediment character, riffles are shallow depositories that form between two bends as the thalweg crosses between channel sides. Pools typically form in the thalweg near the outside bank (erosive side) of bends. Pool-to-pool spacing is typically 7-12 times bankfull width.

riparian
Of or relating to the bank of a river or stream.

sedimentation
A mechanical process in which suspended solids settle to the bottom of a water body under the influence of gravity.

shared streets
Multipurpose right-of-ways that create a common space to be shared by vehicles, pedestrians, bicyclists without conventional mode separators like lanes, sidewalks, and curbs.

soft engineering
Civil engineering systems that integrate engineering, ecological, urban, and landscape design to use biological processes and materials for infrastructural purposes.

submergent vegetation
Vegetation that thrives completely submerged below standing water level.

successional
In both ecology and urbanism, the progressive replacement of one community by another of greater complexity until a climax stage is established.

thalweg
The deepest and lowest channel of a stream marking the natural direction of a watercourse.

urban services
Material benefits that are supplied through urban infrastructure primarily related to housing, commerce, recreation, mobility, public safety, and utilities related to communications, waste treatment, water supply, and power services.

urban stream syndrome
Unhealthy stream flow regimes marked by chronic flash flooding, altered stream morphologies, elevated nutrient and contaminant levels, excessive sedimentation from eroded stream banks, and loss of species diversity.

watershed
The geographical area drained by a river or stream. In the continental United States there are 2,110 watersheds.

watershed approach
A resource management framework that addresses priority water resource goals, taking into consideration multiple stakeholder interests in groundwater and surface water management.

> *"But is it really chaos that lies beneath the lines of rivers? Or is it a competing belief, namely that water is everywhere before it is somewhere: it is rain before it is in rivers; it soaks, saturates, evaporates before it flows? If so, then the lines of the rivers are not universal but rather products of a particular literacy though which water is read, written, and drawn on the earth's surface, on paper, and in the imagination."*

Design in the Terrain of Water
Anuradha Mathur and Dilip da Cunha

water is everywhere before it is somewhere...