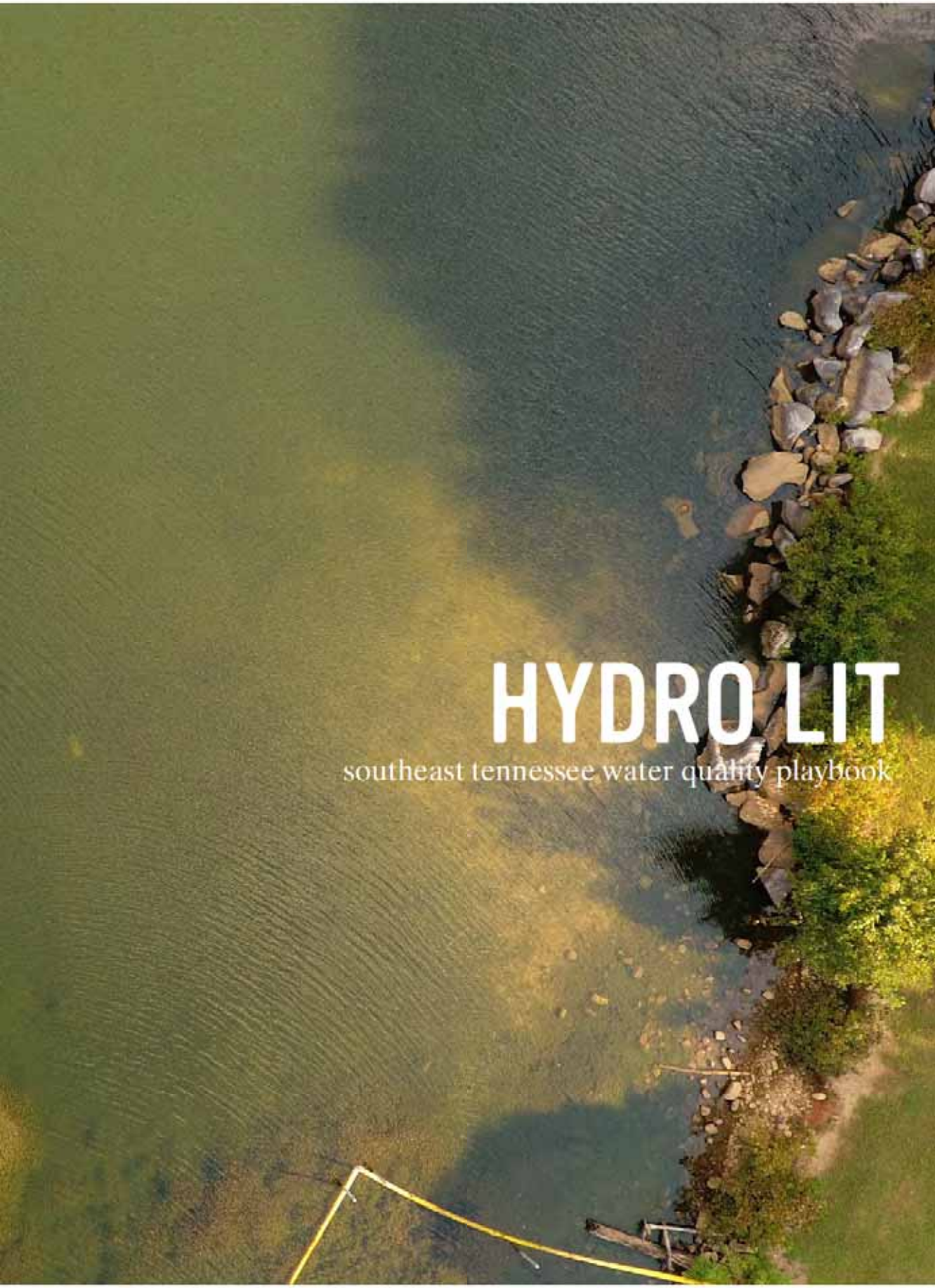

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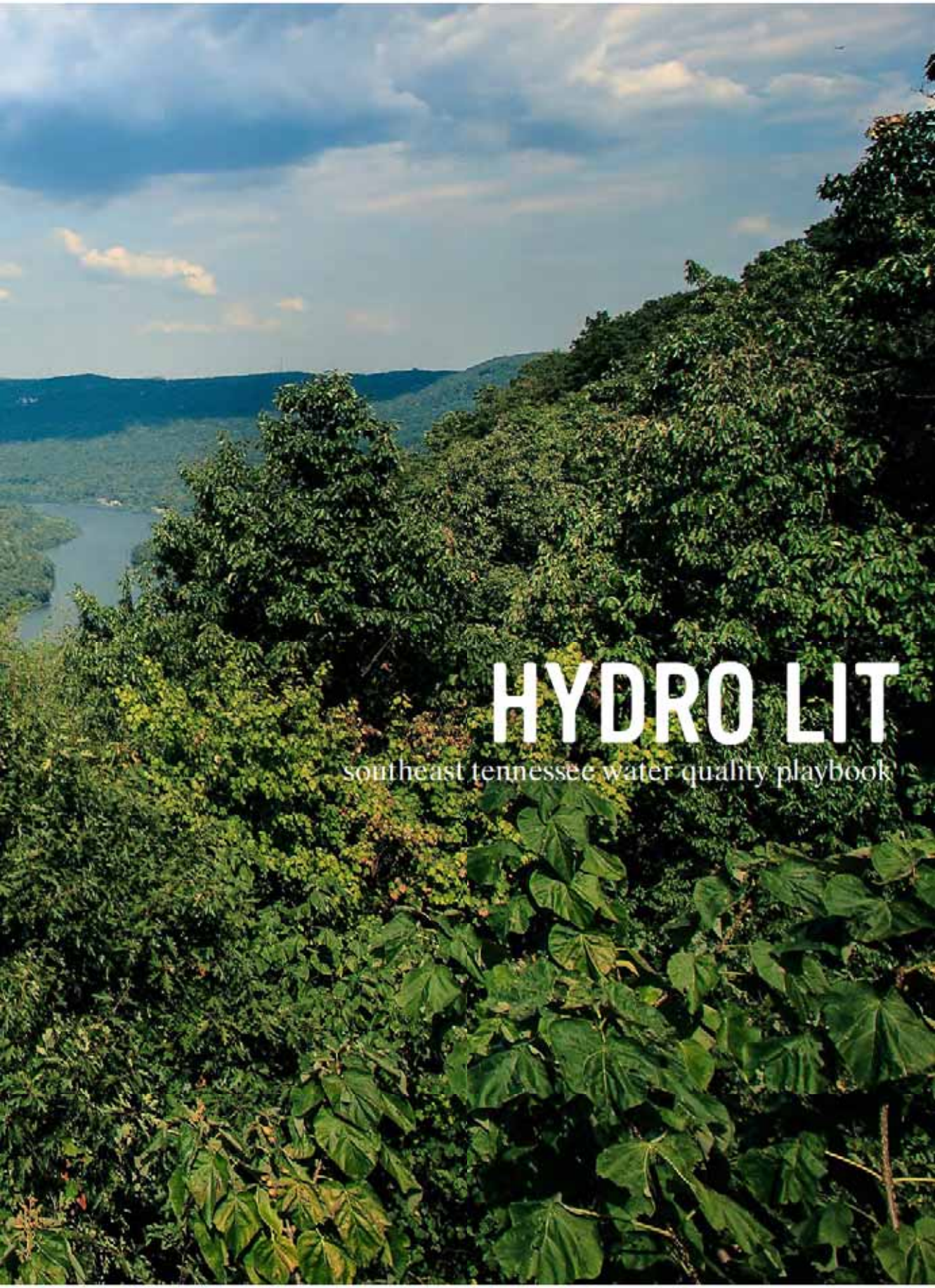
southeast tennessee water quality playbook



HYDRO LIT

southeast tennessee water quality playbook

on the cover

NICKAJACK RESERVOIR

Nickajack Reservoir is the southern-most extent of the Tennessee River before it effectively leaves the political and hydrological boundaries of the SETD. Though also carrying waters and suspended contaminants from the upper reaches of the Tennessee River watershed, the quality of the water in Nickajack is most directly affected by the landscapes of the SETD region.

At the time of this publication, the Tennessee Valley Authority and the U.S. Environmental Protection Agency has rated the water quality of Nickajack Reservoir as follows:

Tennessee Valley Authority[1]:
at the forebay monitoring location
Dissolved Oxygen: Good
Chlorophyll: Poor
Fish: Fair
Bottom Life: Good
Sediment: Fair

U.S. Environmental Protection Agency[2]:
Status: Impaired
Causes of Impairment: Dioxins, Polychlorinated Biphenals
TMDL Development Status: TMDL Needed
NFLA Advisory Report: Restricted catfish consumption, all populations; no consumption, sub-populations; PCBs

PREPARED FOR:

SETD: Southeast Tennessee Development District
by the University of Tennessee, Knoxville, School of Landscape Architecture
College of Architecture + Design
College of Agricultural Sciences and Natural Resources

In Partnership with the UT Smart Communities Initiative

The UT Smart Communities Initiative (SCI) is founded upon the idea that universities and communities should work together to improve the health and vitality of their areas. Through the leveraging of interdisciplinary research and scholarship, community dialogue, human capacity, and innovation, municipal and university partners will collaborate toward the pursuit of smarter, more vibrant communities. SETD was chosen as the 2015-16 SCI Partner.

ISBN 978-0-9915667-8-5

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HYDRO LIT

southeast tennessee water quality playbook

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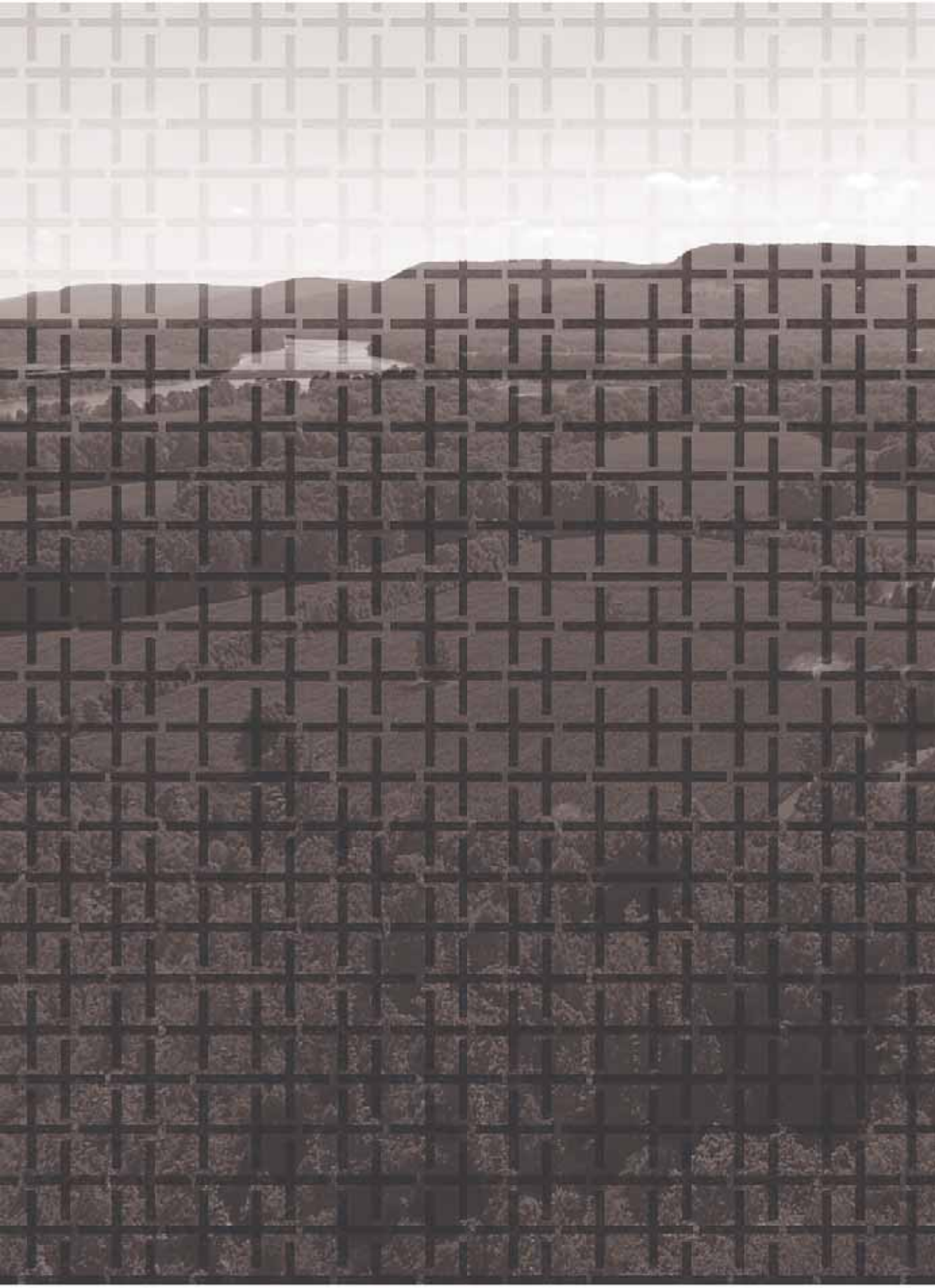

PREFACE


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AIRE

SHARED RESOURCES
WATER IN SOUTHEAST TENNESSEE

"In rivers, the water that you touch is the last of what has passed and the first of that which comes."

- Leonardo da Vinci

Water is a shared resource that shapes Southeast Tennessee's physical, economic and cultural landscapes. The cycles, systems and networks of water resources have fashioned the region's iconic physiography. The Ocoee, Hiwassee, Sequatchie, and Tennessee Rivers and their tributaries carve sublime gorges, pastoral valleys, and rambling hollers from the Blue Ridge and Cumberland Plateau, creating fertile floodplains suitable for agronomic production and human settlement. These waters are home to unique and valuable ecosystems and a diversity of aquatic wildlife that is unrivaled in other North American river systems.[3]

Water has been harnessed to fuel a burgeoning economy with clean renewable energy. Its reliability and abundance sustains growing industries and populations. The region's water resources enable local residents and visiting tourists pursue active lifestyles, enhancing the quality of life offered by Southeast Tennessee and in turn its economic competitiveness.

The social, economic, and environmental benefits of these waters are shared by all. The water carried in Southeast Tennessee's rivers, streams and reservoirs originates from headwater landscapes, springs and aquifers both inside and outside of the region's geography. Water quality is influenced by upstream communities and land uses, while downstream communities inherit the water quality consequences of the region's land use and infrastructure choices.

Water is arguably the most fundamental and emblematic resource of the region, and yet its health is threatened by the same populations, places and patterns that will rely upon its quality and abundance into the future. Though the region celebrates many water resource stewardship success stories, pervasive water quality challenges are symptoms of existing policies, land use and development practices, and wide-spread water management infrastructure approaches that are persistent throughout the region's watersheds. These challenges will be exacerbated by imminent changes anticipated in climate patterns,[4] projected population growth and economic development[5], and the resultant changes to the region's physical landscape and hydrologic footprint.


ATLANTA JUNIOR
ROWING ASSOCIATION

SHARED VISION
ABOUT THIS PUBLICATION

HydroLIT: A Water Quality Playbook for Southeast Tennessee is the product of a partnership between the Southeast Tennessee Development District (SETD), The University of Tennessee, Knoxville Smart Communities Initiative (SCI), the UT School of Landscape Architecture, and the UT Environmental Design Lab.

SCI is a program of the Office of the University Provost and Office of Service Learning designed to match the needs of Tennessee communities with the capacity of the university, its faculty and students, through community-engaged coursework. In the Fall of 2015, a UT School of Landscape Architecture Design Studio under the direction of Assistant Professor Brad Collett collaborated with the SETD, SCI's 2015-2016 partner community, to study existing conditions and future threats to the region's water resources and to develop proposals for water quality improvement.

The findings and proposals of that studio have been shared with and reviewed critically by SETD staff and water resource experts within the region. Their observations and feedback are synthesized, formatted and presented by UT School of Landscape Architecture Faculty and Research Assistants as HydroLIT: A Water Quality Playbook for Southeast Tennessee.

This playbook catalogues the studio's research and water quality improvement strategies, aimed at addressing what it identified as the region's most significant and wide-spread water quality threats. HydroLIT complements existing water resource stewardship publications, including The Southeast Tennessee Green Infrastructure Handbook for Local Governments.[6] Building on this resource's discussion of community development principles, street design and site scale design techniques, HydroLIT expands the region's conversation around water quality improvement to also include practical and innovative strategies for enhanced regional systems, stakeholder collaboration and education, and integrated planning and design.

HydroLIT is designed to stimulate interest in and discussion around water quality improvement strategies and the proactive visions they help achieve. The playbook aims to raise awareness of these issues among the residents and stakeholders whose participation is crucial to any improvement in the condition of the region's water resources. It also calls attention to potential pitfalls, suggest initial actions, and identify precedents and supplementary resources where additional lessons may be learned.

HydroLIT is not intended to be a comprehensive authority on how to implement the suggested strategies, nor does it represent an all-inclusive list of all strategies and implementation sequences necessary to address the totality of the region's complex water quality challenges and future threats. But by working across all boundaries to implement the strategies suggested in this playbook, Southeast Tennessee can make progress towards improved water quality.

SHARED RESPONSIBILITY
FOR WHOM THIS PUBLICATION IS WRITTEN

"Water. Before it is somewhere, it is everywhere."

- Anuradha Mathur
Design in the Terrain of Water

Before water is in a sparkling glass on a café table; it is runoff from a forest, front yard, parking lot or agricultural field. Before it reflects the setting sun on one of the region's rivers or reservoirs, it is discharged as a waste product of industrial processes at power plants, factories, and waste/stormwater management infrastructures. Before it surges forth from a mountain spring or dances downslope as a stream, it precipitates and touches every tree, road and rooftop in the region, mobilizing any debris or trace elements that collect on their surface.

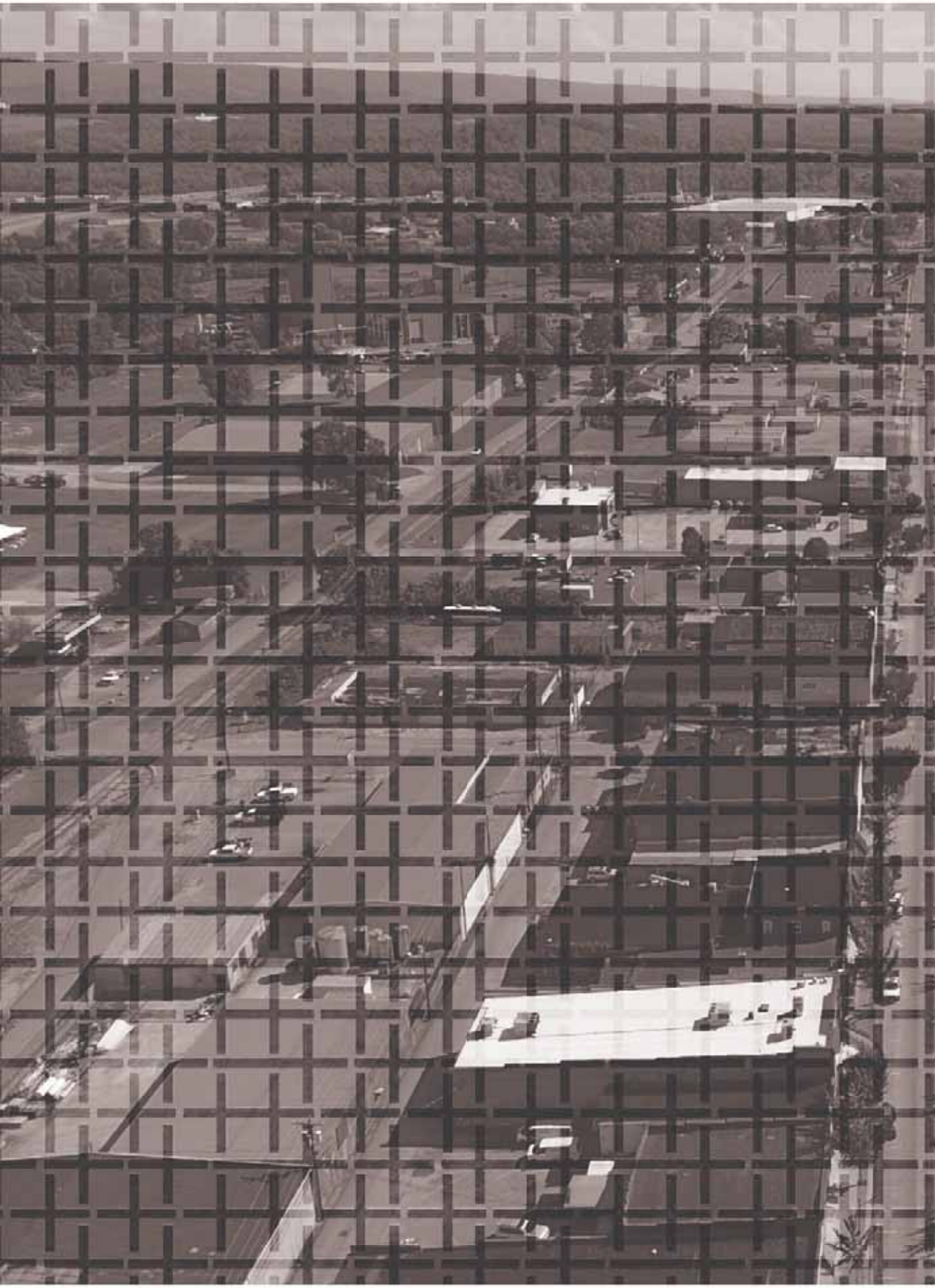
Because water is everywhere, everyone shares a role in its stewardship. As such, this publication is written for a range of stakeholders whose actions, territories, and obligations influence regional water resources, who assert their right to the use of the region's water resources, and who therefore bear responsibility to steward its health. This publication's intended audience includes policy makers, enforcement agencies, developers and builders, community organizations, business owners, and individual residents.

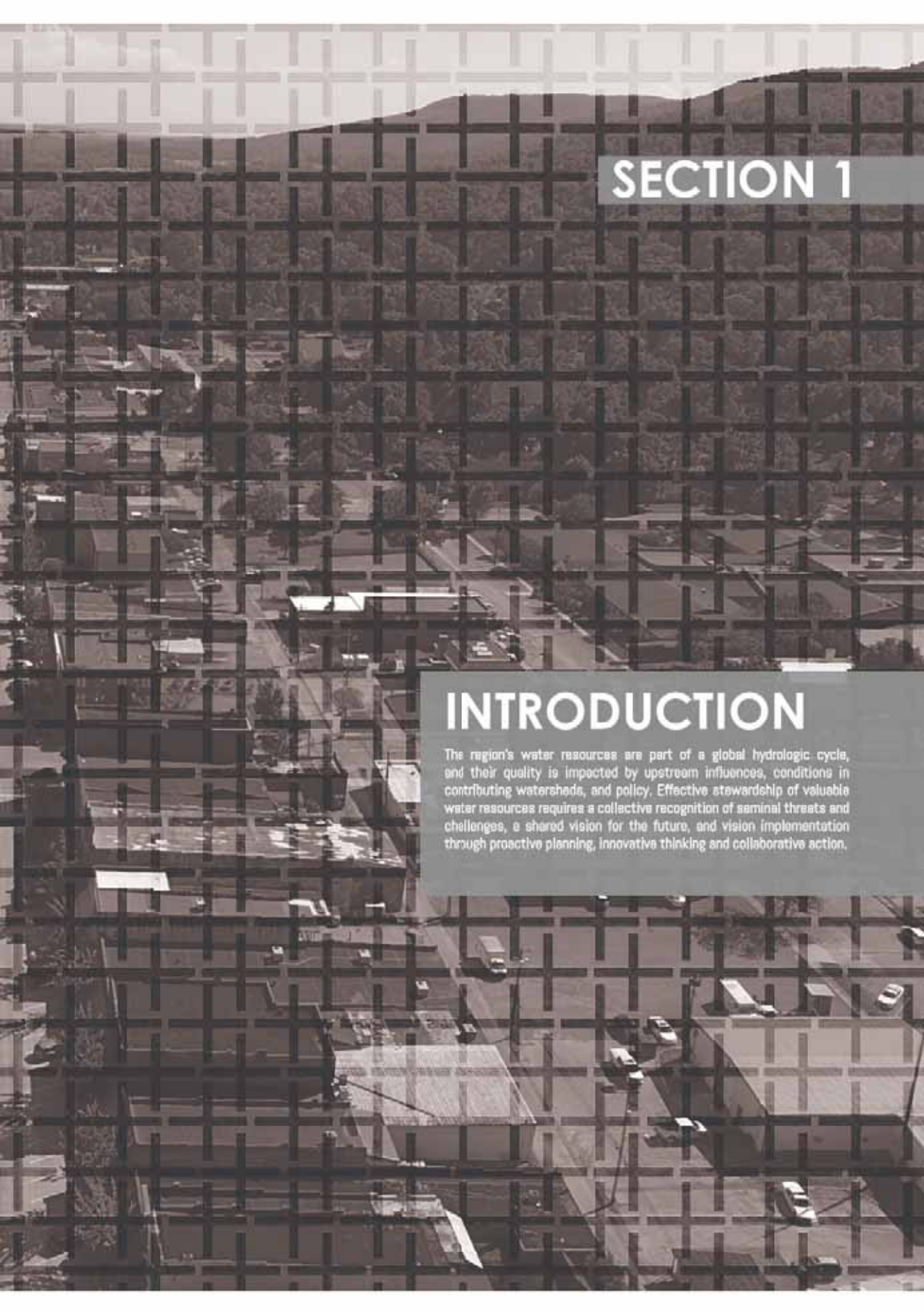
SHARED OPPORTUNITY
WHAT CAN BE ACCOMPLISHED

Southeast Tennessee's legacy of overcoming its past challenges has been made possible through regional collaboration, a 'can do' spirit, and a commitment to achieve shared visions for quality communities, resilient economies, and abundant, healthy natural resources. The grand challenges that face Southeast Tennessee in the next century include increasing demand for water (coupled with likely decreasing water quality), the lingering challenges embedded throughout the landscape by prior economies and obsolete modes of production, and the complex nature of anticipated water quality threats. The region again has the opportunity to assert its leadership in water resource stewardship through innovative approaches, contemporary technologies, and a spirit of regional accountability and collaboration.

Seizing this opportunity is the purpose of this publication and the ideas shared herein. When embraced by regional leaders and community members, HydroLIT is a powerful tool that can

+ Inform the importance of water resources
+ Recalibrate the lens through which water resources are understood and valued
+ Establish connections between water resource health and regional conditions and systems
+ Enable new cultures of advocacy and stewardship
+ Build capacity for enhanced management
+ Empower communities and individuals
+ Call to mind future water resource threats
+ Inspire hydro-centric decision making and proactive planning approaches





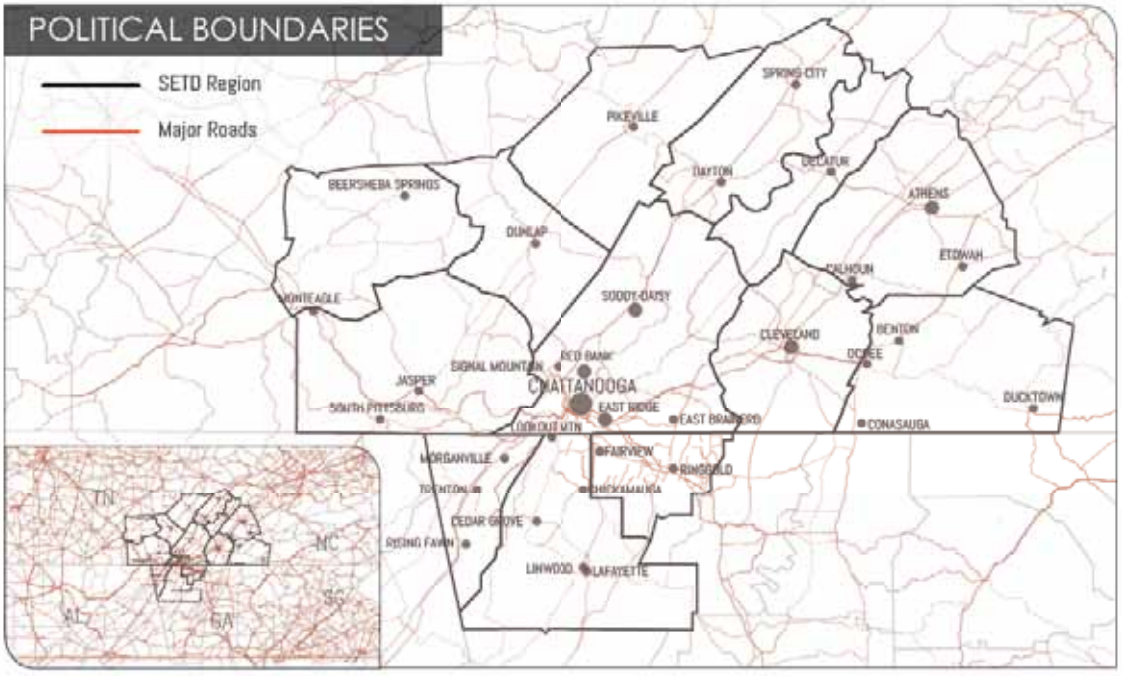
SECTION 1

INTRODUCTION

The region's water resources are part of a global hydrologic cycle, and their quality is impacted by upstream influences, conditions in contributing watersheds, and policy. Effective stewardship of valuable water resources requires a collective recognition of seminal threats and challenges, a shared vision for the future, and vision implementation through proactive planning, innovative thinking and collaborative action.

THE SETD REGION
A Study Area Defined Politically

The area that comprises the Southeast Tennessee Development District is one of the fastest growing regions in the southeastern United States. Low cost of living, reliable and inexpensive water and energy resources, mild climate and a high quality of life makes Southeast Tennessee a popular destination for new businesses and a growing population. The district is comprised of thirteen counties in Tennessee and Northwest Georgia and 54 incorporated communities. Interstates 75 and 24 connect SETD to neighboring growth centers including Nashville, Knoxville, and Atlanta, each a 2-hour drive, and the burgeoning Piedmont Atlantic Metropolitan Region.®



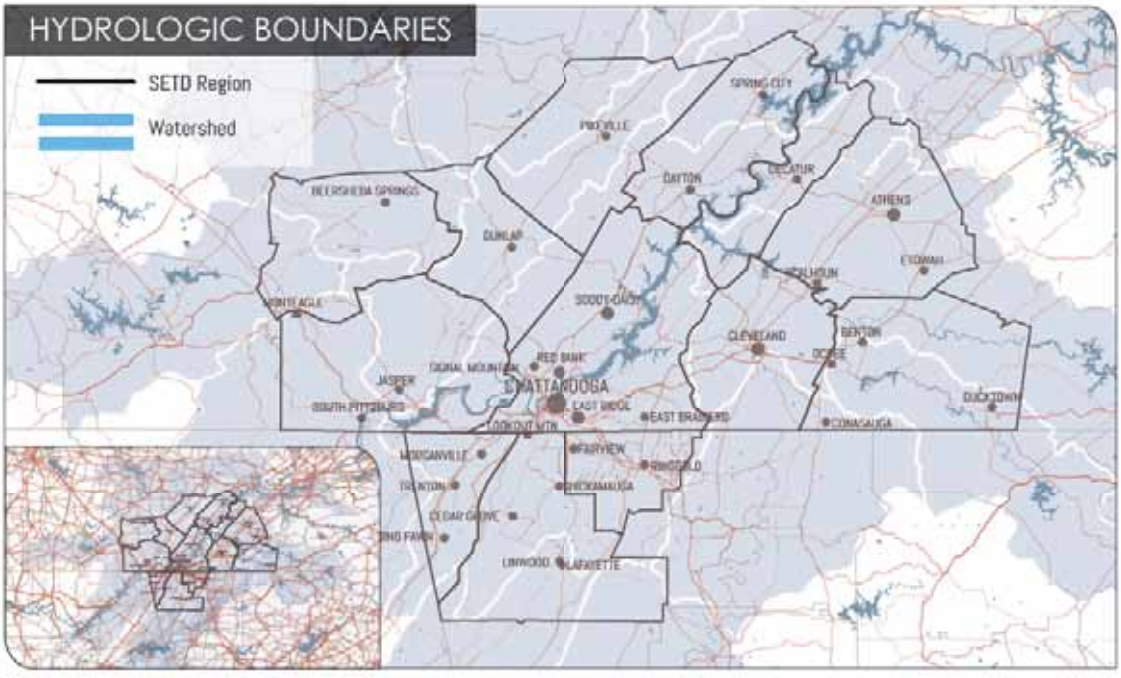
+ 13 counties
  Bledsoe, Bradley, Grundy, Hamilton, Marion, McMinn, Meigs County, Polk, Rhea, Sequatchie, Catoosa (GA), Dade (GA), and Walker (GA)

+ 1 Phase I MS4 Community and 12 Phase II MS4 Communities
  Chattanooga, Athens, Cleveland, Hamilton Co., Bradley Co., Walden, Signal Mountain, Catoosa Co., Chickamauga Co., Lookout Mountain, Fort Oglethorpe, and Walker Co.

+ 300,426 households
+ 793,578 residents
+ 23.7% Projected Population Growth by the year 2050
+ 1,668 linear miles of interstates and highways
+ 14,955 employer businesses

The Hydrologic Perspective

The landscape that affects the region's water quality, because of the watersheds that contribute to the region's surface water resources, is a much larger, hydrologically defined study area. The district's counties touch three major river basins and 12 HUC06 watersheds. The Sequatchie, Ocoee, Hiwassee and Tennessee Rivers form a network of blueways that connect the region's most densely populated and industrialized landscapes. The region's rivers, streams and reservoirs are a haven for hikers, bikers, anglers, canoers, and rafters. They host regional and national fishing tournaments, triathalons, and regattas and are home to the Ocoee Whitewater Center, an Olympic-class whitewater venue.[9]



+ 3 river basins
  Cumberland, Tennessee, and Conasauga

+ 12 watersheds
  Caney, Collins, Upper Elk, Sequatchie, Watts Bar Lake, Guntersville Lake, Chickamauga, Hiawasee, Ocoee, Upper Coosa, Oostanaula, and Conasauga

+ 4 major rivers
  Tennessee, Hiwassee, Ocoee, and Sequatchie

+ 4 state scenic rivers[10]
  Collins, Hiwassee, Conasauga, and Soak Creek

+ 7 reservoirs
  Watts Bar, Chickamauga, Ocoee, Racoon Mtn., Nickajack, Santeelah, and Fontana

VALUE OF WATER RESOURCES
A Triple Bottom Line

The valuation of any resource is traditionally thought of first in economic terms: dollars and cents. The answer to questions like "how much does something cost" ultimately drives most decisions made by communities and individuals. Such an approach to value determination ignores the worth of a resource to populations and ecosystems that can be difficult to quantify in financial terms. Contemporary valuation concepts have been expanded to also encompass the social and environmental value of a resource. These three elements of resource value are commonly referred to as the Triple Bottom Line.[11] This concept is used throughout this publication as a way of describing the costs and benefits of water quality and the value of healthy water resources to the SETD Region.

With the variety of land uses in the landscape of the region, maintaining accessible clean water resources for the overall well-being and growth of a community becomes about more than healthy ecosystems and drinking water. Beyond the ecological and environmental benefits of healthy water, the region's water resources have provided communities with recreational opportunities, industry, and good quality of life.

ECONOMIC

The economic value of water quality for the region is not limited to the cost of clean drinking water. The region's water resources are an inexpensive source of electricity production, are a valuable material input to manufacturing processes and consumer products, and are essential to contemporary waste management practices. The region's rivers and lakes are a playground for its citizens and attract tourists from around the globe. Savvy businesses understand that an educated workforce seeks the quality of life and active lifestyles that healthy water resources contribute to, making clean water resources not only a valuable commodity, but the foundation of tax-base stability and future economic growth.[12]

SOCIAL

People depend on water for every element of daily life. Starting with the human body, which is 70% water, people require water for drinking, food preparation, and overall good health and hygiene. Reducing illness improves quality of life and enables people to work successful jobs and enjoy the fruits of their labor through recreation and leisure. Clean water resources also provide a venue for mentally restorative leisure activities such as fishing and boating, and promote healthy lifestyles through physical activities like swimming, rowing, kayaking, hiking, biking and running. These activities foster socialization among neighbors, building a sense of inclusion and regional identity through clean water resources.[13]

ENVIRONMENTAL

Healthy, balanced ecosystems provide a number of services, such as filtering anthropogenic pollutants from the air and water.[14] If the environment's ability to sustain these services were compromised, humans would be required to invest in more cost-intensive treatment processes[15] in order to provide quality water for drinking supply, manufacturing, and agricultural irrigation. Water resources have shaped and enriched the region's unrivaled aquatic biodiversity,[16] topography, and other natural resources. Preserving water quality means preserving the region's identity for a rich ecological past, present, and future.

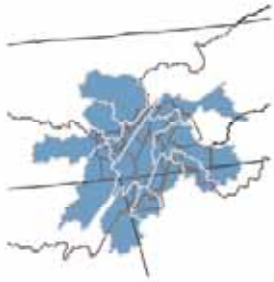
A WATERSHED APPROACH
A Water Quality Imperative

Contemporary water quality management must acknowledge the spatio-temporal movement of water resources within and across the landscape and the physical landscape conditions that affect their health. While states, cities, counties and MS4s are defined by political boundaries, water resources flow with the topography of the region without regard to these invisible lines. Nested watersheds of varying scales define the hydrologic landscape.

Water resources are vulnerable to fragmented upstream and downstream management authorities. Without cooperation and collaboration at the scale of a watershed, the efforts and improvements made by even the most progressive municipality may be compromised to poor water quality practices upstream where regulations may be less stringent and enforcement less effective. The region's streams, rivers and lakes are only as healthy as their contributing watersheds. It is at this scale that improvement strategies must be implemented.

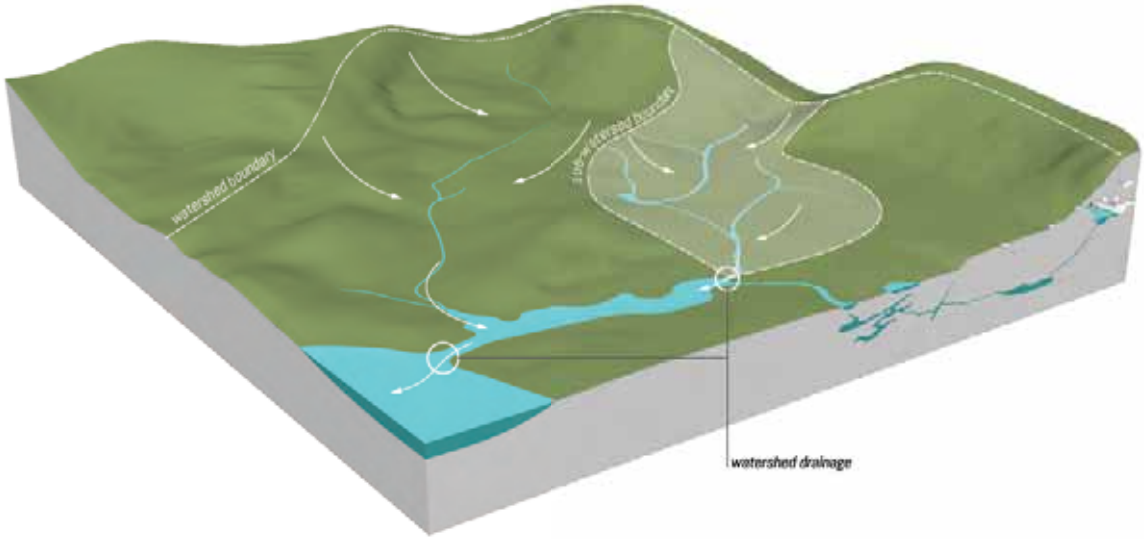
MISSISSIPPI RIVER BASIN

TENNESSEE RIVER WATERSHED



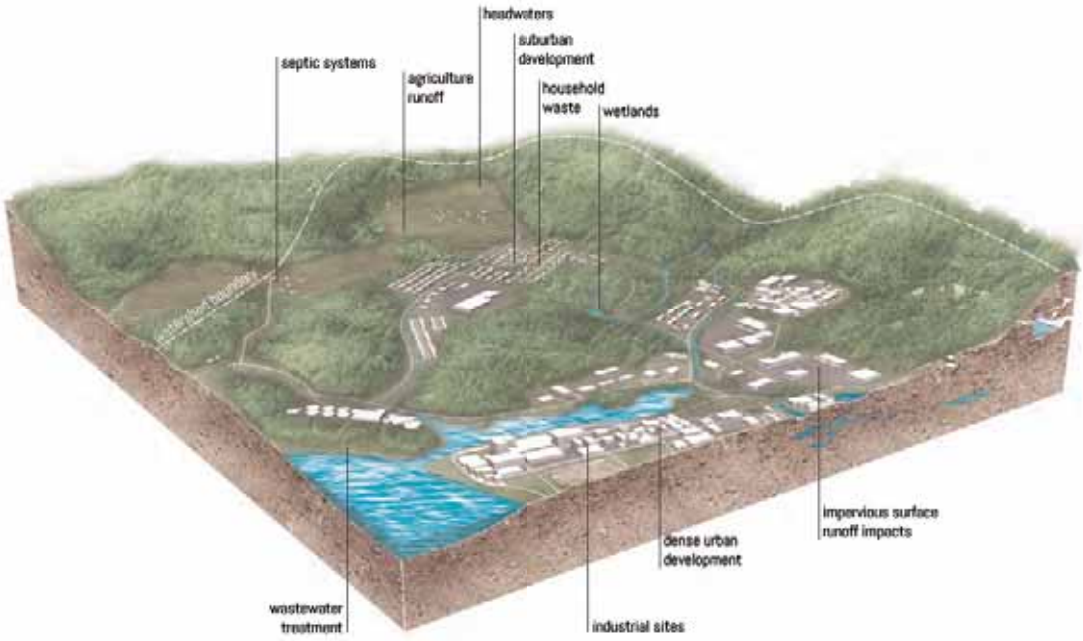
REGIONAL WATERSHEDS

WATERSHED SYSTEM

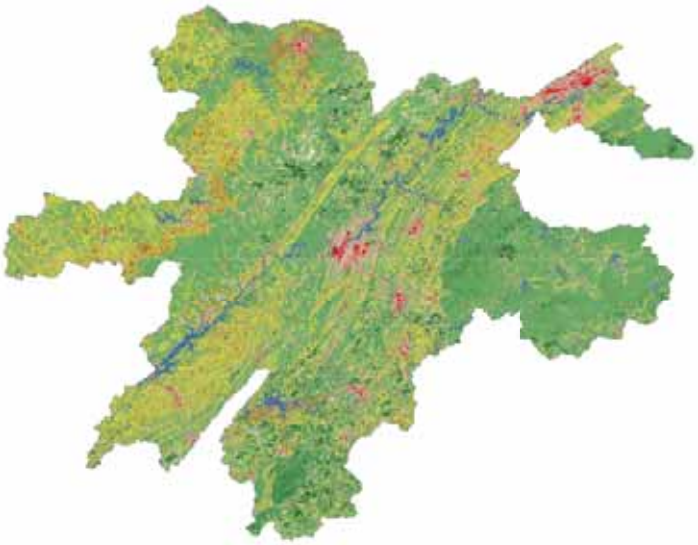


EXISTING CONDITIONS
The Landscapes of the SETD

The watersheds of the SETD region are home to a rich diversity of landscapes that receive consistent rainfall. Additionally, the state has nurtured an index of parks and wildlife conservation areas. However, while the region supports notably robust environmental territories, its current growth pattern and urban typologies have grave implications for the future of its water resources. City expansion and subsequent landscape disturbances consume entire ecosystems, altering natural hydrologic flows and discharging harmful pollutants that are carried downstream. Rural territories subsist with poor management practices and are not privy to the infrastructures found in denser development. At a regional scale, a lack of hydrocentric education and regulation persists, stunting the growth of water quality stewardship. By adopting a watershed approach to water resource management, a shift in the responsibilities and agencies of all stakeholders emerges.





National Land Cover Data[17]
Southeast TN Region
2011

The patterns of development within regional watersheds and the human activities that occur on various land uses affect the magnitude of land disturbance and byproduct release within the environment. Accumulated contaminants and the continuous disruption of natural hydrologic processes across multiple landscape typologies affect the health of the region's shared water resources.

WATER

Open water accounts for only 3% of the physiological character of the SETD region.

URBAN

Developed or urbanized land constitutes 9% of the watersheds' land cover. The edge conditions between the urban fabric and its hydrologic resources are key areas of managing pollutant discharge.

AGRICULTURE

26% of the region is related to the agricultural industry or grasslands. These typologies have the greatest potential for water stewardship.

FOREST

There remains 61% of forest cover in the region. Tennessee has long fostered a range of ecosystems that maintain the health of proximal water resources. These habitats face significant threats and must be protected and properly managed.

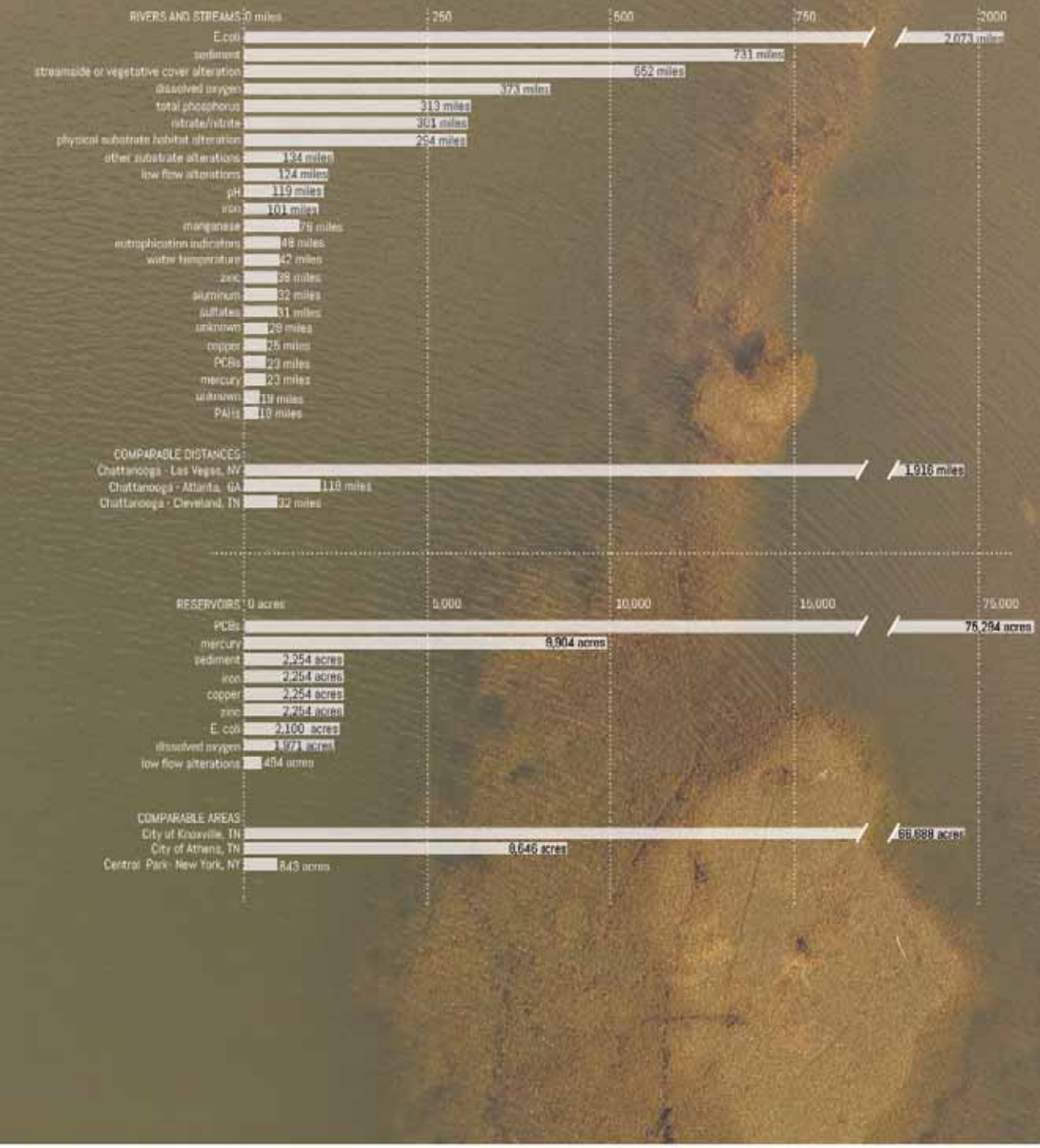
THE HYDROLOGIC CYCLE

Water Movement in the Landscape

Rivers streams and reservoirs are not bodies of water; rather, they are oceans of rainfall — moments in a global hydrologic cycle. This continuous cycle circulates water between the earth's oceans, atmosphere, and land through the physical processes of condensation, precipitation, evaporation and transpiration. Land use and development patterns, largely through the creation of impervious surfaces, modify a watershed's natural hydrology, impacting the quality and quantity of water that runs off built and natural surfaces. The consequences of these modifications aggregate in the region's water resources.[18]


precipitation
condensation
heat island
DENSE URBAN
75%-100% IMPERVIOUS SURFACE
30% evapotranspiration
5% infiltration
55% runoff
industrial discharge
+ point source pollution
livestock waste
sediment disturbance
top soil loss
soil compaction
loss of riparian
vegetation
SUBURBAN
35%-50% IMPERVIOUS SURFACE
35% evapotranspiration
15% infiltration
30% runoff
stormwater outfall +
nonpoint source pollution
stream bank erosion
sedimentation
habitat degradation

REGIONAL SURFACE WATER IMPAIRMENTS[21]



IMPACTS

Water Quality in the SETD Region

The term "water quality" has traditionally referred to the physical characteristics of water resources with regards to proximal environmental health and human consumption, but the site-specific approach to which healthy waters were assessed in the past could not anticipate the magnitude of contemporary urban expansion, industrial growth or land transformation. New standards of water quality and stewardship emerge by framing hydrologic impacts at the regional scale.

Under section 303(d) of the Clean Water Act, states are required to report a list of impaired waters to the Environmental Protection Agency every two years. Impaired waters are those that fail to meet one or more water quality standards for their designated stream type — beneficial uses, numeric and narrative standards, and the non-degradation protections — established by the state. These designations, which include industrial, recreation, and aquatic life, reflect how the water is used. Each use has different water quality standards. For instance, waters designated for recreation have higher water quality standards than those designated for industrial use.[18] When known, the cause of impairment is also reported.

A summary of surface water impairment within the SETD region's contributing watersheds is provided on the facing page.

For rivers and streams, *E. coli* is far and away the leading cause of impairment. More than 2,000 miles of these streams and rivers are impaired due to levels of *E. coli* and associated pathogens, followed by 731 miles of impairment due to sediment loads and 552 miles impaired by alterations to streambank and riverbank vegetative buffers. Nearly 400 miles of rivers and streams are considered to have insufficient levels of dissolved oxygen to support aquatic wildlife, while 300 miles are impaired by high levels of nutrients and physical alterations to habitat-rich stream and river bottoms. Thermal loading, heavy metals, hydrocarbons and other pollutants commonly associated with urbanized and industrial landscapes impair additional stream and river miles.

PCBs are the leading impairment of the region's reservoirs, affecting more than 75,000 acres of these surface water bodies. These chemical compounds were commonly used as coolants and lubricants in transformers, capacitors, and other electrical equipment. Though the manufacture of PCBs was banned by the U.S. EPA in 1979, past discharges and their persistence in the environment due to potentially extended half-lives make PCBs a widespread impairment.[20] Mercury impairs nearly 10,000 acres of reservoirs, while sediment, certain heavy metals, *E. coli*, and dissolved oxygen levels are each causes of impairment of around 2,000 acres. About 500 acres of reservoirs are impaired due to low flow alterations.

Descriptions of the impairments listed in the Regional Summary of Surface Water Impairments are included in the appendix of this publication.

CALL TO ACTION

Here in Southeast Tennessee, water is one of our most precious resources. Water provides nourishment, is a vital component of agriculture, supplies the backbone of our region's infrastructure, and is the basis for both recreation and tourism. In fact, it is difficult to think of what makes Southeast Tennessee great without also thinking about water. If we want to continue to live in a beautiful and thriving region, these resources must be protected.

Unfortunately, many of the activities we participate in every day threaten the quality of our water. Building practices, agriculture, transportation, and all kinds of human development seriously endanger water resources. However, this statement begs the question – what can be done? Agriculture, construction, and transportation cannot and should not simply stop. Instead, what is needed is an overhaul in our thinking about development.

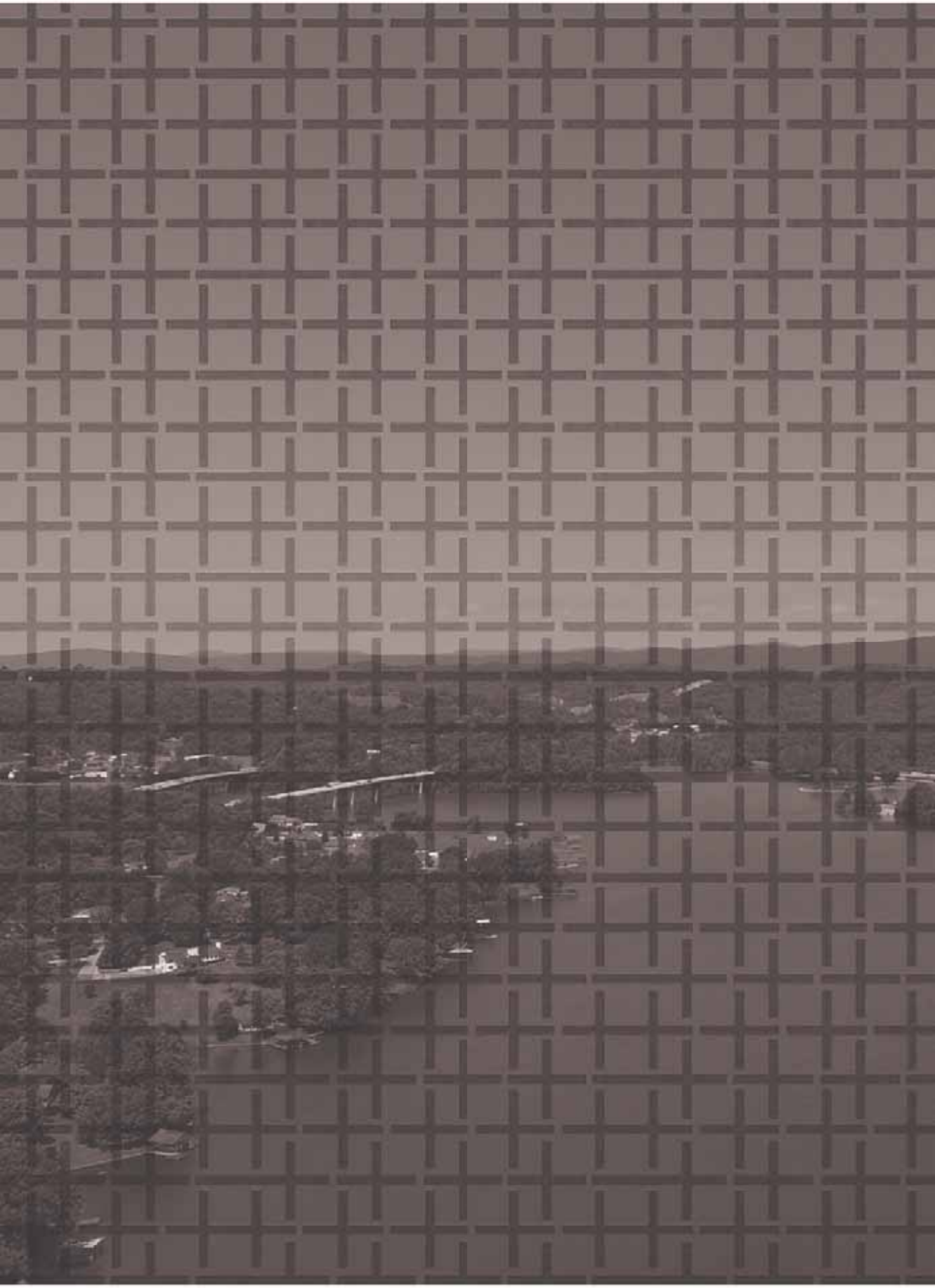
Enter HydroLIT, short for Hydro Literacy. This publication intends to provide the educational tools necessary to understand how our actions impact water quality, followed with strategies to reduce those impacts. This document is meant for everyone: from a developer working on a multi-billion dollar project to a family trying to waste less water in their home.

A corporate, personal, and governmental understanding of how our actions impact water quality is absolutely necessary to ensure the continued vitality of Southeast Tennessee's regional water resources. As citizens of this region, we have a responsibility to make water quality a priority in our lives, in our workplaces, and to our governmental representatives. This publication is a wonderful positive step in that direction, and I encourage you to use it to its full potential.

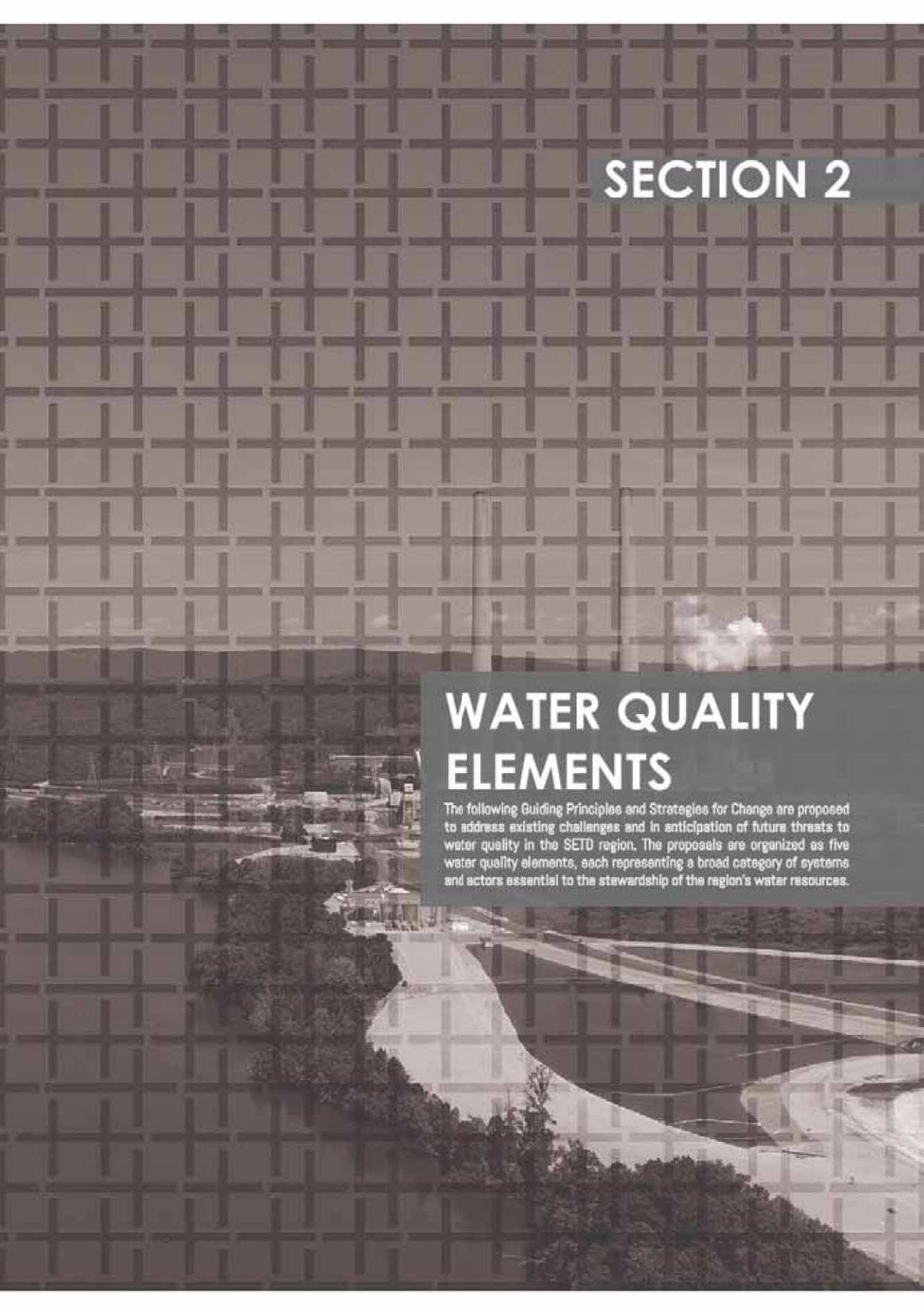
Respectfully,

Beth Jones

Beth Jones
Executive Director
Southeast Tennessee Development District



SECTION 2



WATER QUALITY ELEMENTS

The following Guiding Principles and Strategies for Change are proposed to address existing challenges and in anticipation of future threats to water quality in the SETD region. The proposals are organized as five water quality elements, each representing a broad category of systems and actors essential to the stewardship of the region's water resources.

WATER QUALITY ELEMENTS
Principles and Strategies for Improvement

Through careful analysis, regional observations, and conversations with regional stakeholders, the project identified five over-arching elements as driving challenges to existing water resource conditions and future water quality threats: DEVELOPMENT, TRANSPORTATION, ECOLOGICAL PROTECTION, WASTE MANAGEMENT, and EDUCATION.

Within these water quality elements, guiding principles have been identified to focus future water quality improvement efforts in the region. Strategies for change are proposed that create pathways to healthy water resources throughout the region today and for the future.

Below is a summary of each water quality element, the identified guiding principles, and proposed strategies for change. Each element is introduced, principles are defined, and strategies are described in detail in Section 2.

ELEMENT

Within each element are proactive visions: goals that guide each strategy for change. The four strategies within each element provide directed ways of addressing water quality.

GUIDING PRINCIPLES

The fundamental ideas and shared values that drive innovative thinking for water resource stewardship. These core concepts remain constant regardless of inevitable changes in regional politics, leadership, and technology.

STRATEGIES FOR CHANGE

Strategies for change put the guiding principles into action. They are "how" the visions will be achieved.

DEVELOPMENT

The region's water resources attract development, and are essential to economic growth and building livable communities. A clearer understanding of the relationships between development and water catalyzes reconsideration of growth patterns and land uses in urban and rural areas.

GUIDING PRINCIPLES

1. LAND OF OPPORTUNITY: territory as economy
2. RETHINKING INFRASTRUCTURE: territory as public + private
3. FOUND SPACE: landscape urbanism
4. COMMUNICATION: collaboration + connection

STRATEGIES FOR CHANGE

a. invigorate underutilized land
b. reclaim brownfields
c. exchange development rights
d. use stormwater district managment

TRANSPORTATION

A diversity of efficient, equitable transportation options mobilizes the region toward accessible, transit-oriented development patterns for the future, mitigating the impacts of growth and development on water quality and extending the capacity and life cycles of existing infrastructure.

GUIDING PRINCIPLES

1. CONNECTIVITY: equity of access
2. MOBILITY: intellectual + economic movement
3. INTEGRATION: ecology in transportation
4. SHARING: re-envisioning place-making

STRATEGIES FOR CHANGE

a. employ regional transit
b. improve pedestrian + bike access
c. develop T.O.D. sites
d. adopt shared space

ECOLOGICAL PROTECTION

Healthy aquatic ecosystems perform valuable services for the region. Ensuring the integrity of natural hydrologic processes and maintaining ecological balance in the face of evolving social values and increased development pressure is one of the region's most pressing water quality challenges.

GUIDING PRINCIPLES

1. ECOLOGICAL FUNCTION: regenerative region
2. NETWORKS: natural + urban
3. RESEARCH: synthesis + innovation
4. EQUITABLE ASSETS: inherent valuation

STRATEGIES FOR CHANGE

a. protect headwaters + ridges
b. protect, restore, + construct wetlands
c. develop complete creeks
d. guide via gps collars

WASTE MANAGEMENT

Rethinking the flow of waste fosters new products and tactical strategies for water quality stewardship. Current regulations try to control waste release and mitigate environmental damage, but new regulations are needed to keep up with contemporary waste cycles.

GUIDING PRINCIPLES

1. LOCALIZE ECONOMY: production through reuse
2. REDEFINE INFRASTRUCTURE: innovate use
3. COMMODIFY WASTE: create new goods
4. REVITALIZE ENVIRONMENT: waste for ecological benefit

STRATEGIES FOR CHANGE

a. recycle solid waste
b. incorporate coal ash
c. reduce pollution pressure
d. monitor household waste

EDUCATION

Education plays an integral role in fostering a culture of stewardship and sustainability. It can leverage past successes, existing facilities, and water quality knowledge to assert a leadership position in water resource stewardship, research, and innovation.

GUIDING PRINCIPLES

1. SCALE: regional capacity + legibility
2. RESOLUTION: hydro-informed decision-making
3. CULTURE: water quality reconceptualization
4. DISCUSSION: facilitating cooperative strategies

STRATEGIES FOR CHANGE

a. mobilize the creek squad
b. pilot mobile learning
c. establish the hydro academy
d. synthesize + visualize data

A GRAPHIC APPROACH
Describing Strategies for Change

Within each strategy, short and long-term approaches to change are visualized giving clear examples of their water quality benefits. Identified territories, stakeholders, and tactical interventions suggest ways to improve existing conditions and ensure smart growth in the region.

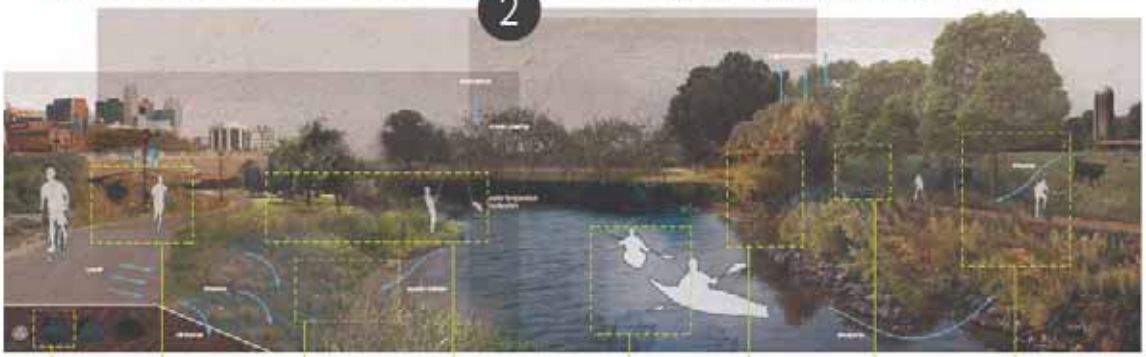
1. **Introductory Text**
   The main themes of the strategy are introduced here and lay the foundation for the supporting segments.
2. **Primary Graphic**
   Visual depictions of the strategy are shown here and provide ideas for communities.
3. **Hydrologic Benefits**
   Iconographic representation of benefits to water resources help connect strategies with communities' needs.
4. **Implementation Territories**
   Landscape typologies are defined as opportunities for proposed change or contributions to water quality issues.
5. **Stakeholders**
   Individuals and community groups are identified to establish functional networks of people who might see projects through.
6. **Anticipated Challenges**
   Preparing for challenges may aid in planning efforts and help to avoid roadblocks.
7. **Tactical Site Interventions**
   Intermediate/temporary projects introduce change in an area to gain support or test an idea before making it permanent.
8. **Precedents**
   Precedents provide project leaders with first-hand descriptions of successful implementation and establish contacts. More information about these projects can be found in the appendix.

1

DEVELOP COMPLETE CREEKS

The concept of Complete Creeks is a reconceptualization of riparian corridor planning and design to efficiently accommodate a range of uses, users, landscapes, and infrastructures. The linear nature and gentle topography common to these corridors have historically made them logical pathways for gravity sewer systems and other infrastructures. Creek movement and bank erosion caused by high volumes of rapidly concentrated, fast moving urban stormwater contravene the integrity of these systems, triggering costly and necessitating infrastructure announcements. Utility renovation projects may catalyze stream restoration initiatives, providing an opportunity to strategically reorganize riparian corridors as shared rights of way. Reconfiguration of existing easements, agreements for public access through private riparian buffers and flood plains, can enable the region's hydrologic systems to become multi-modal transportation, recreation and ecological networks. This necessary cost alleviates pedestrian and wildlife movement between and within urban, suburban, and rural landscapes. This multi-functional approach to riparian corridor planning helps regenerate the ecological health, water quality, and structural integrity of streams in developed areas while also proactively buffering territories in undeveloped landscapes from future development pressures.

2



3

HYDROLOGIC BENEFITS

The Complete Creek concept strategically co-locates multiple uses and functionalities to enhance and protect the region's waterway networks. The flood plains and buffer zones that are protected or restored as a result of Complete Creek planning not only filter and absorb water for a complete hydrologic system they also promote healthy use of those waterways and the adjacent land for all community members.

UTILITY CORRIDORS
Adequate buffers between utilities and waterway edges must be planned and maintained to allow for natural meandering over time without damaging utility infrastructure.

HEALTHY CORRIDOR
Converting waterways to Complete Creeks offers a healthy corridor for walking, biking, and running within and outside the city for use as transportation and recreation. Greenways also help to increase property values and catalyze new economic investment.

BANK RESTORATION
Reestablishing proper stream bank geometry and soil stability provides the restoration of riparian vegetation along the banks of streams. This vegetation filters runoff from adjacent landscapes, supports habitats and microcellars, and moderates stream water temperature.[4]

DAM REMOVAL
The removal of obsolete low-head and mill dams reveals a previously inundated flood plain with new potential for habitation, recreation and flood water storage while also restoring connectivity of aquatic habitat.

RELEVANCE
Accessible waterways can provide a new node of transportation or recreational opportunity, buffering those waterways from runoff and pollution ensures healthy water for such activities.

STREAM BUFFER
In addition to runoff protection and edge stabilization, vegetation along banks provides shade, moderating the health of many aquatic communities and mitigating flood risks.[4]

FLOODPLAIN FUNCTION
Protecting floodplains from development pressures helps mitigate flood damages and stabilize river and stream systems to naturally replenish surrounding landscapes with nutrient rich, alluvial soils.[4]

TRANSPORTATION ACCESS
Since streams flow throughout the region, this thoroughfare can connect urban, suburban, and rural areas, reducing carbon heavy transit.

4

IMPLEMENTATION TERRITORIES

Urban Context	Waterways in densely urbanized landscapes stand to benefit from restored hydrologic functions, regenerated habitats, and mobility networks possible through Complete Creek strategies.
Rural Communities	An increase in accessibility and the fostering of a stronger regional identity can strengthen the connection between urban and rural communities and can catalyze agricultural buffer investments.
Public Assets	Existing public lands provide opportunities for initial investments in Complete Creek infrastructures, catalyzing network connections, and value recognition on adjacent private land.
Recreational	Alternative transportation and recreational systems can connect through the region's floodplains and hydrologic networks.
Educational Systems	Addressing water quality stewardship and alternative development practices within the educational system can provide early exposure and ownership of nearby creek zones.

5

STAKEHOLDERS

6

ANTICIPATED CHALLENGES

Connectivity Gaps	Comprehensive network establishment may require new agreements for private land.
Alignment	Topography, urbanized stream corridors, and stream morphology may complicate routes.
Risk	Shared use negotiations can complicate permitting and extend project time lines.
Liability	Liability and user safety are perceived risks associated with shared use of private land.

7

TACTICAL SITE INTERVENTIONS

The elements of a Complete Creek can be implemented in phases. Individual communities can choose tactics that best suit their needs and the environment of their waterways. Developing a Complete Creek design includes acquiring access to land that is typically owned by private parties. Appraisal and land easements may be difficult to come by and so it is important to gauge the community attitude towards this type of development (Figure 3) in lieu of preconceptions about community acceptance levels. One strategy is to identify existing resources and public use areas that are the most readily available (Figure 2). Education is important for gaining support. Community walks (Figure 1) through potential areas can help to educate the public on the importance of keeping creek zones intact. Similarly, drop information tours (Figure 4) with private land owners can help alleviate concerns and discuss potential benefits of having Complete Creek zones running on their land.

8

PRECEDENTS

Mill River Park
Stamford, CT
2010

Mill River sits in the heart of downtown Stamford, CT. Efforts to restore the urban segment of the river have been on going for the past century. The goals of the city were to restore the ecological value and hydrologic dynamics of the waterway, providing buffers to limit future impacts while offering recreational opportunities for the residents of Stamford.

Long Creek Greenway
Commerce City, CO
2011

Long Creek ran through a heavily industrialized portion of Commerce City. The ecological significance of the site was little known until efforts to restore the area began. The overarching goal of the restoration effort was to transform the creek bank into a diverse habitat and into a recreational resource for residents.

aquatic biochemical balance

Nutrient, sediment, pH, and oxygen levels in water resources are balanced within normal or acceptable levels

aquatic wildlife proliferation

Favorable conditions are created for aquatic habitats, such as necessary amounts of oxygen, micro-organisms, and vegetation that allow wildlife to flourish

disruption avoidance

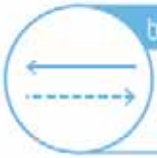
Activities destructive to the landscape, such as greenfield development, harvest and raw material extraction, and their associated water resource impacts, are redirected

aquifer recharge

Water percolates to groundwater as a result of reduced soil compaction, minimization of impervious surfaces, and the protection and restoration of healthy soil environments

drinking water supply protection

Reservoirs, rivers, aquifers and other drinking water sources are protected or improved



behavior change

Modified behavior improves water quality conditions through water resource impact mitigation

environmental aesthetic enhancement

In addition to improving water quality, the appearance and sense of spatial order of the landscape is enhanced

capacity-building

Individuals and organizations gain new skills, knowledge, and access to demonstration projects that enable effective action and advocacy on behalf of water quality

erosion reduction

The amount of sediment entering and suspended in water resources as a result of surface disturbance, runoff volume and velocity or loss of vegetated cover is mitigated

HYDROLOGIC BENEFITS

What can be gained?

The proposed Strategies for Change have multiple hydrologic benefits that are identified and defined below. Each benefit has a unique icon that is repeated throughout this book as a means to help users identify strategies that may provide a particular benefit. A quick reference for the definitions of these hydrologic benefits and their corresponding icons can be found in the inside fold-out of the book's back cover.

habitat regeneration + preservation

Forests, riparian corridors, meadows, and other wildlife-supporting landscapes are protected or made more suitable for wildlife biodiversity and ecological health

non-point-source pollution mitigation

Water resource contamination from predictable, yet widespread land uses, surface characteristics, and human behaviors is reduced

runoff volume reduction

Runoff volume, velocity, and non-point source pollutants carried to receiving waters are minimized, mitigating stream bank erosion and habitat degradation

on-site recreation optimization

Boating, fishing, swimming, and other aquatic recreational activities are made more favorable

informed decision-making

Stakeholders are enabled to make informed decisions and recognize long-term economic, social and environmental implications of watershed and water resource health

runoff rate reduction

The rate at which runoff concentrates on a site or is discharged to receiving waters is reduced

infrastructure cost reduction

First costs, operation and maintenance costs, or life-cycle costs associated with infrastructure investments are reduced or avoided

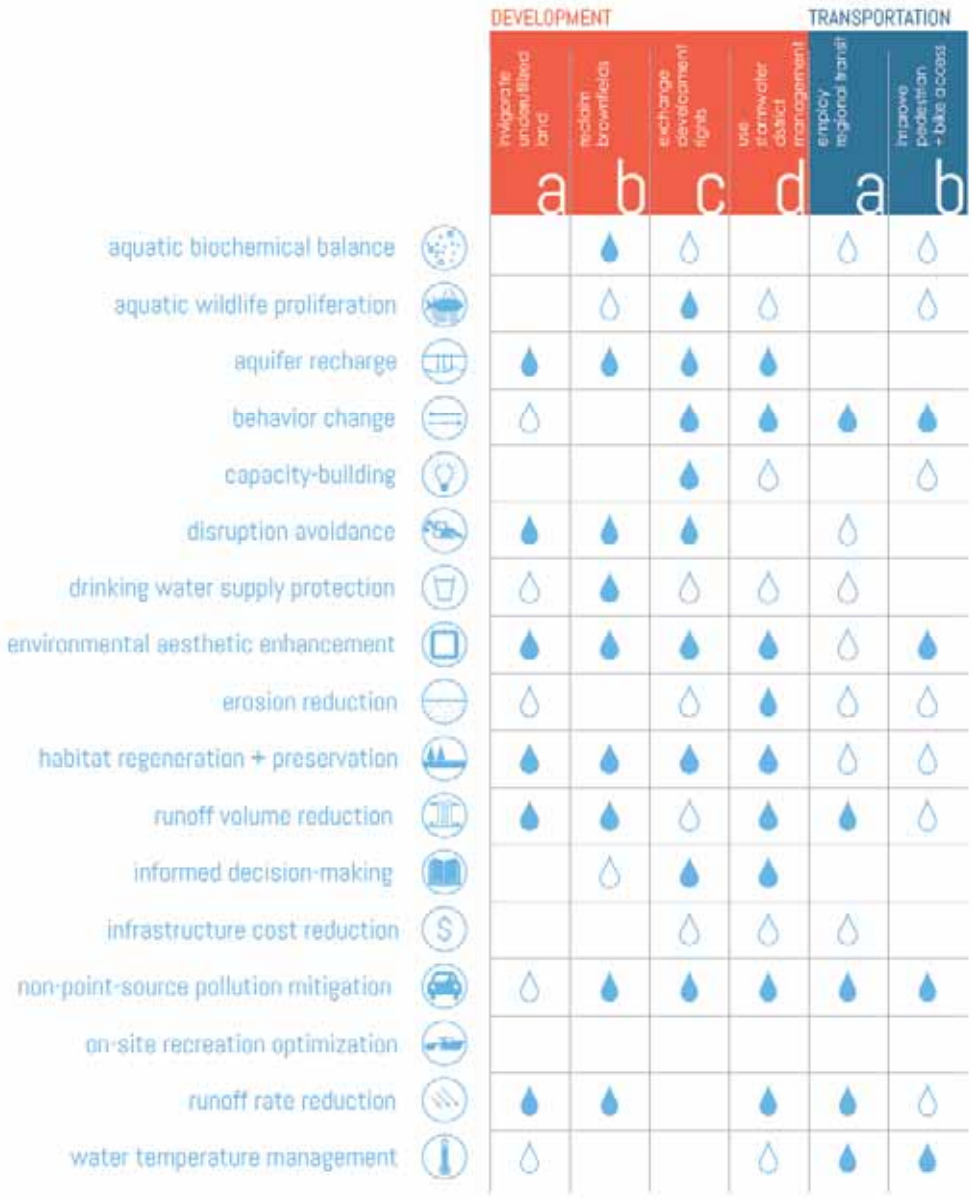
water temperature management

Fluctuations in water body temperatures due to solar heat gain, industrial discharges, or runoff temperature are maintained within normal or acceptable levels

BENEFITS MATRIX

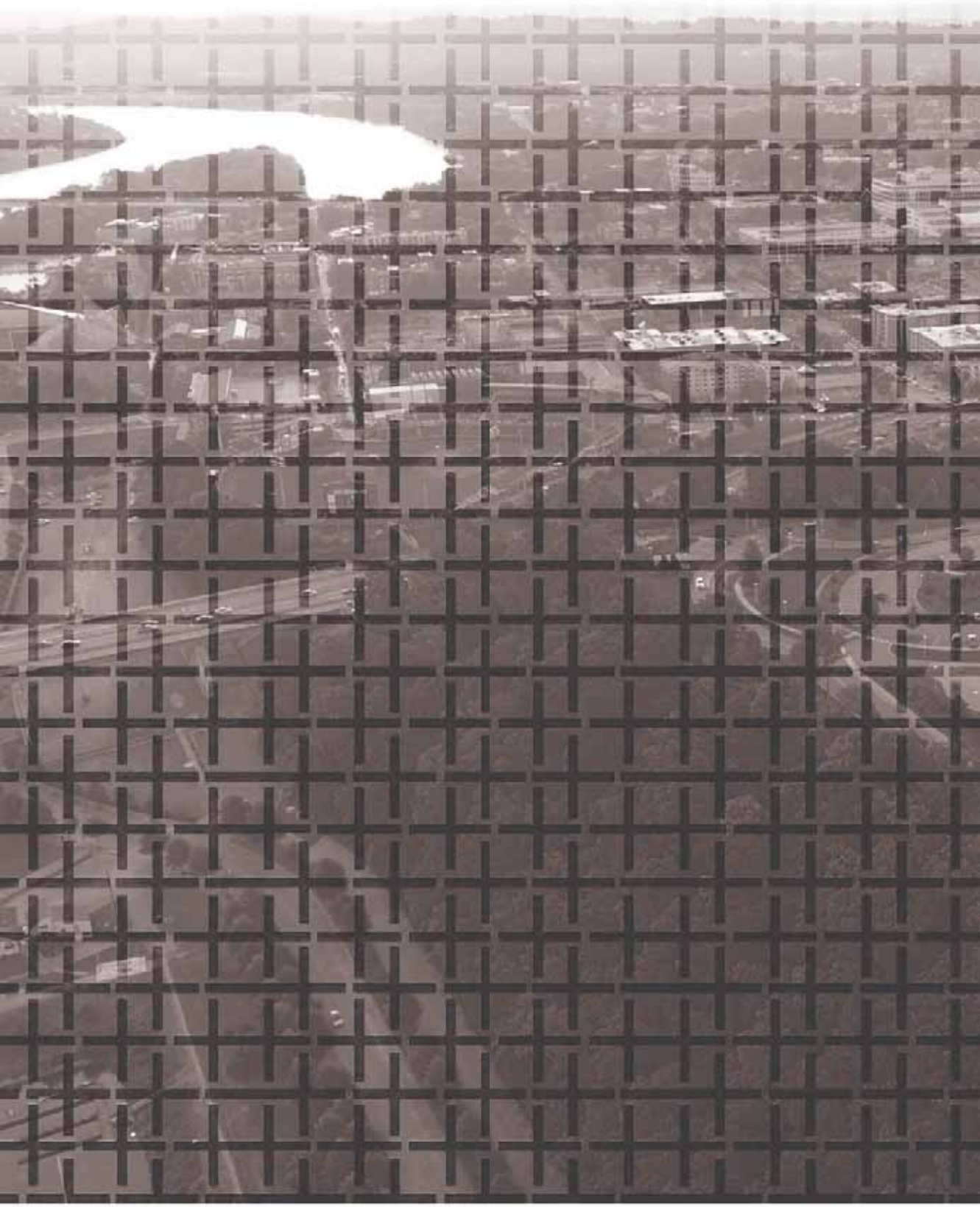
Connecting Water Quality Benefits and Strategies

Viewing connections between strategies and water quality benefits can assist in identifying appropriate strategies based on a community's needs. The matrix below summarizes the primary water quality improvement benefits of the proposed strategies for change.



LEGEND
primary benefit ●
secondary benefit ○

			ECOLOGICAL PROTECTION				WASTE MANAGEMENT				EDUCATION			
	develop f.o.d. sites	adopt shared space	protect headwaters + edges	protect scenic + construct wetlands	develop complete creeks	[illegible]	recycle solid waste	incorporate coal ash	reduce pollution pressure	monitor hazardous waste	mobilize the creek squad	pilot mobile learning	establish the hydro academy	synthesize + visualize data
	c	d	a	b	c	d	a	b	c	d	a	b	c	d
1			●	●	●	●	○	●	●	●	○	○	○	○
2			●	●	●	●		○	●		○	○	○	○
3			○	●		○	○				○	○	○	○
4	○	●	●	●	○	●	●		●	●	●	●	●	○
5			○	○		●					●	●	●	●
6	●	●	●	●		●		○		○	○	○	○	○
7			●	○	○	○	○	●	●	●	○	○	○	○
8	●	○			●		○	○		○				
9	○		●	○	●	●	○	○			○	○	○	○
10	○		●	●	●	●	●	○			○	○	○	○
11				○							○	○	○	○
12		○	○	○		●					●	●	●	●
13			●	●			●		○	○				
14	●	○	●	○	●	●	●			●	○	○	○	○
15			○	○	●	○			●					
16	○			○	●	○					○	○	○	○
17	○				●	○					○	○	○	○



DEVELOPMENT

The region's water resources attract development, and are essential to economic growth and building livable communities. A deeper understanding of the relationships between development and water resources has the potential to catalyze new growth patterns and land uses in urban and rural areas.

The city of Pikeville, TN is a modest city that has the opportunity to plan for efficient and sustainable urban expansion.

DEVELOPMENT

In the Southeast Tennessee District, developed landscapes include urban, residential, recreational, industrial, infrastructural and agricultural land uses. In this publication, the developed landscape is considered to be any land area that has been changed by humans from an undisturbed, indigenous condition for a specific purpose. Development is both the process of making that change and the resultant land use.

EXISTING CONDITIONS

Tennessee's wealth of natural resources has catalyzed various forms of development throughout the state. Cities were settled on rivers for the commercial ports they provided. Coal, copper and other mineral mining towns dot the Southeast Tennessee landscape. Farms take advantage of abundant freshwater and fertile floodplain soils to sustain crop and livestock operations. Forests supported some of the region's earliest economies, providing timber to build the region's first communities and commodities for export. The rivers were harnessed by TVA for power, flood control and commerce. All look to the region's water as a reliable, sustaining resource for drinking, irrigation, navigation, and industry.

While enabling vital economic and social activities, the close proximity and complex relationship between water resources and the developed landscapes they support poses significant threats and future challenges to water quality.

Advances in transportation technology and infrastructure, population growth, in addition to cultural, political, and economic dynamics have shaped the pattern of development through which communities grow and evolve. Over time, development patterns have expanded city limits, converted land uses, modified infrastructure, and attracted industry and tourism. These patterns determine how people experience their cities, residences, public spaces, and rural landscapes.

Though the SETD includes many vibrant, dense and dynamic community centers, much of the region's urbanized landscape and persistent growth pattern can be characterized as low-density, single-use auto-centric suburban sprawl that follows corridors established by transportation and other supporting infrastructures.[22] Existing urbanized landscapes were commonly developed in a manner that privileged human needs and perceived infrastructural efficiency over the dynamic nature and physical presence of creeks and streams. Gridded street patterns were constructed with limited consideration to flood plains and watershed hydrology. In some cases, stream and creeks are buried under entire blocks or

buildings. Developed landscapes discharge high volumes of rapidly concentrated, polluted stormwater to receiving waterways, restricting their flow through buried culverts and pipes and disrupting the protective performance of their flood plains and wetland buffers. New development often consumes productive or scenic greenfield landscapes for commercial, industrial or residential uses, compacting soils and reducing tree canopy during construction and adding a disproportionate amount of new impervious surfaces and stormwater runoff, especially when compared to alternative growth and development patterns.

Given the accessibility of abundant natural resources and the quality of life they afford, as well as a mild climate, attractive cost of living, and projected job growth, regional, national and global populations may be increasingly drawn to call Southeast Tennessee home.[23] The pace of this growth and the pattern of the developed landscape built to accommodate it compound the future water quality challenges already posed by existing development.

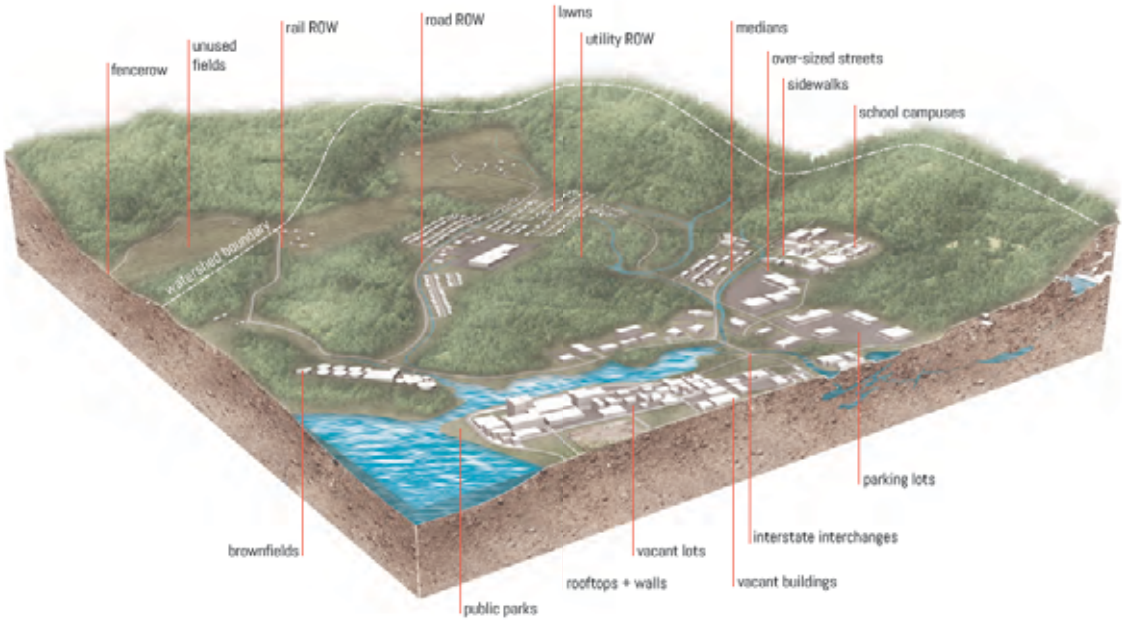
APPROACH

The ability of communities to sustain existing economic activity while attracting new growth depends on the availability of clean water and landscape resources. In order to grow in a manner that does not compromise the health of the water resources necessary to support that growth, water resource health needs to be at the forefront of conversations that will affect future development.

Inspired by the successes of communities around the region and around the country, this section explores novel opportunities for recalibrating existing developed landscapes and how new development can maximize the utilization of the urbanized landscape, continue to cultivate dynamic communities, and to avoid, reduce or repair the impacts on water resources. A focus on reinvestment in existing communities, infill, and redevelopment enables a compact development pattern that minimizes disturbances to undeveloped landscapes, avoids stormwater generation, and enhances environmental health while accommodating, if not catalyzing, economic growth and social priorities.

These opportunities for innovative, hydro-conscious development also seek to strengthen existing communities where populations and connective infrastructures are already in place. Additionally, they are useful in areas where populations are aging, regional connectivity is becoming more critical, or traditional economic roles cannot be established. Reconsidering traditional land use paradigms, access rights, and engaging community organizations in rural and urban communities alike can help the region move forward towards achieving its collective development vision.

By integrating these efficient and innovative development practices, the region will be able to provide for the economic and social vitality it seeks without compromising the health of the very resources that enable and attract it.



The territories identified above include those landscapes where the following water quality improvement strategies may be implemented.

WHAT GUIDING PRINCIPLES

1 LAND OF OPPORTUNITY: Territory as Economy

- To employ smart growth strategies for economic investment
- To combine public and private support
- To share access to underutilized land as a revitalization strategy

2 RETHINKING INFRASTRUCTURE: Territory as Public and Private

- To reconceptualize infrastructural landscapes as new multi-functional territories for meeting social needs
- To interconnect public and private land for holistic use

3 FOUND SPACE: Landscape as Urbanism

- To invest in low-cost, multi-use, oper-space development
- To redeploy post-industrial and interstitial 'waste' landscapes as social assets and catalysts for future investment

4 COMMUNICATION: Collaboration and Connection

- To encourage civic involvement
- To address a wide range of socioeconomic conditions
- To strengthen urban and rural relationships in the new image of the Southeast Region

HOW STRATEGIES FOR CHANGE

INVIGORATE UNDERUTILIZED LAND a

Temporary and fixed interventions on underutilized landscapes enliven communities as new territories for social connectivity, economic activity, environmental diversity and stormwater mitigation

RECLAIM BROWNFIELDS b

Once productive economic territories, these environmental liabilities are renewed as economic assets and social centers through innovative collaborations and solutions that operate over time

EXCHANGE DEVELOPMENT RIGHTS c

Transferring development rights to designated areas protects natural resources and encourages smart urban growth while providing economic capitalization opportunity for owners of sensitive, valuable landscapes

USE STORMWATER DISTRICT MANAGEMENT d

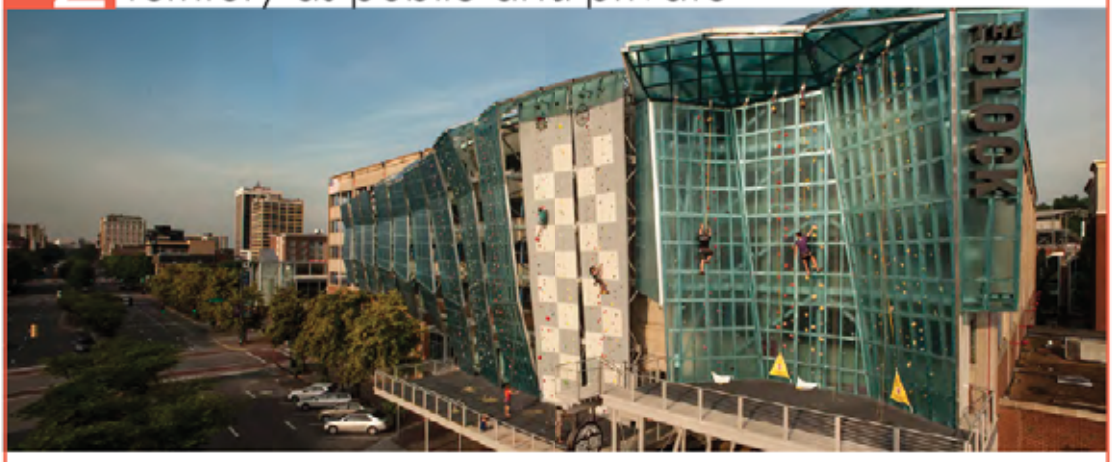
Public space and cooperative stormwater management marketplaces afford multiple creative solutions and efficient land use to property owners in dense urban landscapes

WHAT GUIDING PRINCIPLES

1 LAND OF OPPORTUNITY: territory as economy

Landscapes providing economic development and water quality improvement harness new territories for commerce, production, and efficiency. Property conventionally considered 'vacant' can be used to generate income, create new economies, and reduce runoff. This requires a re-conceptualization of existing landscapes as well as traditional attitudes toward their access and temporality. Support from private and public entities will promote the success, impact, and sustainability of these landscapes.

2 RETHINKING INFRASTRUCTURE: territory as public and private



The movement of economic activity, social energy, and water transcends delineations between public and private. By rethinking how ownership is defined, newly accessible space and permissible functions can open doors to innovative uses. Reconceptualizing relationships between public and private landscapes can expand territory for mutually beneficial infrastructures, yielding levels of connectivity, synergies of space, and efficiencies of investment otherwise unattainable.

3 FOUND SPACE: landscape urbanism

Rediscovering the potential of in-between and lost space — abandoned or vacant sites, greyfields, oversized infrastructures and landscapes previously deemed unfit — can recalibrate landscapes for productive futures and catalyze new investment in the surrounding community. Starting with small, low-cost interventions can test and build awareness for new land use initiatives and reveal how larger development proposals may manifest and be received by a community.

4 COMMUNICATION: collaboration and connection

In all approaches and scales of development, building sustainable connections and collaboration amongst and between communities is key to facilitating a consensus vision, project acceptance, and a spirit of regional cooperation that yields mutually beneficial relationships between urban and rural communities. Understanding different socio-economic conditions and needs is important to equitably invigorating existing places and distributing new investments.

CONNECTING
PRINCIPLES & STRATEGIES

	a INVIGORATE UNDERUTILIZED LAND	b RECLAIM BROWNFIELDS
1 OPPORTUNITY	Underutilized land can be repurposed for economic gain by growing plants for produce or fibers or by hosting markets, pop-up shops, and other seasonal or temporary enterprises. Doing this can encourage usable space for pedestrians and bicyclists.	Reclamation reactivates the economic productivity of once-vibrant places of industry and social activity by remediating perceived and real health threats.
2 INFRASTRUCTURE	Infrastructural spaces can be captured as both public and private, increasing utilization rates and public safety as well as broadening mairtenance regimes.	Improving brownfields permits public use of remediated private properties awaiting redevelopment, reintroduces territory as a productive landscape, and conditions communities to embrace evolving uses.
3 SPACE	New energy stimulates existing communities by recognizing the productive potential of vacant, abandoned, mono-functional and in-between spaces.	Blighted properties, as well as the communities and infrastructures that once supported them, are repositioned for new futures.
4 COMMUNICATION	Communities broaden agency and authorship of the new vision around the temporary use and potential redevelopment of underutilized land.	Dialogue is enhanced amongst civic leaders, land owners, developers, and community members in under-served communities maintain a new.

C EXCHANGE DEVELOPMENT RIGHTS

Areas are established specifically for concentrated development, agriculture and conservation that can create enduring, economically-distinct districts and regions.

Landscape is positioned as shared infrastructures with public and private benefits by aligning land use with its most productive capacity and watershed context.

Incentives can encourage strategic organization of land uses and green infrastructures capable of catalyzing development, investment, and building community.

Designating areas for development enables equitable, shared benefits of future growth and development while stewarding productive landscapes and water resources.

d USE STORMWATER DISTRICT MANAGEMENT

Stormwater districts create land-use efficiencies, infrastructural economies of scale, previously unattainable densities, and land development yields.

Multi-functional infrastructures with scale and accessibility considerations generate shared public and private value.

Infrastructure is reconceptualized as public space and offers new amenities.

Stakeholders gain equitable access to multi-functional amenity networks through shared infrastructure investments.

HYDROLOGIC BENEFITS

By changing surface characteristics and soil quality of existing properties, creating new demand for harvested rainwater, enhancing quality of life, and catalyzing reinvestment and infill development, the invigoration of underutilized land yields multiple hydrologic and other benefits.

TEMPORARY INTERVENTIONS

Pop-up parks and other temporary land uses can improve stormwater conditions and facilitate social interaction. These approaches test certain conditions and determine the best uses of space for the community, economy and environment.

REVEGETATION

Urban meadows and gardens on properties once dominated by abandoned parking lots, drives, or foundations create a biodiverse ecosystem and reduce runoff by improving soil, absorbing precipitation, and returning it to the atmosphere.[24] Urban farms create demand for harvested rainwater.

COMMUNITY MARKETS

Providing on-site sale of goods gives patrons a first-hand look at products grown in the vicinity and easy access to local goods.

INVIGORATE UNDERUTILIZED LAND

a

Underutilized land can be any territory not utilized to its maximum potential. Vacant lots immediately come to mind as one type of underutilized space, but there are many more within the limits of the existing developed landscape that could be engaged for additional uses, whether it be infrastructural, social, or environmental in function, including unused or single-use public parks, road, rail and utility rights-of-way, abandoned properties, rooftops, landscape buffers, over-sized streets, and parking lots. Cataloging the variety of underutilized spaces in rural and urban landscapes and thinking creatively about their additional potential can help strengthen existing communities and minimize impacts to undeveloped landscapes. Realizing the undiscovered potential of these sites may require innovative public/private use and maintenance agreements. Overcoming these hurdles can be a boon for economic prosperity, infrastructural efficiency, social well-being, community health, and overall quality of life. Such projects often begin with low-cost landscape experiments by empowered citizens, establishing community ownership and authorship in the beginning phases of project planning and implementation.

ROAD DIET

Recalibrating road sections to align with actual use volumes improves bicycle and pedestrian safety and access, while also reducing impervious surfaces. Street trees and pervious pavement reduce runoff quantity, and green streets manage runoff quality.[26]

INFILL

New construction on vacant properties and redeveloping under-performing greyfields reduce development pressure on greenfields. This mitigates growth's impacts on water quality and while helping to revive existing neighborhoods by attracting new investment to the area.

GREEN ROOFS

Intercepting water that would otherwise run off into lawns or onto impervious surfaces can reduce heating and cooling costs and can be a suitable location for personal or community farming.[28]

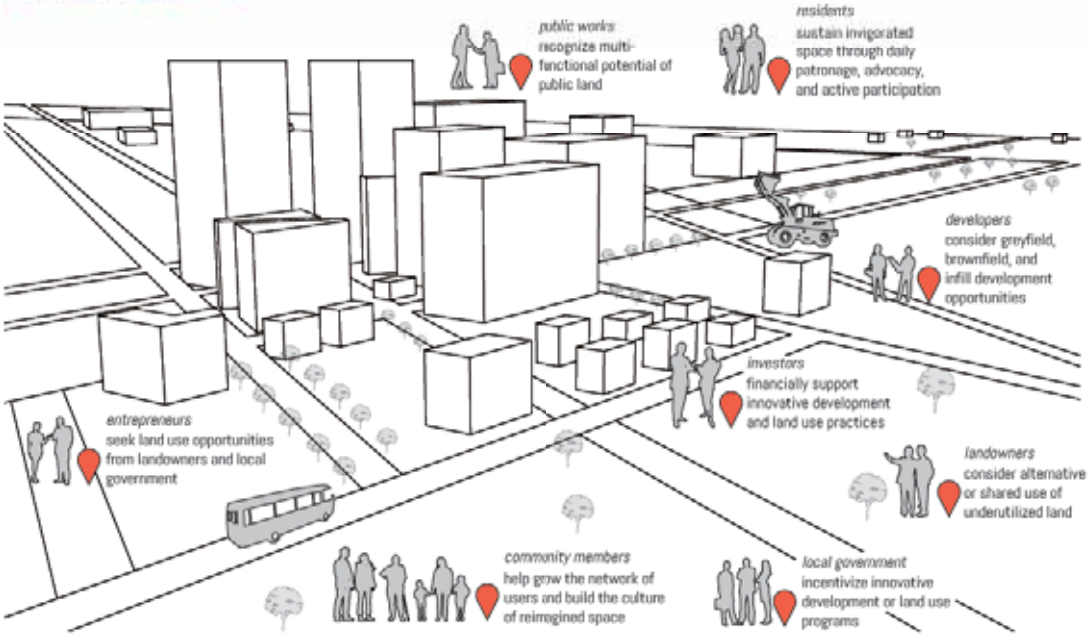
MULTI-FUNCTIONAL PARKS

Unlocking the multi-functional potential of existing public land is an opportunity to manage stormwater, while a healthy urban canopy reduces runoff and the heat island effect. Well-maintained public land can be a strong facilitator of community engagement and healthy citizens.[27]

IMPLEMENTATION TERRITORIES

Brownfields	Post-industrial sites can be redeveloped, reclaiming prime locations and revitalizing the local economy.
Interstate Interchanges	Complex interchanges carry high traffic volumes and have opportunity to optimize land density, local access, and environmental productivity.
Parking Lots	Oversized and abandoned parking lots can be reorganized as venues for new social and economic activity while reducing impervious surfaces and stormwater runoff volume.
Rights-of-Way	Highway, rail, and utility rights-of-way require zones of clearance that can also accommodate additional uses that can further environmental, social, and multi-modal transportation initiatives.
Vacant Lots + Buildings	Both rural and urban areas possess vacant infrastructure that have the capacity for revenue generation.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Funding	Creative funding mechanisms will be necessary when limited public funding is available.
Land Ownership	Innovative use agreements, easements, land swaps, or out-right purchases may be needed.
Maintenance	Maintenance approaches and responsibilities, as well as liability limits, must be agreed upon.
Public Investment	Community authorship and investment of new uses must be genuine and sustainable.

TACTICAL SITE INTERVENTIONS

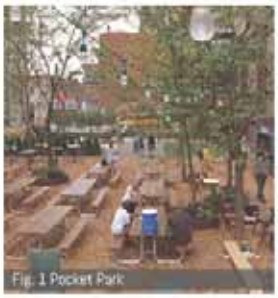


Fig. 1 Pocket Park


Fig. 2 Pop-Up Plaza

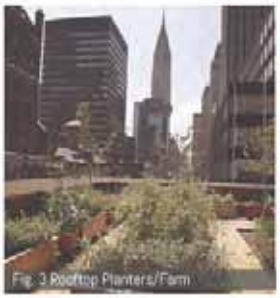


Fig. 3 Rooftop Planters/Farm


Fig. 4 Biodiverse Meadow

Underutilized land can be re-designed to provide a function or opportunity to the community that was not there before — while simultaneously improving stormwater interception and infiltration. These examples use impervious surfaces, such as sections of roadway or rooftops (Figures 2 + 3), or unused lots (Figures 1 + 4) that may exist between buildings, at the end of a street, or on the grounds of businesses, schools, or residences. Pocket parks and pop-up plazas can provide social gathering spaces with surfaces that absorb stormwater. Rooftop planters are one way to use precipitation for production and can be a temporary strategy for testing the success of rooftop farms, a future permanent strategy. Simply planting wildflowers on a lot can improve biodiversity of plants and animals, but will also beautify the neighborhood, absorb runoff, and provide educational opportunities.

PRECEDENTS

DENSO Manufacturing
Athens, TN
2016 (phase 1)

This auto parts manufacturer has set aside an unused part of their Athens, TN property for a landscape that will filter and detain water from their facility and provide an ecologically diverse park that provides wildlife habitats and outdoor leisure for DENSO employees.

DyeScapes
Louisville, KY
2014

DyeScapes is a network of gardens on vacant properties that was established to provide local women with jobs producing dyes and textiles. The gardens produce local dyes, which takes advantage of rainwater for irrigation, and reduces costs and pollution due to transportation. This project addresses economic, social, ecological, and water quality issues in its local community.

HYDROLOGIC BENEFITS

Removing deteriorating industrial infrastructures and remediating contaminated soils, waste stock piles and other artifacts of previous industrial uses prevents pollutants from being carried to receiving waters or leaching into groundwater supplies while reducing runoff and restoring natural hydrologic regimes.

WASTE EXCAVATION

Off-site disposal and treatment of industrial waste quickly removes bulk material from the site. Although this process requires a higher initial investment, it is an immediate action that prevents further contaminant leaching.

REVEGETATION + PHYTOREMEDIATION

Hardy plant species have proven capable of gradually metabolizing, or stabilizing select soil contaminants in situ, protecting groundwater and filtering polluted runoff.[28] This is an affordable but time-intensive approach that restores wildlife habitat and hydrologic regimes.

RECLAIM BROWNFIELDS

b

Brownfields are idle landscapes that retain hazardous remnants of previous land uses. In many instances, brownfields aggregate as large swaths of abandoned land along infrastructure corridors that previously supported industrial facilities. These territories can vary greatly in individual size, location and toxin concentrations. According to the EPA, there are over half a million such sites in the United States.[29] Given the Southeast's industrial heritage, many are located in prime development locations at the center of existing communities — close to transportation networks and the local workforce. As manufacturing economies migrated over time, these abandoned facilities and discarded land were left unregulated and exposed to natural processes of successional vegetation, which hid visible indicators of industrial waste without removing the actual contaminants. Ubiquitous and largely under-documented, brownfields have traditionally posed challenges for federal, state, and local governments that are now revisiting these territories in hopes of remediation and reclamation as infill development sites or alternative land uses. Identifying, mapping and assessing these properties, proactively positioning them for interim and future uses, and strategically partnering with private interests can enable these challenged sites to again be part of the economic, social and environmental vitality of their surrounding communities.

CONTAINMENT

Natural and artificial barriers prevent the spread of infrastructural or chemical waste to nearby surface and groundwater resources. Containment is critical in areas that risk human exposure.

CONSTRUCTION

New projects and property values increase as a direct result of reclaimed post-industrial territories and improved water resources on brownfield sites and their surrounding communities.[30]

BIOFUEL

Specific plant species can supplement a native riparian habitat or meadow, filtrating toxins and creating a harvestable fuel source of renewable energy.[31]

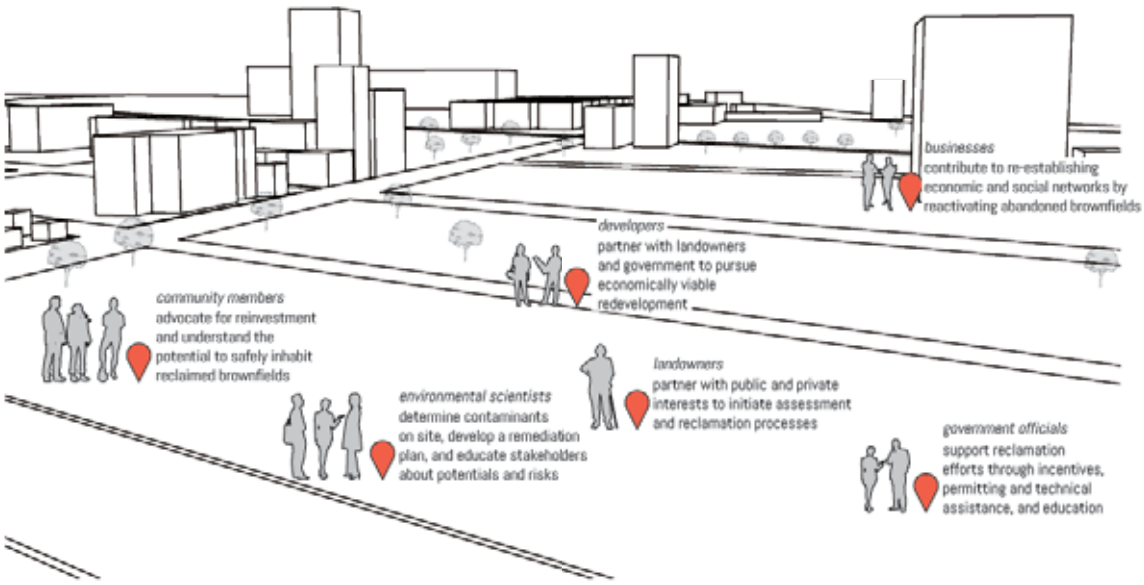
PARKS

Remediating public spaces opens new socio-economic opportunities and can create stronger community engagement.[32]

IMPLEMENTATION TERRITORIES

Rail Yards	Rail yards are centralized locations in which rail cars and locomotives are maintained, often accumulating environmentally harmful contaminants.
Mining Industry	Unregulated and abandoned mine sites may continuously expose tailings, waste rock, and mine drainage contaminants to the surrounding environment.[33]
Petroleum	Approximately one-half of all brownfield sites are believed to be impacted by leaking petroleum tanks or spills, contaminating the groundwater of both rural and urban communities.[34]
Heavy Manufacturing	Steel and heavy manufacturing plants are often sites of concentrated industrial waste disposal areas, and often predate contemporary hazardous waste management practices and regulations.
Landfills + Dumps	Older landfills that were not held to the modern regulatory standards of contemporary waste management are often unlined and filled with industrial waste and hazardous chemicals.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Funding	Although grants may provide funds for cleanup, organizations may be required to share the costs.[35]
Public Reassurance	Public may have misgivings about residual contaminants.
Timeline	Affordable approaches may span many years before determined safe for human occupation.[36]
Risk	Uncertain site conditions increase development risks, limiting funding and partners.

TACTICAL SITE INTERVENTIONS


Fig. 1 Typology Mapping


Fig. 2 Pollutant Containment


Fig. 3 Biofuel Phytoremediation

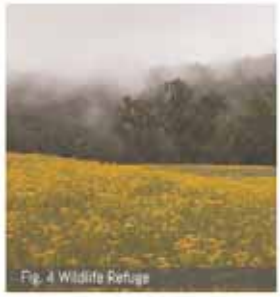


Fig. 4 Wildlife Refuge

Brownfield remediation programs have proliferated in recent years. Cities look to reclaim lost territory to meet the demands of an increasing population. Initial strategies to tackle brownfields include the mapping and investigating of potential post-industrial sites, as seen in Figure 1. Low-cost pollutant containment can be accomplished through the planting of hardy, phyto-remediating plants that can potentially double as a harvestable biofuel. Ultimately, by treating these brownfields and positioning them for future development, these sites can in the short-term remain biologically productive, providing refuge and support for native wildlife.

PRECEDENTS

Renaissance Park
Chattanooga, TN
2006

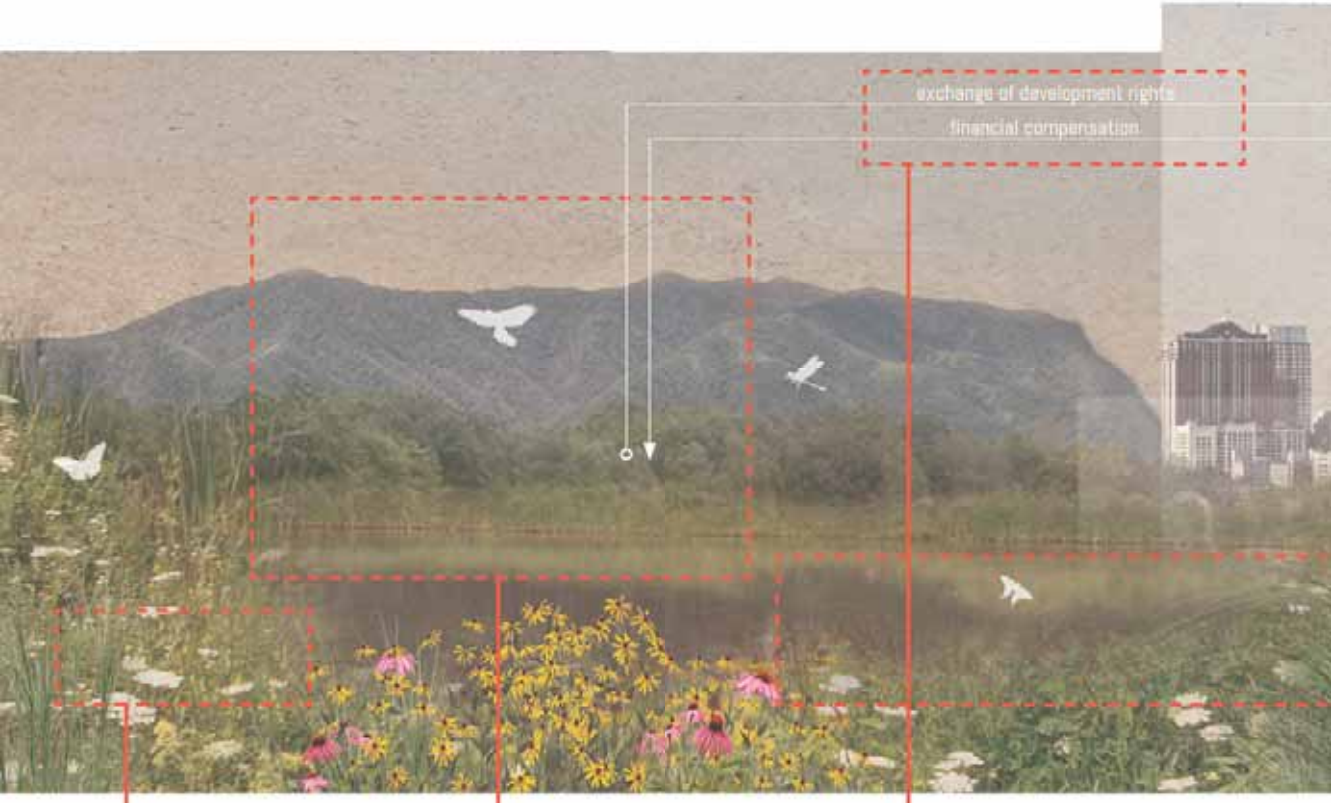
This project in Chattanooga's North Shore neighborhood transformed a 22-acre brownfield into a vibrant public space and catalyst for private investment on adjacent properties. The multi-functional design invites public recreation while safely managing contaminated soil on site, eliminating groundwater pollution and creating a constructed wetland for site stormwater management.

Old Grundy County High School
Tracy City, TN
2007

This building was originally built in the 1930s during a time of prosperous coal mining and production. However, it became vacant in the mid 1990s, exhibiting a legacy of abandoned toxins, mines, and rail lines. EPA grant money was used to perform Phase I and II on the property. Now, local and grant funds are being used to redevelop the site into the South Cumberland Learning & Development Center for Grundy County.

HYDROLOGIC BENEFITS

Redirecting urbanization from hydrologically sensitive landscapes, productive farmsteads and scenic resources through development rights exchanges avoids the disruption of natural hydrologic regimes while promoting compact, livable communities, habitat conservation, and stewardship of natural resources, each of which contributes regionally and locally to quality of life and economic competitiveness.



PRODUCTIVE, SCENIC + SENSITIVE SITES

The region's agriculturally-productive, scenic, and hydrologically sensitive landscapes–such as wetlands and riparian corridors, productive farmsteads and scenic open spaces, ridge-tops and hillsides–nourish growing populations, help maintain healthy ecosystems and water supplies, mitigate flooding, and enhance quality of life.

SENDING AREAS

The location of sensitive and productive landscapes guide the strategic delineation of sending areas. Owners of land within a sending area may recognize the communal benefit of maintaining their property's current condition, yet may wish to realize financial benefit from the legal development potential of their property. Through a TDR exchange, these owners may elect to sell their future development rights to an owner or developer of a property within a receiving area.

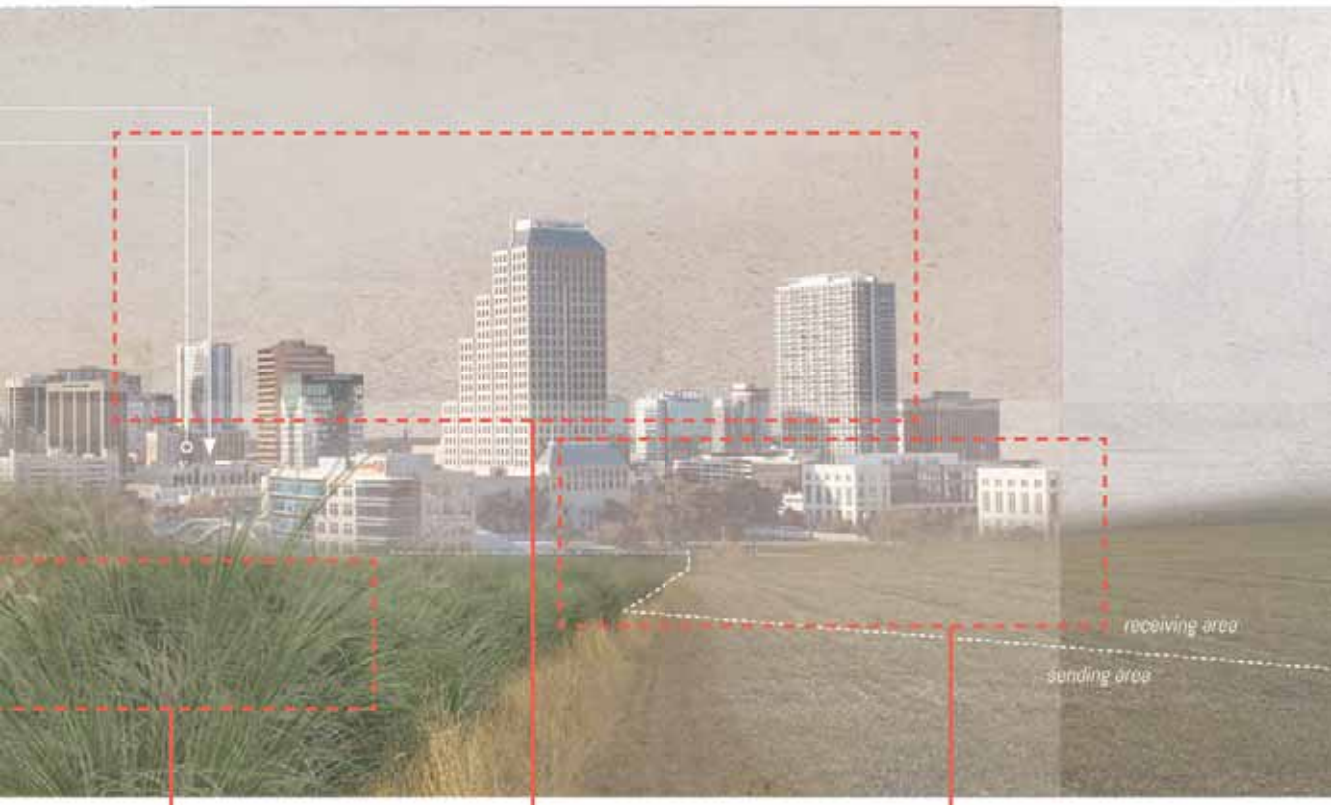
TDR BANKING

A TDR Bank is an important instrument in TDR programs that can help accelerate exchanges on high priority properties, act as a revolving fund to buy and sell development rights, and temporarily hold development rights in order to bridge gaps in time between when rights are sold and when rights are purchased by willing participants.[37]

EXCHANGE DEVELOPMENT RIGHTS

C

Hydrologically sensitive landscapes are subject to increasing urbanization pressures due to population growth and prevailing development patterns in Southeast Tennessee. Transfer of Development Rights (TDR) programs are voluntary marketplaces that make the legal right to develop one's property an exchangeable commodity, thus providing an opportunity to preserve valued landscapes while simultaneously enabling the private citizens who own them to profit from their legal development potential. Clearly and strategically delineated sending areas and receiving areas are fundamental to TDR programs. Owners of property in designated sending areas can elect to sell their development rights to owners or investors with real-estate development interests on a specific site within a designated receiving area. When rights are exchanged, an easement or deed restriction is placed on the sending property that limits its future development in order to preserve the hydrologic, agricultural, scenic, or ecological value of sending areas, and a more compact development pattern with a reduced stormwater footprint becomes possible in receiving areas. Offering incentives such as density bonuses, intensity bonuses, and scaling exchange ratios encourages TDR program participation by sellers and buyers. TDR programs require recognition of fair land value among all parties, as well as effective administration in order to maximize their economic and hydrologic benefits.



CONSERVATION

Once development rights from a sending property have been sold, a variety of legal instruments can be used to limit the property's future land use or development potential. The original land owner maintains possession of the property unless otherwise explicitly and voluntarily agreed as a condition of the exchange.

RECEIVING AREAS

The location of land that has access to existing services and infrastructure, high redevelopment potential, or is otherwise determined capable of accommodating additional growth guides the strategic delineation of receiving areas. Land owners or developers of sites in receiving areas may purchase development rights from sending properties to increase the development yield of their projects.

SMART GROWTH

Through the strategic delineation of sending areas and the use of participation incentives, urban growth is concentrated, resisting sprawl development and its associated water quality impacts, while ensuring an efficient expansion of municipal services and infrastructures.

IMPLEMENTATION TERRITORIES

Services + Utility Infrastructure	"Receiving areas" will most likely have existing municipal services and infrastructures, allowing them to more efficiently accommodate new development.
Cropland + Pasture	Rural cropland and pasture are ideal "sending areas" that continue feeding growing populations while yielding an economic windfall to landowners once development rights have been sold.
Forests	Both fragmented and contiguous forests may qualify as protected land for their environmental services or scenic landscapes.
Wetlands	TDR programs can incentivize the conservation of these critically threatened ecosystems that contribute to water quality as well as the environmental and economic health of the region.[38]
Transportation Networks	Strategically delineated receiving areas can catalyze efficient growth patterns and denser development when organized around existing and proposed multi-modal transportation networks.

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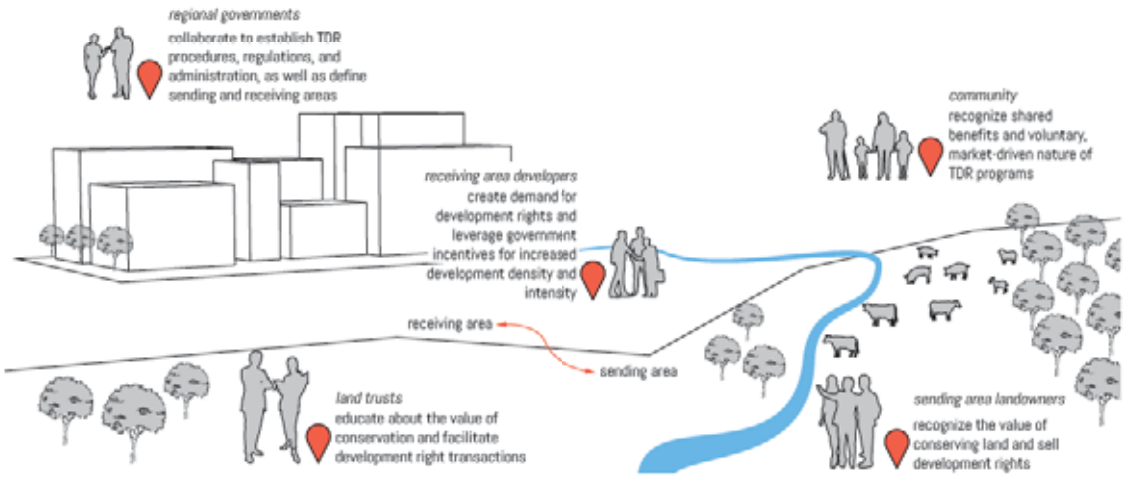


ANTICIPATED CHALLENGES

Community Trust	TDR programs are voluntary and require community buy-in.
Education	Local governments need to educate the public about TDR principles and benefits.
Valuation	Fair valuation of sending areas' development rights is essential to TDR program success.
Zoning	TDR programs do not reduce the need for zoning and require careful administration.

TACTICAL SITE INTERVENTIONS

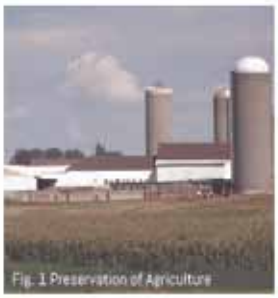


Fig. 1 Preservation of Agriculture


Fig. 2 Forest Preservation


Fig. 3 Increased Density


Fig. 4 Increased Livability

The TDR marketplace gives land owners and developers an opportunity to secure and preserve land by converting their development rights to a liquid, transferable commodity. This market-driven concept allows development to occur where demand is highest — typically in higher density areas with existing infrastructure and public services — and away from hydrologically sensitive natural resources, scenic landscapes and productive agricultural land. Figures 1 and 2 are examples of how TDR programs have aided in the environmental preservation of land. Figure 1 shows a working farm that will remain agricultural land. Figure 2 is showing the preservation of a natural area. Figure 3 is an example of how TDRs can be used to benefit developers and residents on the receiving end by allowing increased development intensity in higher demand areas. There are also indirect benefits to the communities, including increased livability, walkability, connectivity and local produce, as shown in Figure 4.

PRECEDENTS

Chattahoochee Hill Country
Fulton County, GA
2002 - ongoing

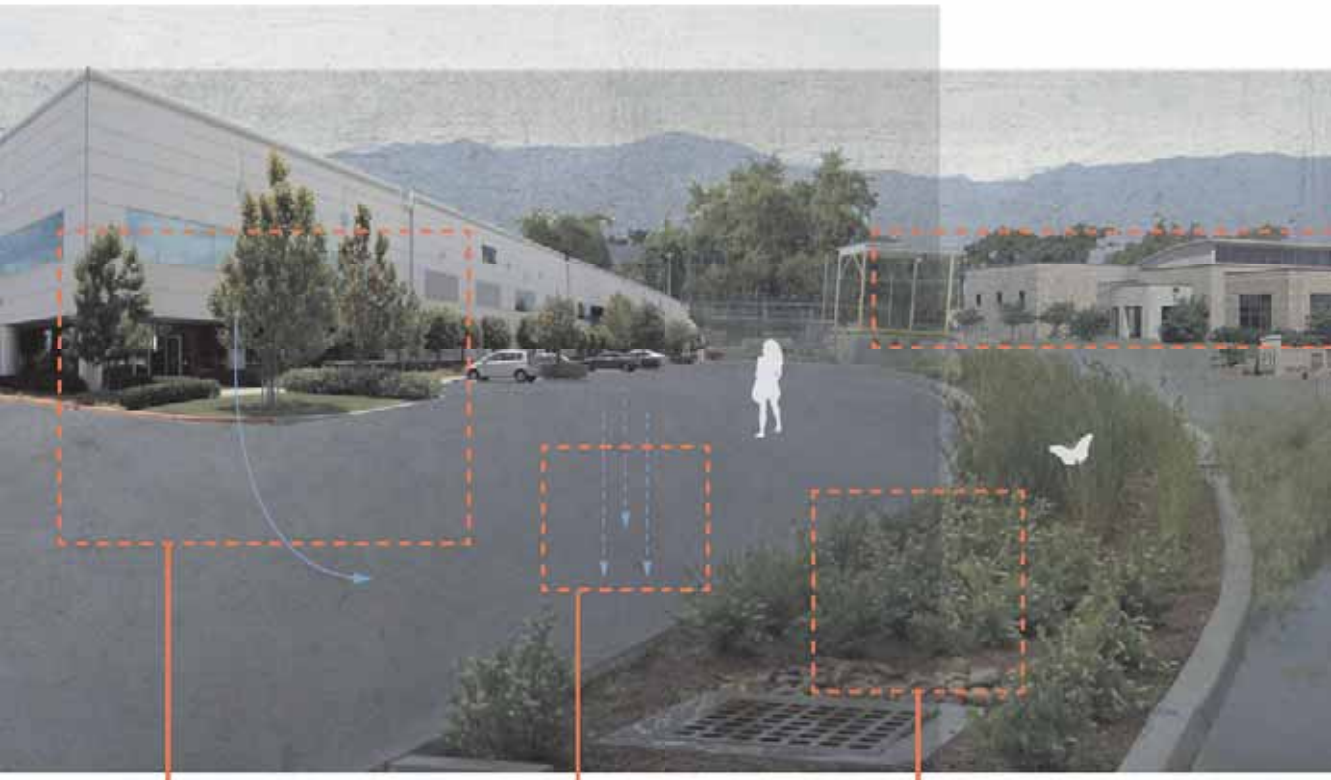
This 65,000 acre area sits immediately southeast of Atlanta, GA. In 2000, the Chattahoochee Hill Country Alliance was formed to help combat the sprawling growth of metropolitan Atlanta into Fulton County. Fulton then became the first community in the Southeast region to adopt a TDR program. The CHCA used the program to protect rural lands and to direct development to target areas.

Farmland and City of Seattle
King County, WA
2013

The 2013 Transfer of Development Rights Agreement transferred the development rights of farmland in King County to the City of Seattle. This agreement resulted in $1.8 million for land protection, the purchase of 800 development rights, and subsequently an increase in tax revenue from the new development.

HYDROLOGIC BENEFITS

The district approach to stormwater management enables efficiencies of space and economies of scale that would otherwise be unachievable. Though the hydrologic and development benefits of this approach may be most obvious in urban landscapes, stormwater mitigation can be established across municipal and regional scales, directing management and restoration investments to landscapes that need them most.



INDIVIDUAL VS COLLECTIVE STORMWATER MANAGEMENT

Stormwater management requirements may be difficult to meet on individual sites due to development density, topography or soil conditions. A district approach manages runoff for multiple properties, allowing for denser, more walkable development districts and better connected multi-functional open space networks.

PERVIOUS PAVEMENT

Widespread use of pervious pavement throughout a district helps minimize total runoff volume, reducing the amount of real estate needed for stormwater management facilities.

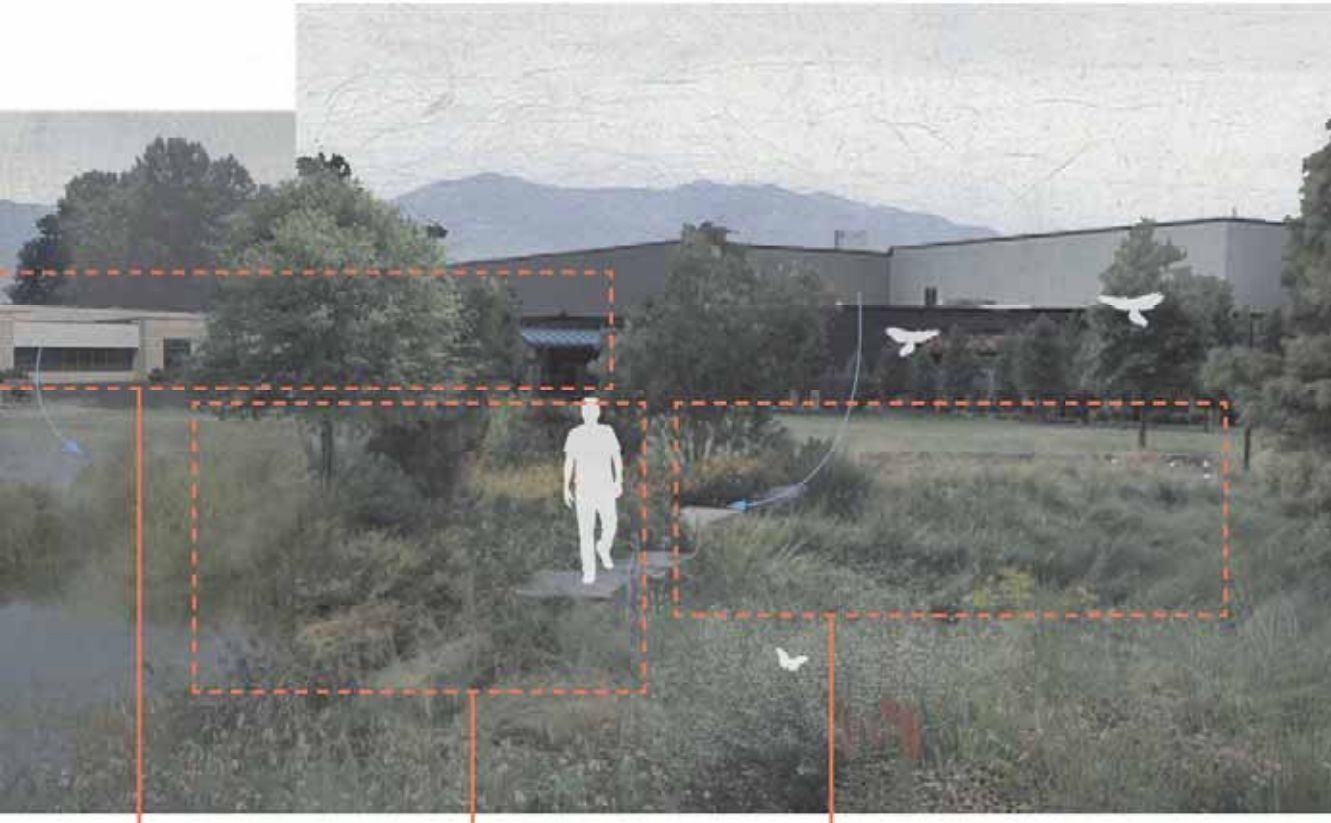
PUBLIC SPACE FOR INTERVENTIONS

Public spaces such as medians, landscape buffers and streetscapes can be utilized for stormwater collection, retention, treatment and infiltration.

USE DISTRICT STORMWATER MANAGEMENT

d

Traditional approaches to meeting stormwater management requirements are limited to practices implemented within that specific property's boundaries.[39] Satisfying such requirements may be costly, inefficient or impractical in some circumstances, especially in high density urban landscapes where on-site open space is limited, and special use districts, such as campuses. A district approach to stormwater management permits multi-property collaboration in order to fulfill a district's collective stormwater retention and treatment responsibilities. Hydrologically and infrastructurally-delineated Stormwater Districts can create collaborative exchanges where the need for stormwater retention on one site can be met through retention surpluses on other private properties within the district, or on public landscapes — such as sponge parks and green streets. Using public space to offset the stormwater impacts of private development can incentivize smart growth and promote multi-functional public spaces. Enabling private developments to 'sell' stormwater management credits incentivizes innovative stormwater avoidance, minimization, and management.



STORMWATER CREDIT EXCHANGE

Properties can sell and trade stormwater credits as a means to collectively manage stormwater within the district. Stormwater management surpluses on one property help compensate for the shortages or space limitations on another site.

MULTI-FUNCTIONAL DESIGN ELEMENTS

Stormwater management control measures such as constructed wetlands have the capacity to provide multiple benefits, such as retaining and treating runoff from surrounding sites, providing an opportunity for ecological amenities, enhancing the site aesthetic, and providing inhabitable open space for social interaction.

SPONGE PARKS

District common areas can be designed as shared open spaces that absorb stormwater from several surrounding sites while providing opportunities for wildlife habitat and public recreation, and gathering. These investments can be used to offset stormwater management requirements of district infrastructure such as roads, or to generate revenue from the sale of surplus stormwater credits.

IMPLEMENTATION TERRITORIES

Commercial + Industrial Centers	Stormwater management as a cooperative effort can alleviate pressure from individual parcel owners who may be unable to meet stormwater requirements with on-site infrastructure alone.
Public Parks + Rights-of-Way	Existing open spaces, as well as transportation and utility corridors, can be designed as connective, multi-functional infrastructures, offering shared amenities.
Campuses	Multi-building campuses, such as universities and office parks, can include stormwater quads to demonstrate responsible stormwater principles and learning opportunities for water stewardship.
Urban + Suburban Neighborhoods	Neighborhoods as stormwater management districts can incentivize the use of shared open space as multi-functional landscapes and promote efficient development patterns.
Vacant Lots + Unused Fields	Stormwater districts can increase the functional value of underutilized urban and rural land, facilitating infiltration across potentially vast areas.

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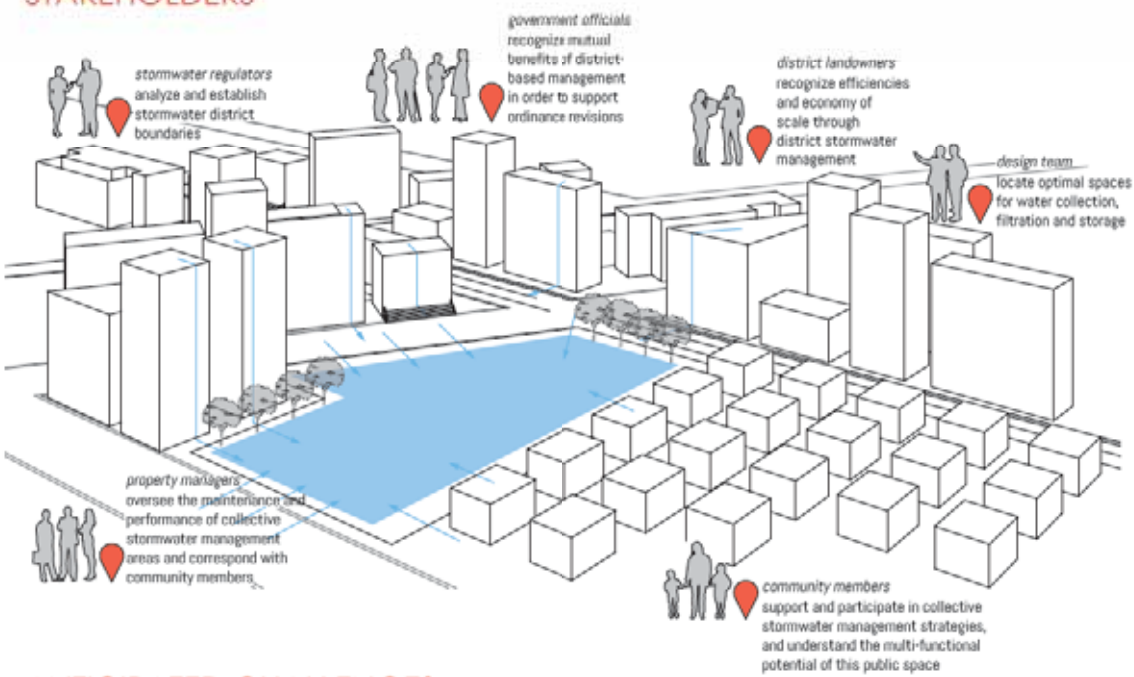


ANTICIPATED CHALLENGES

Aesthetics	Multi-functional landscapes may challenge prevailing cultural aesthetic expectations.
Education	Proper education of owners and maintenance staff is necessary to sustain shared infrastructures.
Ownership	Collective management requires cooperation between multiple land owners.
Permitting	Uncertainties and accountabilities may complicate ordinance revisions and permitting processes.

TACTICAL SITE INTERVENTIONS


Fig. 1 Community Engagement

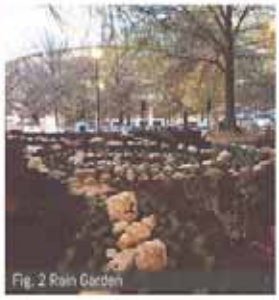


Fig. 2 Rain Garden


Fig. 3 Vegetated Streetscapes

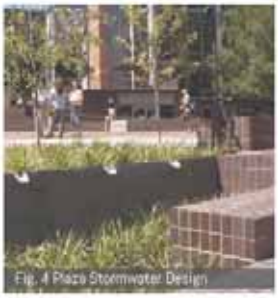


Fig. 4 Plaza Stormwater Design

Stormwater district design should be focused on the collaborative stormwater management efforts of an entire district. Community engagement and education are important interventions that can be pursued immediately. Figure 1 shows students engaging in an exhibit at the Billion Oyster Project's Harbor School. Figure 2 is an image of the Claxton Rain Garden on UT's campus that serves as a low-cost demonstration landscape of how previously overlooked landscape fragments can be utilized to manage stormwater from surrounding buildings. Figures 3 and 4 show a vegetative 'green' streetscape and common plaza that act as sponge landscapes that reduce runoff and retain some of the site's stormwater. These interventions are also demonstrate the aesthetic potential of infrastructural landscapes as public space, building the critical social awareness and cultural adoption necessary to enable wide-spread of district stormwater management applications.

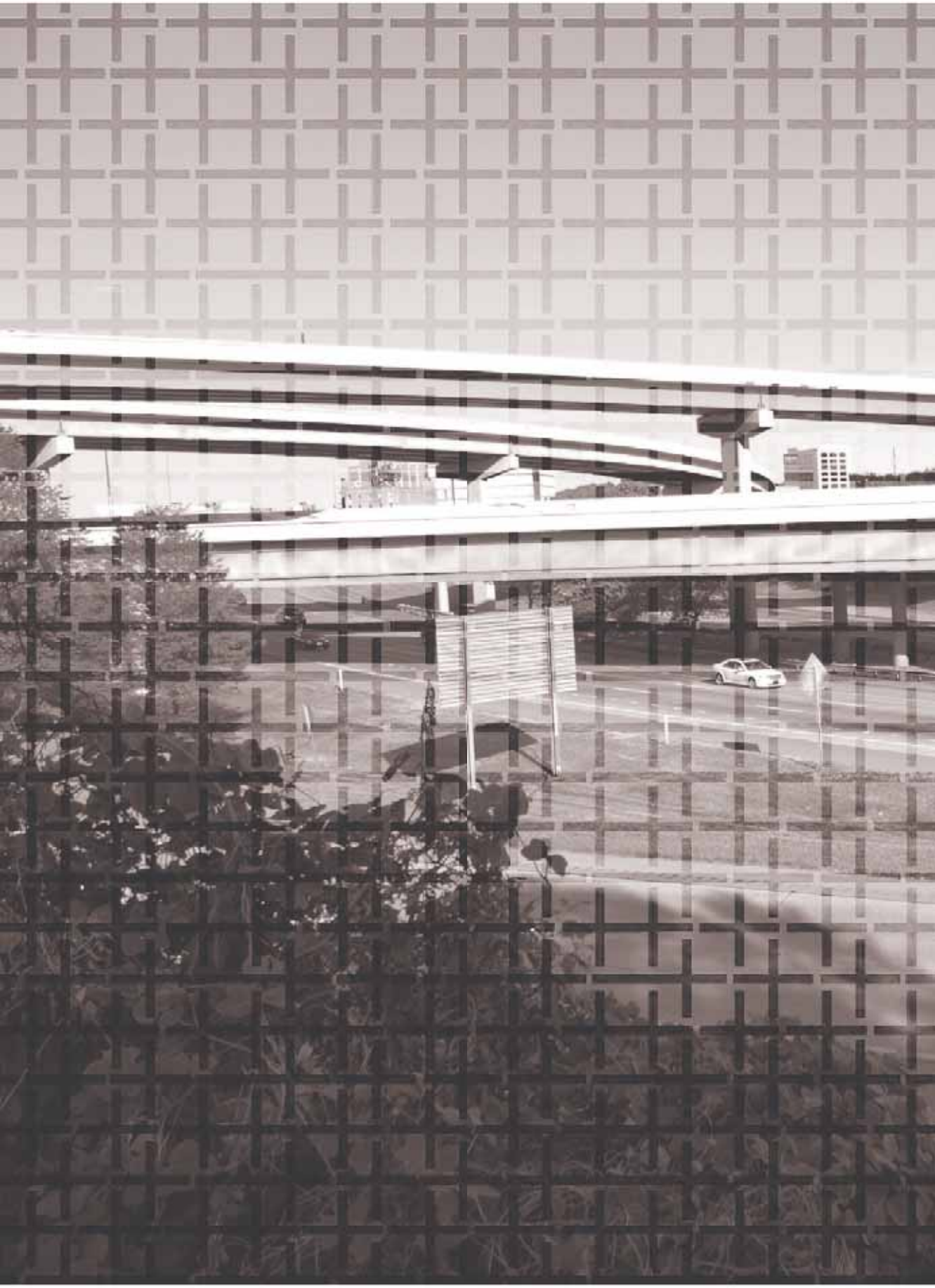
PRECEDENTS

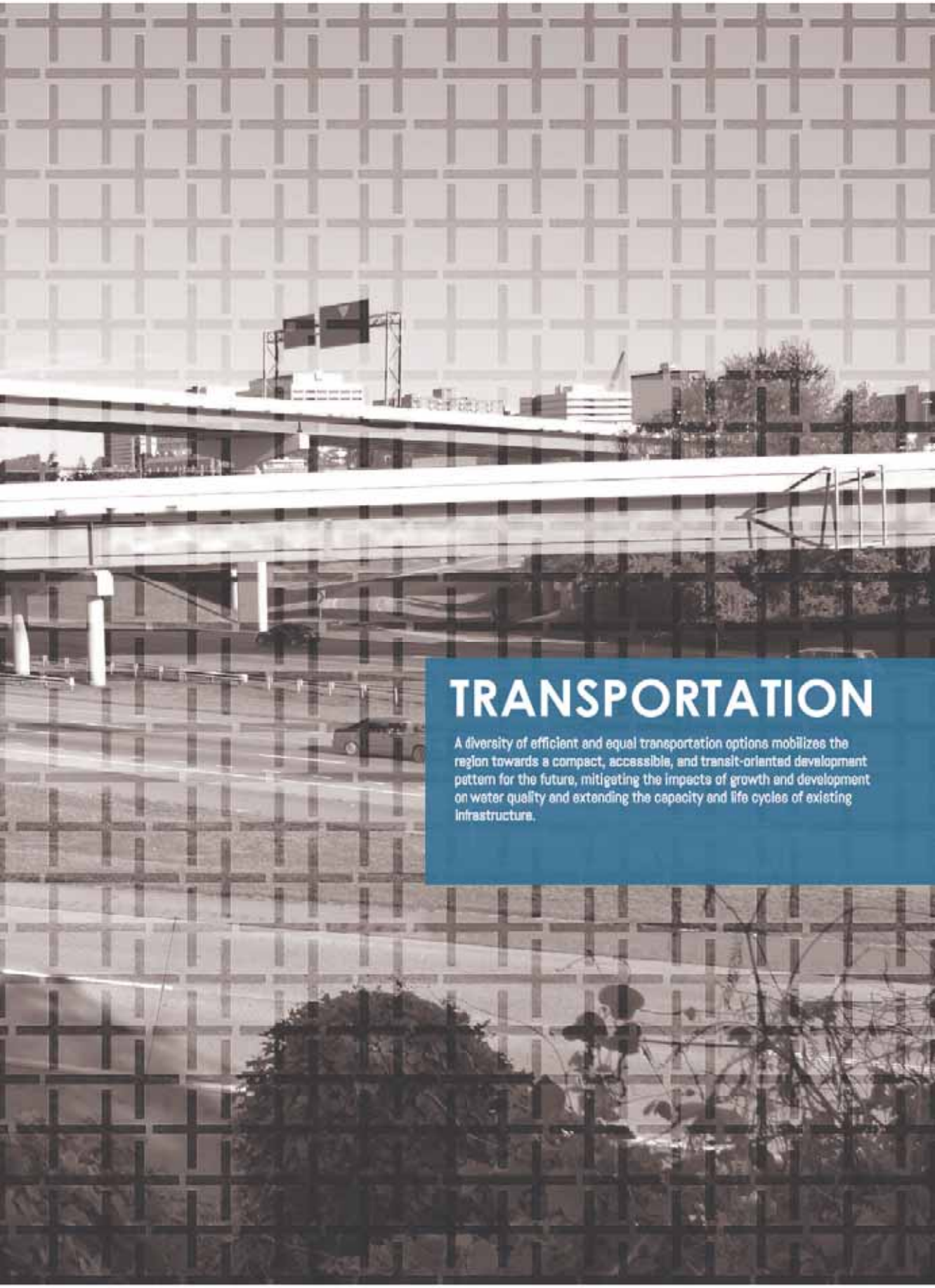
Eco-Commons, Georgia Tech
Atlanta, GA
2011

Georgia Tech University's Eco-Commons is part of the campus landscape master plan that integrates ecological diversity to the campus landscape while reducing stormwater runoff by 50 percent. Their innovative district approach connects existing campus open spaces to create efficient, multi-functional stormwater management solutions which provide new recreational and educational opportunities.

Shoemaker Green, U of PA
Philadelphia, PA
2013

Shoemaker Green at the University of Pennsylvania is an example of district stormwater design. This 3.75 acre site captures stormwater from the area and surrounding rooftops while providing a traditional campus open space. The design is engineered to optimize water collection and infiltration from the surrounding buildings and is programmed as a hub of social activity and campus recreation.





TRANSPORTATION

A diversity of efficient and equal transportation options mobilizes the region towards a compact, accessible, and transit-oriented development pattern for the future, mitigating the impacts of growth and development on water quality and extending the capacity and life cycles of existing infrastructure.

Interstate 24 travels immediately adjacent to the Tennessee River in downtown Chattanooga.

TRANSPORTATION

Safe, reliable and efficient transportation is fundamental to the economic competitiveness of a region and the mobility of its citizens and its knowledge capital. It is the means through which businesses, communities and individuals distribute products, access essential services, and connect with others to share ideas and experiences. Such mobility also enables access to the region's wealth of natural resources and remote landscapes, including rivers, lakes and streams.

EXISTING CONDITIONS

In the SETD region, the automobile serves as the primary, if not exclusive, mode of personal transportation. Less than 1% of the region's population utilizes public transit.[40] These realities are both a driver and consequence of the form and scale of the region's sprawling built environment and its supporting transportation infrastructure. The public and private infrastructure necessary to facilitate the movement and temporary parking of automobiles yields a pattern of low density, decentralized development where the resultant community scale and distances between destinations requires personal automobile ownership and usage, disadvantaging those who cannot afford it. Characteristic to this pattern are prolific impervious surfaces that are costly to install and maintain. Plainly stated, the planning and design of communities since the mid-twentieth century privileges cars, vans and trucks, bowing to their perceived convenience and perpetuating a culture of mono-modalism. This reality has economic, social, and water quality consequences.

The cost of maintaining existing infrastructure and building new roads to support sprawling growth strains municipal and state transportation budgets. TDOT's current backlog of approved but unfunded projects is greater that $6 billion, many of which cannot be considered for funding until 2022, and others that will not be completed or under contract until 2035.[41] Many of the region's citizens spend a significant amount of their personal income on transportation expenses, while others in urban landscapes and remote rural areas cannot afford an automobile or have no alternative means of transportation, harming their ability to access basic services, fresh healthy food and employment opportunities[42]. Time spent commuting and lost in congestion could otherwise be committed to productive activities.

The region's vast impervious surfaces, their installation and maintenance regimes, and the disruption of natural hydrologic cycles by the sprawling footprint of an auto-centric development pattern create a disproportional volume of contaminated stormwater when compared to compact growth patterns supported by public transportation and conducive to pedestrian mobility. Parking lots, roads and gas

stations are all hot spots for non-point source contaminants, including petrochemicals and heavy metals, that become mobilized in runoff and are eventually discharged to receiving streams, rivers and reservoirs.[43] These impervious surfaces superheat runoff during hot summer months, raising the temperature and decreasing the available oxygen of receiving waters. The gradual degradation of road surfaces and their hydrocarbon binders, as well as the processes to repair and replace these surfaces, cause additional water quality challenges.

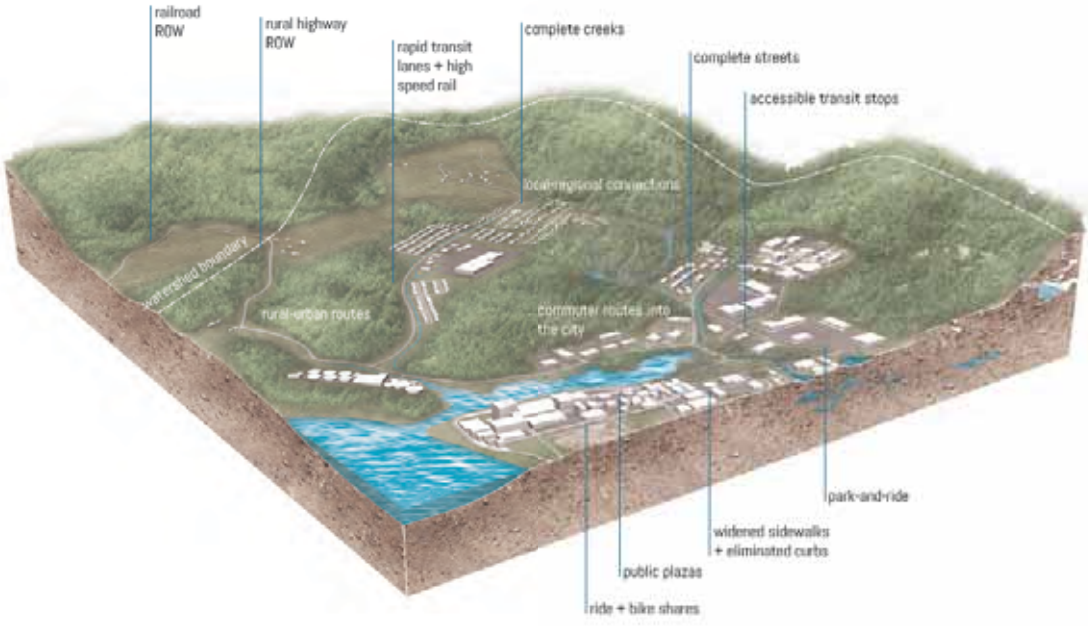
Serving the transportation needs of existing populations and that of the region and the state's projected population growth is very much at the center of SETD's existing water quality challenges, future water quality threats, and potential watershed health solutions. Proactive thinking, strategic transportation investments, and creative planning and development will be necessary to mitigate these challenges through a more compact, transit-oriented development pattern supported by a diversity of complementary, efficient and clean transportation options.

APPROACH

Opportunities to yield additional capacity from existing road and rail infrastructure must be realized, alternative growth patterns with reduced hydrologic footprints must become mainstream, and the anecdotal perceptions, special interest influences and regulatory impediments that delay or prevent progress towards these ambitions must be overcome.

Some progress is being made. Chattanooga and Cleveland both operate bus transit systems, and discussions are ongoing regarding the possibility of light rail in Hamilton County.[44] Flexible ride-sharing services like Uber and Lyft are becoming more popular and expanding their reach within the region, and the popularity of the region's greenways are evidence of a demand for safe and comprehensive bicycle and pedestrian networks.[45] The popularity of the healthy lifestyles afforded by dense, mixed use development patterns is supported by demographic trends, urban housing demand, and successful redevelopment initiatives in Chattanooga[46] and elsewhere around the region. However, there is much work to be done.

If the region is to realize a future where denser development patterns with a reduced hydrologic footprint are possible, strategic planning, visioning processes and meaningful investments in alternative transportation, pedestrian mobility, and walkable communities must be made today. A vision for a diverse mix of transportation options operating at multiple scales, development patterns that catalyze their success, and policies and incentives to create vibrant, livable urban centers must be established, pursued, and unconditionally supported. Establishing this vision and taking incremental steps towards its full realization are the focus of the strategies in the following section. Such investments today will position the region for an economically competitive tomorrow that is prepared to connect to future inter-regional transportation systems and attract populations and businesses that are seeking the quality of life provided by connected, walkable communities.



The territories identified above include those landscapes where the following water quality improvement strategies may be implemented.

WHAT GUIDING PRINCIPLES

1

CONNECTIVITY: Equality of Access

- To connect rural and urban areas efficiently and reliably
- To expand opportunities for all communities through easily accessible and affordable transportation options supported by interconnected roads and pedestrian networks

2

MOBILITY: Intellectual and Economic Movement

- To facilitate the spread of ideas and expertise
- To distribute goods and services more fluidly
- To enable efficient access to economic opportunities

3

INTEGRATION: Ecology in Transportation

- To incorporate ecological processes in infrastructure approaches and maintenance regimes
- To use vegetation to improve the environmental quality and ecological performance of transportation routes

4

SHARING: Re-envisioning Place-making

- To use existing infrastructure for implementing innovative solutions and capacity maximization
- To maintain a critical eye toward the effectiveness of existing conditions

HOW STRATEGIES FOR CHANGE

EMPLOY REGIONAL TRANSIT

A regional transit system that offers diverse options accessible to all can bring more economic and intellectual opportunities to the region

a

IMPROVE PEDESTRIAN + BIKE ACCESS

Attractive, environmentally-designed pedestrian and bike-friendly spaces in a city or town can improve people's health and support dense urbanism

b

DEVELOP VIA TOD SITES

Transportation investments at strategically-selected sites create a framework for future communities with reduced hydrologic footprints

c

ADOPT SHARED SPACE

New transit zones may reconceptualize traditional models of urban street design and create environmental and socio-economic opportunities

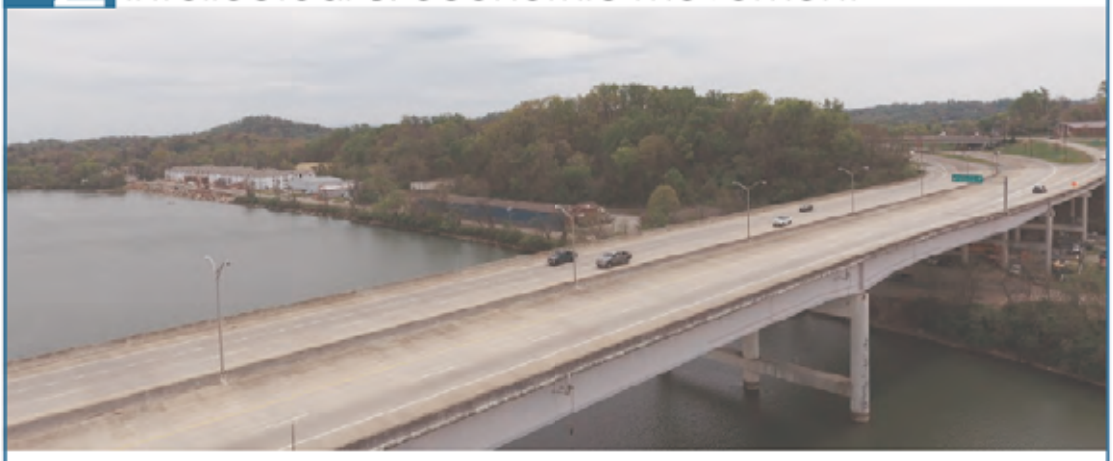
d

WHAT GUIDING PRINCIPLES

1 CONNECTIVITY: equality of access

Regional transit has the potential to connect communities across the region. Regional transit systems are supported by reliable local transit systems such as park-and-rides, shared bikes and automobiles, pedestrian routes, and bike lanes. Increasing options that suit all socioeconomic profiles can create a strong network of connectivity throughout the region, making mobility more than simply about a person's access to a private vehicle.

2 MOBILITY: intellectual & economic movement



Increasing options for transportation modes, enhancing connectivity networks and improving system resiliency keeps people and ideas moving efficiently throughout the region. This allows for greater time utilization and productivity maximization, enhancing the economic competitiveness of the region. With efficient and reliable transit that connects compact, vibrant communities, all residents can have equal access to basic economic opportunities, and commerce can thrive in new and innovative ways.

3 INTEGRATION: ecology in transportation

On many routes today, rights-of-way support limited biodiversity due in part to DOT maintenance protocols and design standards. Redeveloping transportation corridors as expansive ecological corridors can improve water quality by absorbing and filtering runoff, while providing valuable habitat as well as shade to reduce the heat island effect, enhancing comfort for pedestrian and bike traffic. Incorporating ecological centers at TOD sites offers habitats for wildlife that travels along these new eco-corridors.

4 SHARING: re-envisioning place-making

Aside from streets with sidewalks, many transportation corridors serve a single mode of transportation, and therefore may have latent capacity due to infrequent use. By safely integrating multiple modes of transportation into shared rights-of-way, such as integrating pedestrian thoroughfares within railroad and riparian corridors, new primary routes can be established for alternative transportation and capacity maximization can be realized for otherwise underutilized infrastructures.

CONNECTING
PRINCIPLES & STRATEGIES

	a EMPLOY REGIONAL TRANSIT	b INCREASE PEDESTRIAN + BIKE ACCESS
1 CONNECTIVITY	Regional transit provides a variety of reliable and accessible options connecting communities across the region.	Providing communities with routes for walking and biking is an important connector between transit stops, common routes, and final destinations.
2 MOBILITY	Quick, convenient transit throughout the region facilitates the sharing of ideas, goods, and services for the benefit of the greater intellectual and business community.	Businesses often are located along transportation routes. Walking or biking increases exposure to commerce, builds patronage and encourages social engagement.
3 INTEGRATION	A regional transit system can reduce the amount of impervious surfaces and stormwater runoff, opening opportunities for ecological corridor preservation and regeneration.	Pedestrian and bike routes can use planting strategies to establish vegetated corridors and buffer zones that improve air quality, manage stormwater, and protect water resources.
4 SHARING	Rethinking the functional capacity of infrastructure rights-of-way for regional transit reduces the need to locate new routes, maintain existing ones, and mitigate existing traffic issues.	Identifying prime locations for pedestrian and bike access can improve traffic flow within cities and provide alternative transportation for suburban and rural areas.

C DEVELOP VIA TOD SITES

Centralizing businesses and housing will reduce sprawling urban growth and promote local transit connections.

By investing in transportation nodes and providing a combination of regional and local transportation options, users may have better access to urban centers and other communities.

TOD sites can support a more efficient use of land, a reduced hydrologic footprint, and adapt existing infrastructure to more contemporary standards of transit and livability.

Combining commercial and residential transportation networks can cultivate smarter, socio-economic growth in rural and urban areas.

d ADOPT SHARED SPACE

New transit zones can facilitate a new perspective about connectivity between communities and the region's long-standing auto-centric view of travel.

Maximizing the efficient use of space and connections to goods and services, via adapted vehicles and modified streets, can help city centers to flourish.

The engineered ambiguity of shared spaces has the potential to keep users conscientious of each other and their safety.

Erasing conventional boundaries can create a safe, singular plane for pedestrian and vehicular movement.

HYDROLOGIC BENEFITS

An efficient regional transit system with rail, bus, and ride-sharing promotes compact growth, reduces impervious surfaces and associated non-point source pollution, and enables traditional rights-of-way to serve as eco-corridors. Eco-corridors along pedestrian and bike routes improve micro-climate conditions that otherwise would have adverse effects on water quality and human health.

TOD SITES

Beginning as park-and-ride stops, these transit centers provide better access to urban centers while encouraging sustainable development in rural areas.

REDUCE INDEPENDENT AUTO

Placing a greater emphasis on public transportation can help to reduce the amount of traffic on the road, decreasing congestion and extending infrastructure life cycles. Similarly, ride-sharing can reduce the number of individual cars while sustaining availability of transportation.

AUTONOMOUS VEHICLES

As driverless cars become more common, designated lanes can help maintain a continuous flow of traffic separate from driven vehicles. Widespread use of linked, autonomous vehicles is anticipated to reduce the need for expansive parking lots and reduce traffic, allowing road rights of way to be reorganized.

RAPID TRANSIT LINE

Buses often provide transit within the city but can also be incorporated into regional transit. Converting the shoulder or one lane to a bus-only lane will reduce overall travel time and give people more incentive to ride the bus.

EMPLOY REGIONAL TRANSIT

a

A wide-reaching public transit system is important to the region not only for its ability to reduce automobile pollution and impervious surfaces, but also to increase accessibility between communities, the mobility of its citizens, and future economic competitiveness. The SETD region is made up of many small rural towns. Providing these communities with an easy way to reach population and employment centers through regional transit networks can open economic opportunities that might otherwise be inaccessible. Providing a diverse ecosystem of on-demand transportation options within communities encourages livability and affordability of dense, walkable communities. Transportation today is primarily independent; people rely on individual resources to move around the region because shared options are limited in reach, perceived to be unsafe, or considered unreliable. State and local transportation budget limitations, amplified by regional growth projections, require that the capacity and life-span of existing infrastructure be extended. A functional regional transportation system, supported by diverse local transportation options, can make this increase in capacity possible while catalyzing compact growth and vibrant walkable communities with a reduced hydrologic footprint.

INFRASTRUCTURE RUNOFF

Reducing impervious transit infrastructure improves runoff conditions, mitigating risks of urban flash flooding and decreasing the amount of vehicular pollutants washed into stream and lake ecosystems.[47]

CONNECT COMMUNITIES

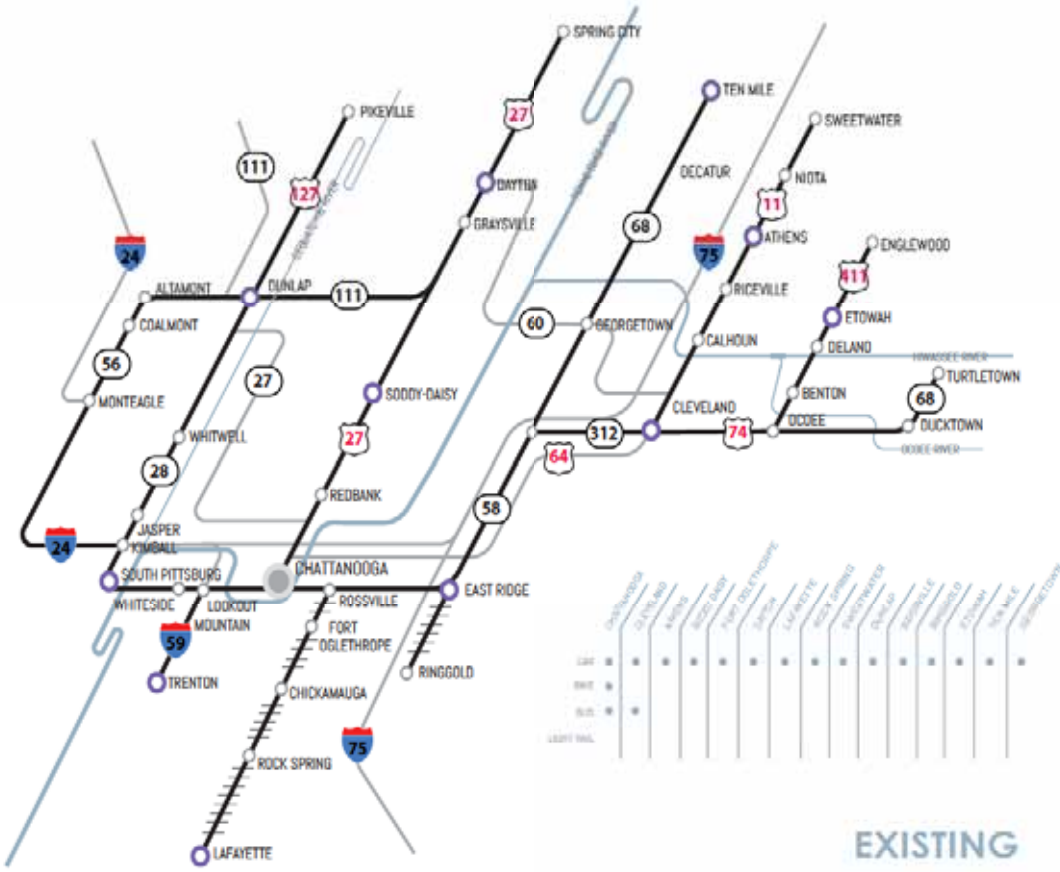
Rail provides quick, efficient access between communities, as well as throughout them. Thus local and regional rail lines are important elements of a new transit plan, positioning the region to connect to future inter-regional high-speed rail infrastructures.

RIDE SHARING

Ride share services such as Uber and Lyft offer flexibility of travel without the need to own and maintain a vehicle. Bike shares offer this same access and flexibility.

BIKE + PEDESTRIAN

Local transit plays a vital role in regional transit as people need safe routes between transit stops and their ultimate destinations.

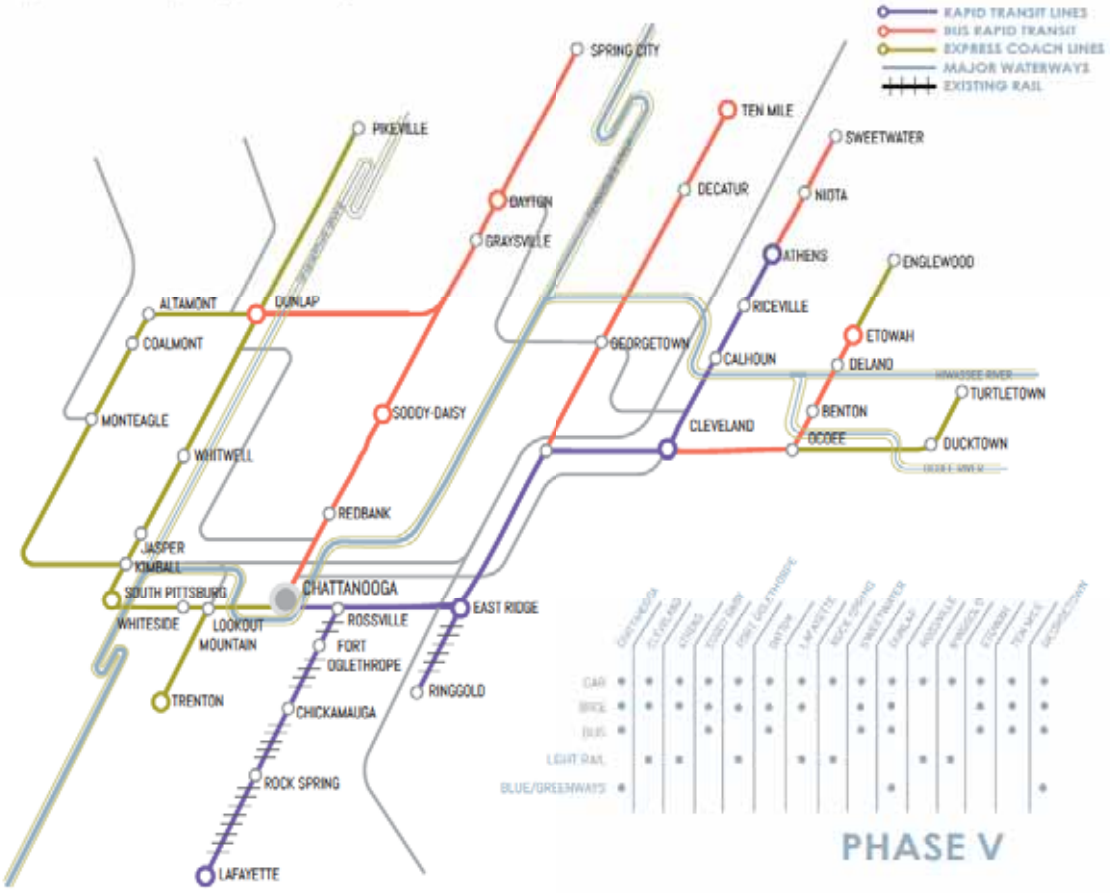

SPRING CITY
PIKEVILLE
TEN MILE
SWEETWATER
DECATUR
NIOTA
ATHENS
ENGLEWOOD
ETOWAH
DELANO
RICEVILLE
CALHOUN
GEORGETOWN
ALTAMONT
DUNLAP
COALMONT
MONTEAGLE
WHITWELL
SODDY-DAISY
GRAYSVILLE
DAYTON
REDBANK
JASPER
KIMBALL
SOUTH PITTSBURG
WHITESIDE
LOOKOUT MOUNTAIN
TRENTON
CHATTANOOGA
ROSSVILLE
FORT OGLETHORPE
CHICKAMAUGA
ROCK SPRING
LAFAYETTE
EAST RIDGE
RINGGOLD
CLEVELAND
BENTON
OCOEE
TURTLETOWN
DUCKTOWN
EXISTING


PHASE I


PHASE II

REGIONAL TRANSIT PHASING PLAN

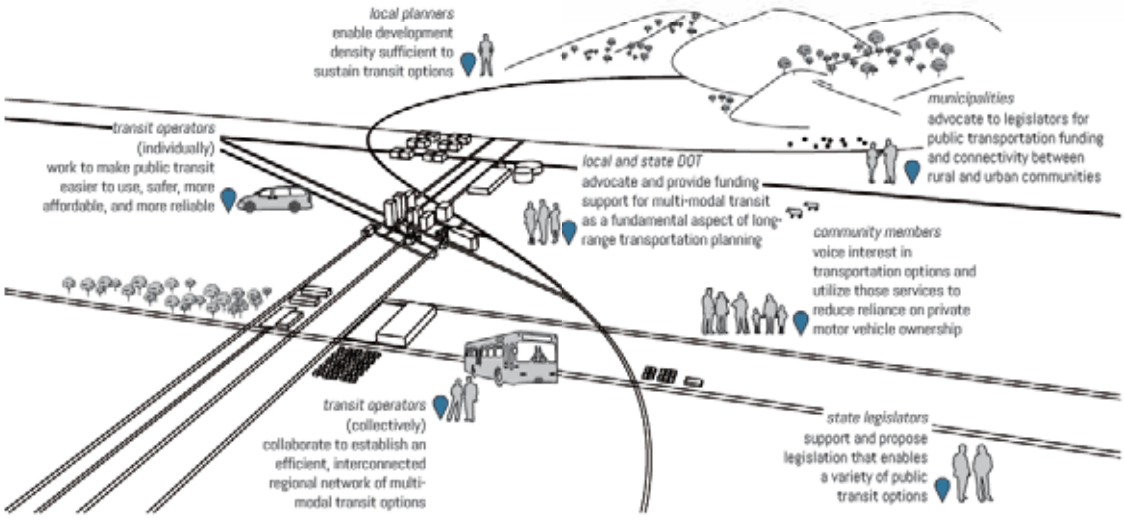
Existing infrastructure primarily supports automobiles via interstates and highways. A phased approach to developing a regional transit system can facilitate the deployment of bicycle and pedestrian networks, buses, greenways, blueways, and eventually light rail as demand and population density increases. Ultimately, the fifth phase of this proposal realizes one potential vision for a regional transportation system that is highly connected by rapid, efficient, safe, dependable, and equitable transportation, positioning it for connections to larger interstate and inter-regional rapid transportation networks. This particular phasing plan was a studio project done by a student speculating possibilities and opportunities for a phasing plan in the region.



IMPLEMENTATION TERRITORIES

Complete Creeks + Streets	New infrastructural and riparian corridors can connect rural and urban communities, promoting the growth of commerce and access to employment opportunities.
Rapid Bus Transit	Prioritizing affordable public transportation on the road and changing methods of fare collection can reduce many of the delays experienced in conventional bus systems.[48]
Ride + Bike Shares	Establishing carpooling, car sharing and cycling systems can ease road congestion and lessen the emission of automotive pollutants in urban, suburban and rural communities.[49]
Railways	Vacant or degraded railway infrastructure can be reactivated to become multi-modal corridors and active freight lines can be recalibrated to accommodate commuter traffic.
Rural Highway ROW	Rural highways are expansive and typically underutilized, but can be retrofitted to include rapid transit bus routes as well as allow safer travel for pedestrians who choose to walk or cycle.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Perception	Cultural perceptions of public transportation safety and efficiency prevent widespread use.
Service Area	Expanse of existing development can limit the ability to provide service to all citizens economically.
Commitment	Long-term success requires investment endurance in the face of criticism and challenges.
Legislation	State budgets and regulations[50] limit local authorship of transportation systems.

TACTICAL SITE INTERVENTIONS


Fig. 1 Mapping

Fig. 2 Park and Rides


Fig. 3 Accessible Stops

Fig. 4 Easier Payment

An efficient regional transportation system usually involves the collaboration of different communities and existing systems. As figure 1 expresses, mapping and GIS data can be used to identify current commuting patterns. This data can reveal where and what type of transit options may be successful. Figures 2-4 show ways that current systems can make incremental improvements. In areas that lack public transit options, ride-sharing programs can be introduced as an option for regional travel. Figure 2 is an example of a park-ride location. Figures 3 and 4 are two different tactics used to improve existing systems and increase ridership by making it easier to use the transportation. One way is to make current bus stops and transit stations more accessible, safe and comfortable like the stop shown in Figure 3. Figure 4 improves accessibility differently by providing commuters with a more efficient payment method.

PRECEDENTS

Southeast Tennessee Rural Regional Transit
2016 (phase 1)

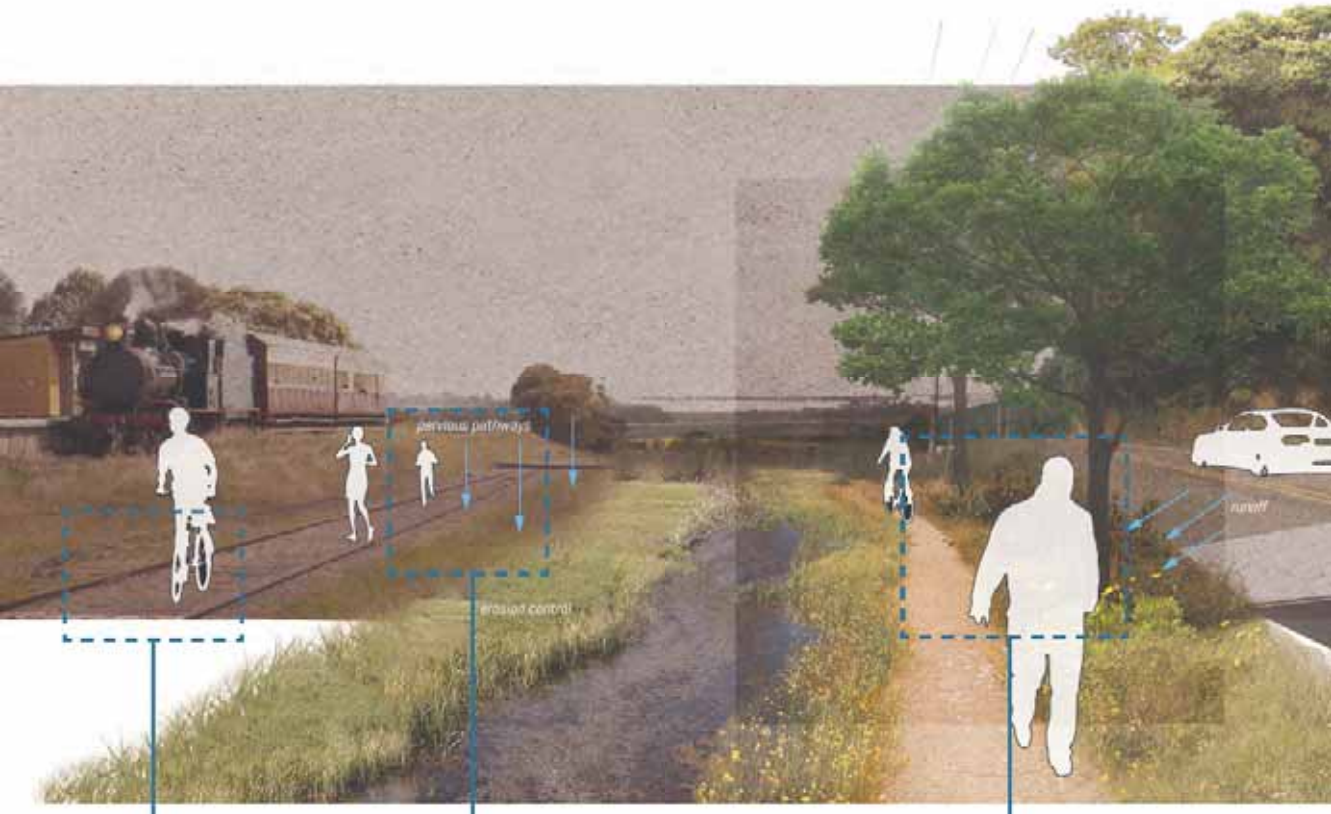
This service is offered by the Southeast Tennessee Human Resource Agency as a way to improve rural mobility within the region. The system provides mass transportation service to 9 counties in southeastern Tennessee. Originally aimed towards providing seniors and the disabled with accessible transportation, this service is now available to all community members.

Sound Regional Transit
Puget Sound Region, WA
1999

In response to increasingly congested roadways, this regional system was created to serve the multiple counties that make up the Greater Seattle area. This network includes multiple modes of transit that work together to transport people in, out, and around the city and its surrounding suburbs.

HYDROLOGIC BENEFITS

Providing more opportunities for pedestrian and bike traffic in both urban and rural areas reduces the need for impervious surfaces and their maintenance, as well as lessening the amount of auto pollution in the air and water. Lining these routes with trees and other vegetation mitigates runoff and temperature extremes.



RAIL TRAILS

Greenway trails beside functioning railroads or on former tracks serve as commuter routes because of their existing connections between communities.

COMPLETE CREEKS

Creeks and streams travel throughout urban and rural areas, so locating greenways along these waterways can provide logical routes through the region. See the section on "Ecological Protection" for more information about this concept.

RURAL HIGHWAY R.O.W.

Some rural roadways are narrow and leave little room for pedestrian access. Employing the right-of-way and creating a vegetative barrier gives pedestrians a safer way to navigate rural roads.

INCREASE PEDESTRIAN + BIKE ACCESS

b

Complete Streets is one policy many cities are using to create more sustainable streetscapes that improve stormwater strategies in addition to strengthening community, economic, and environmental health.[51] The proposed model serves as the foundation for the Complete Streets strategy as it incorporates vegetation for water absorption and filtration, shade for reduced heat island effect, and bike and pedestrian access for less vehicle traffic. It is critical to understand pedestrian access as not merely providing physical space such as a sidewalk or trail, but rather giving equal consideration to pedestrian comfort and safety through shading, buffering from vehicular lanes, lighting and adequate sizing. Likewise, bike lanes should be designated on roadways, but can be made safer by inserting bollards or vegetation between bike and vehicle lanes. The benefits of these vegetative zones extends beyond pedestrian and bike safety, providing multi-functional urban canopies, vegetative buffers and eco-corridors that may integrate stormwater management and flood mitigation features in areas that typically experience high amounts of runoff. Using vegetation and other natural features to retain water can reduce the need for costly storm drains and pipes that require maintenance and repair, and can lessen the risk of the damaging consequences of overflows and floods.

BIKE LANES + CYCLE TRACKS

Bicyclists should be provided with shared access or separate bike lanes to make motorists aware of their presence on the road. Shown here is a lane set apart by a vegetative barrier, which separates riders from both vehicles and pedestrians. Supporting infrastructure like bike racks at destinations and repair stations help expand bike culture.

VEGETATION BARRIERS

In addition to providing visible division and protection from vehicles, plantings along a roadway provide stormwater infrastructure and shade control for healthier surface and water temperatures.

URBAN PEDESTRIANS

Pedestrians are attracted to wide sidewalks, and vegetation creates a more comfortable and aesthetically pleasing atmosphere.[52] Increasing pedestrian traffic can improve economic growth and the health of the community while reducing car dependence and congestion.

IMPLEMENTATION TERRITORIES

Bike Shares	Bike rental stations in communities of various sizes can make it easier for people to get to their destinations without the need to own a bike or car.
Railroad ROW	Many railroads are only used periodically or are maintained for potential future use, making them potential routes for pedestrians and bicyclists in the interim.
Rural Highway ROW	Adding barriers or buffers on rural highways can make it safer for people to travel through rural areas on bike or foot, increasing access to opportunities or resources in other towns.[53]
Complete Streets	Vegetated barriers and slower traffic can help make complete streets healthy and safer forms of transportation in towns and cities.[54]
Complete Creeks	Similar to complete streets, this multi-modal system invites bicycle, pedestrian, and wildlife mobility by enhancing the health and accessibility of natural corridors and networks.

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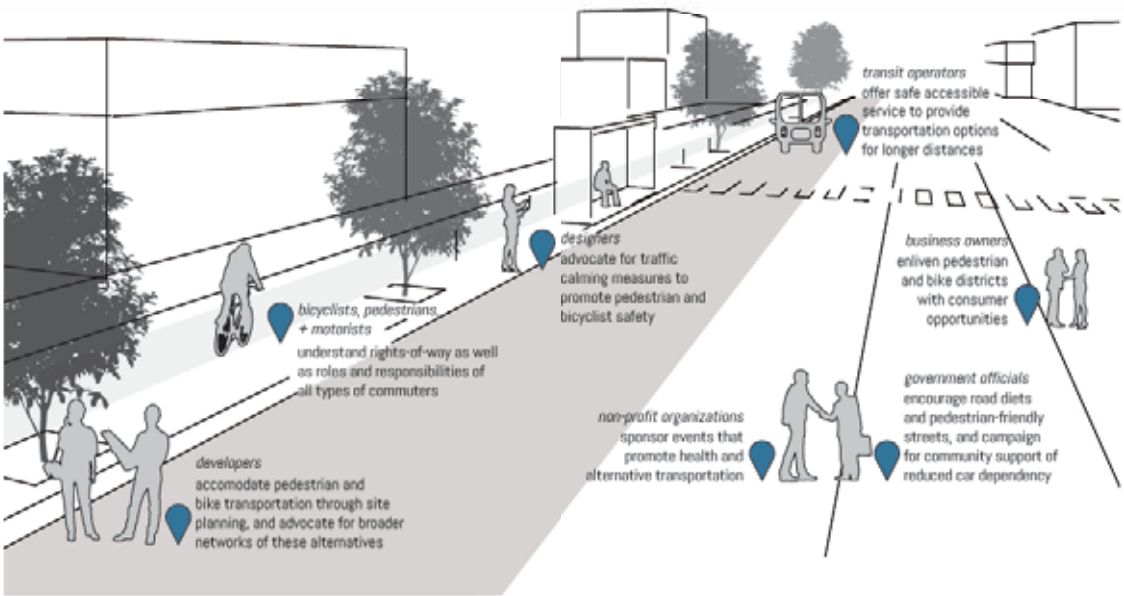


ANTICIPATED CHALLENGES

Change	Many projects require the reorganization of historically auto-centric rights-of-way.
Safety	Education of rights and responsibilities of pedestrians and cyclists is necessary to promote safety.
Commitment	Long-term success is afforded by endurance of short-term resistance and challenges.
Environment	Safety and comfort are also factors that affect the usage of sidewalks and bike lanes.

TACTICAL SITE INTERVENTIONS

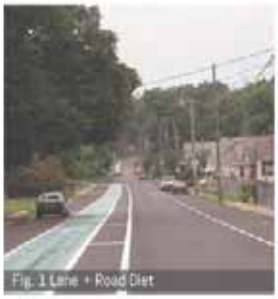


Fig. 1 Lane + Road Diet


Fig. 2 Bike Infrastructure

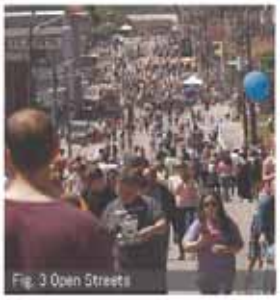


Fig. 3 Open Streets


Fig. 4 Community Bike Ride

There are many inexpensive projects that communities can undertake to help expand pedestrian and bike culture. These include lane diets, which reorganize space allocations to include bike lanes or side walks on existing pavement surfaces through striping, as shown in Figure 1. Road diets reconsider the extents of pavements and reorganize the right-of-way through more extensive and permanent construction, such as eliminating a travel lane to provide space for street trees and expanded sidewalks. Inexpensive bike infrastructures in Figure 2 include bike stands that enable cyclists to make simple repairs and inflate tires, and bike racks that permit safe bicycle storage. Both help overcome common obstacles that can otherwise deter ridership. Many communities have adopted Open Streets events (Figure 3) that temporarily close thoroughfares to allow pedestrian activity only, and Community Bike Rides (Figure 4) that help overcome anxiety about urban bike ridership and increase visibility of cyclists to motorists.

PRECEDENTS

Market Square
Knoxville, TN

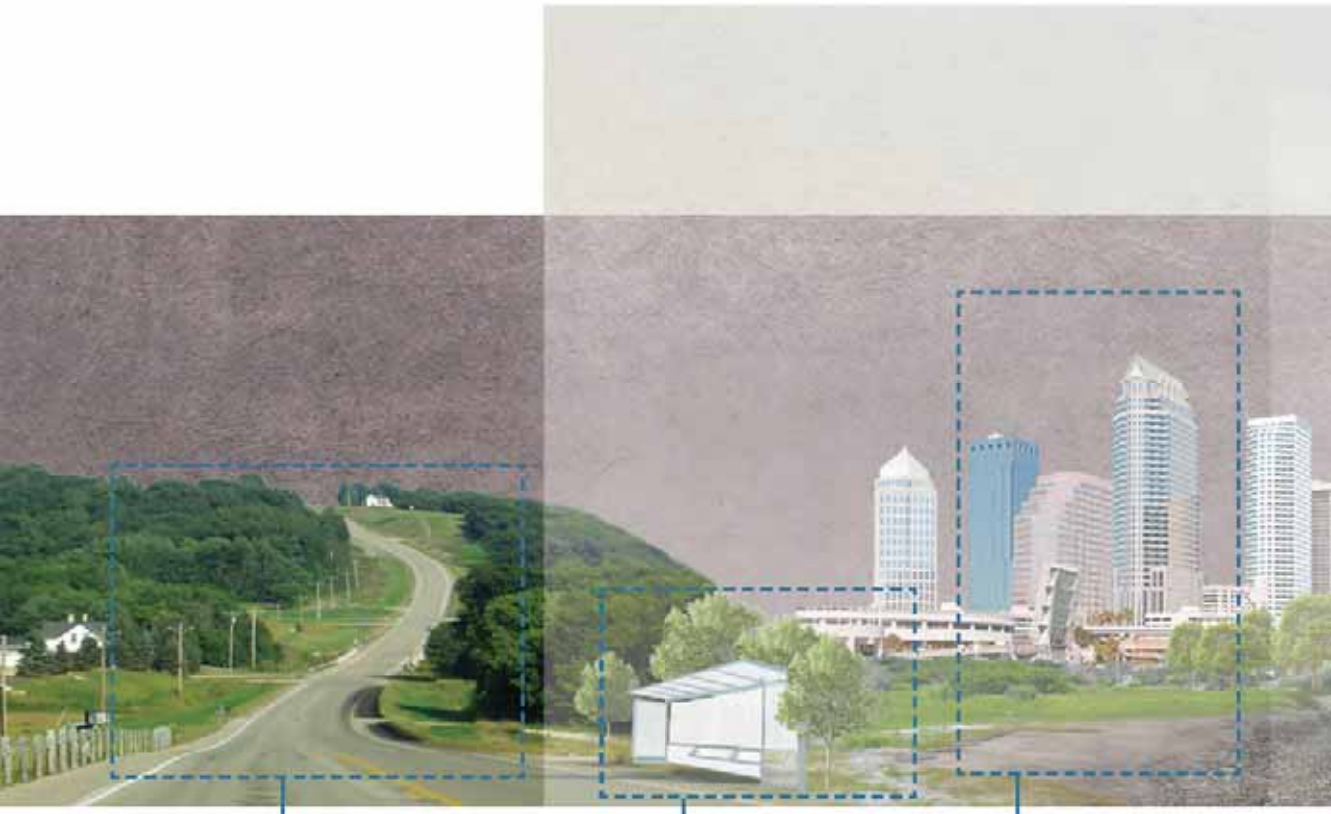
Market Square is a pedestrian-only plaza in downtown Knoxville. Bucking the 20th century cannon that pedestrian malls are not economically viable, this vibrant urban space is free of auto obstructions, creating a safe area that invites foot and bike traffic from all over downtown. The space also plays host to special events, including a farmer's markets, movies and concerts, which draw even more pedestrian traffic and economic activity.

Whitwell Multi-Modal
Whitwell, TN

The purpose of this grant-funded project is to address the needs of non-motorist users including pedestrians and cyclists. The project will add 4,850 feet of sidewalk along rural Highway 28, thereby increasing connectivity and accessibility along the corridor, and beginning to provide a delineated zone for pedestrians.

HYDROLOGIC BENEFITS

Transit Oriented Development enhances regional water quality through its walkable, compact form and reduced stormwater footprint compared to alternative growth patterns. Higher population densities support the success of local commuter transit systems and regional networks, reducing congestion and demand for the expansion and maintenance of roads, parking lots and other auto-centric surfaces and services.



RURAL TRANSIT

Communities located outside urban centers are more likely to have below-average transit services. A regional fixed-route bus transport would increase economic connectivity and ease highway congestion.

TOD STATIONS

Both rural and urban stations must be easily accessible, well-lit and adhere to reliable schedules.[55] These sites gradually evolve over time as park-and-ride stops and urbanizing TOD districts as populations grow and transit modes expand accordingly.

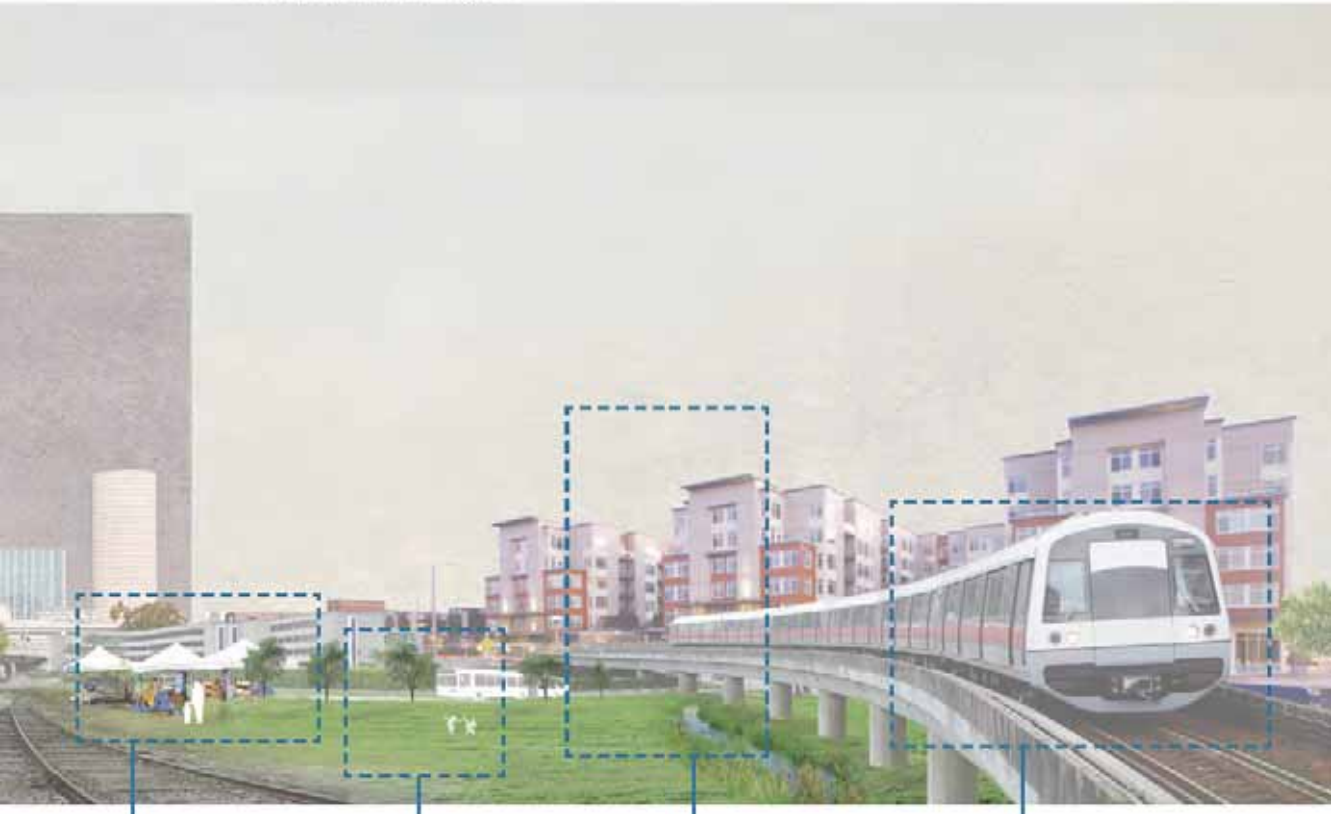
URBAN DENSITY

Densely populated, walkable neighborhoods aggregate around new transit stations, increasing ridership and transit viability. Older transportation infrastructure provides opportunities for novel and retrofitted commuter patterns.

DEVELOP VIA TOD SITES

C

Transit Oriented Development (TOD)[56] sites are a coordinated investment of transportation and land use projects that offer a range of economic and housing opportunities, as well as a more efficient use of land and existing infrastructure. TOD resists sprawling urban growth, reducing the need to commute long distances by providing better access to education and business. A phased approach to TOD development allows sites strategically selected for their proximity to populations and future multi-modal transportation infrastructure to be transit-ready before they are transit-oriented. Regional bus transportation stops and park-and-ride facilities at these sites increase their utilization and the visibility of surrounding properties through increased traffic from rural and suburban users. This increased activity can stimulate economic exchange between rural and urban networks, enabling the site to gradually evolve into compact, mixed use developments as investment in public infrastructure gains the interest of private partners. Parks and green spaces within TOD projects will provide visitors and residents with lively gathering spaces that can also reduce and treat stormwater runoff. Successful TOD projects can activate economic activity on adjacent sites and expansions of regional transportation systems, thus catalyzing opportunities for new TOD projects and economic growth.[57]



URBAN PARKS

Urban parks create a sense of respite and social connection within the built environment that many seek from suburban communities, enhancing quality of life for TOD residents. These parks should be strategically distributed and perform a range of functions, including stormwater management.

PARK + RIDE

Swaths of green space maximize the relationship between land uses and provide a range of formal and informal gathering spaces. These amenities can double as transit nodes for park-and-ride or other incentivized commuter parking facilities.

AFFORDABLE HOUSING

TOD sites not only contribute lower cost and accessible housing, but also reduce household transportation expenditures.[58] A variety of housing types provide increased housing choice and living styles for a range of family types.

COMMUTER RAIL

Advanced rail will address the region's transportation requirements while encouraging sustainable urban growth. A modern commuter rail service will reinvigorate an underutilized transportation resource and attract new riders from a range of communities.[59]

IMPLEMENTATION TERRITORIES

Urban Centers	Compact, mixed-use development can invigorate existing urban centers and stimulate new investments in housing, jobs, shopping and recreational choices.
Transit Stations	Co-location of transit hubs for bus and rail transit can increase transition efficiency so individuals within the community can better walk, bike or take public transit to their destinations.
Vacant Lots	Positioning vacant and underutilized parcels that are adjacent to bus or future commuter rail lines as future TOD sites can help develop a sense of community and stimulate investment.
Neighborhoods	Populations in suburbs may assume that an auto-centric landscape is the only option, but they can be educated about the efficiencies and lifestyle benefits of alternative modes of transportation.
Rural Transit	Planned park-and-rides, bus, and rail can aim to provide rural areas the opportunity to become more connected to the resources and economic opportunities in urban areas.

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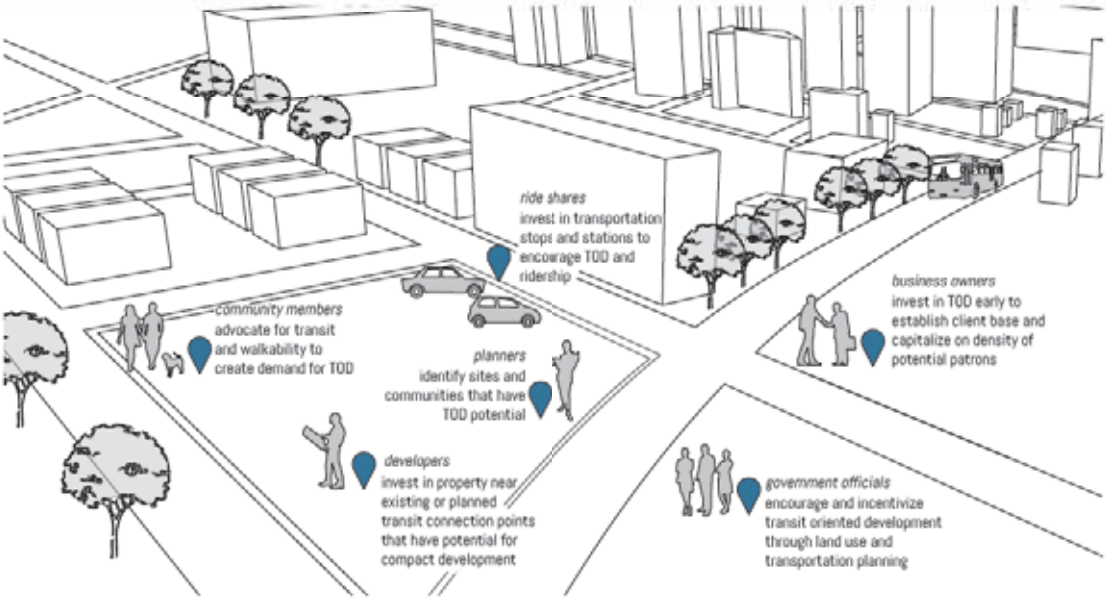


ANTICIPATED CHALLENGES

Funding	Funding TOD projects requires investment from multiple public and private sources.
Zoning	Current codes may not allow for mixed land use and density needed to support transit.
Collaboration	Success of TOD sites is dependent on a synergistic relationship between development partners.
Fragmentation	Ideal TOD sites contain small parcels and multiple owners, requiring acquisition and consolidation.

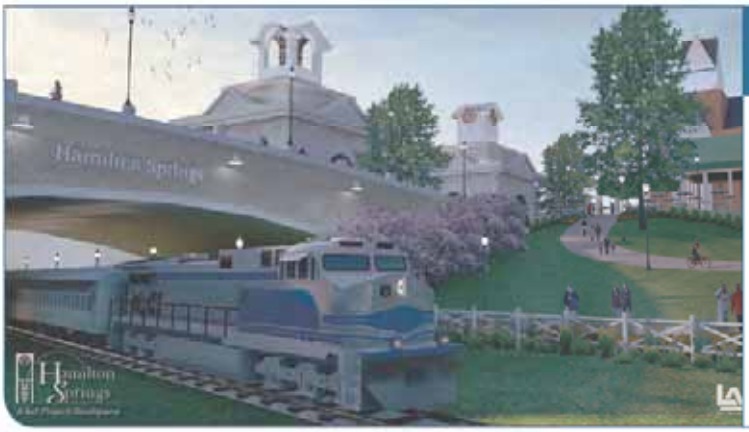
TACTICAL SITE INTERVENTIONS

Fig. 1 Change Land Use Around Stations

Fig. 2 Pop-up Market

Development at TOD sites vary depending on the goals of the individual communities, which means that each TOD site is unique to its location. There are simple interventions that can be implemented in various places without necessarily adding infrastructure. Figure 1 shows a rendering of development around a light rail station. Mix-use development could include mixed-income housing, retail and commercial strips, and office spaces for employment opportunities. Having this type of development fabric around stations relieves residents of their dependency on private cars. Attracting people to the area can also be done without building permanent infrastructure. Pop-up plazas and park can temporarily achieve the same benefit as cafés and shops. Figure 2 displays a pop-up market near mass transit options. This can be done near existing stations and stops to increase ridership and capitalize on pedestrian traffic.

PRECEDENTS



Hamilton Springs
Lebanon, TN
2012

Poised to be Tennessee's first TOD, Hamilton Springs is a neighborhood built in anticipation of a new rail station. One of the objectives of this project is to provide commuters with an alternative to suburban living and driving on congested roadways, by making transit available within walking distance of homes, shops, and businesses of this vibrant district.

MLK Rail Station
East Austin, TX
2010

Prior to this rail station being built, the surrounding area was sparsely developed. The station stimulated new economic investment in its immediate proximity and is now the center of mixed-income housing while providing affordable commuting options for the district's residents.

HYDROLOGIC BENEFITS

Shared space reconfigures traditional street features to merge pedestrians and vehicles onto the same plane. By exchanging curbs, traffic lights, and road markings for a wide open street void of distinct control devices, vehicular traffic is reduced and pedestrian safety is prioritized, enhancing quality of life in dense districts with a reduced hydrologic footprint.

STANDARD SIGNAGE

Traditional traffic regulations depend on distinct systems of traffic lights, painted signage, sidewalks, etc, that can often mislead, malfunction, and separate users from owning a sense of personal responsibility for safety.

TRAFFIC CONGESTION

Traffic is a costly inconvenience for the region's economy. Outdated transit systems and eroded infrastructure increase the probability of dangerous accidents.

PEDESTRIAN VULNERABILITIES

Heavily used roads are difficult to outfit with bike lanes and extended sidewalks. Retrofitting infrastructure according to standard traffic protocol will not prioritize pedestrian travel or their safety.

ADOPT SHARED SPACE

d

Shared Space[60] is an innovative urban design concept that creates a safer environment for pedestrians and motorists in strategically selected locations in cities where intense pedestrian activity and transit traffic is anticipated or desired. It is realized by eliminating road markings and traffic signals typically found in urban rights-of-way — the effectiveness of which depends on the coordination of travelers who must abide by the regulations set forth along the road. Outdated infrastructure, increased congestion and the introduction of multi-modal uses have compromised the safety in urban streetscapes. Layering signage on increasingly busy roads can create confusion and separates users from their responsibility to observe or respond to hazardous situations. By merging the sidewalk with the road and erasing conventional signals, users can instead find themselves in a cautious and conscientious transit flow that privileges pedestrians and discourages through traffic.[61] These efficient and vibrant spaces can facilitate healthy lifestyles, social interaction and enable compact livable communities with reduced hydrologic footprints and opportunities for innovative stormwater management strategies. This strategy aims to mitigate auto-dependency and its associated water quality impacts.

PARKLETS

Parklets are small open spaces that capitalize on storefronts, curb edges, and plaza vacancies. These are opportunities for a range of lively programs that contribute to visitor and residents experiences alike.

REQUESTED TRANSPORT

An on-demand vehicle can be available for persons with disabilities or any pedestrians requiring walking aid within the shared space zone. These vehicles will replace the cars currently creating gridlocks and delays, introducing a more sustainable traffic flow that improves conditions for cyclists and pedestrians.[62]

NEW BOUNDARIES

Shared Space will exchange standard signage and heavy vehicular traffic for a more environmentally friendly arrangement that prioritizes pedestrian movement. Erasing curbs and merging the sidewalk with roads will allow persons to experience zones of social respect and negotiation.

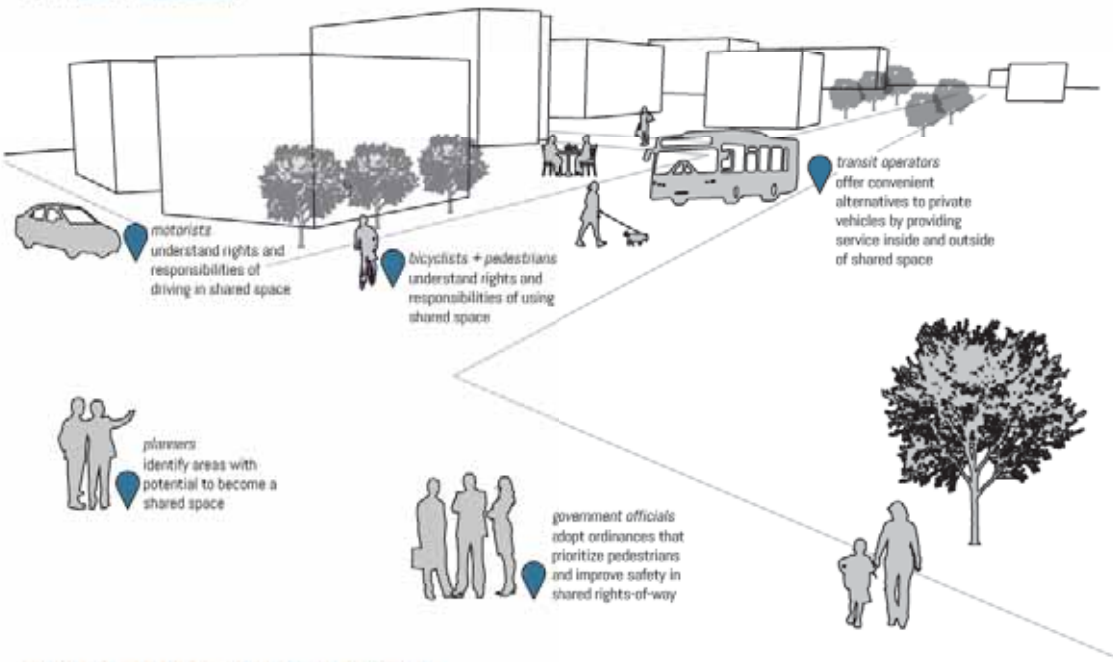
BUS TRANSPORT

Bus transportation will provide access to communities located outside of the space and become the principal movement within its boundaries.

IMPLEMENTATION TERRITORIES

Campuses	Campus prototypes can introduce shared space concepts in a controlled environment that already has high pedestrian concentrations and reduced vehicular traffic.
Downtowns	Urban commercial sectors possess regular cycles of pedestrian and motorist congestion that can inform shared space project planning and design.
Residential Areas	Neighborhoods or residential areas of slower traffic can adjust to changes in curbside and signage while maintaining communication between pedestrians, cyclists and motorists.
Urban Parks	Integrating recreational urban parks into shared space can visually signal areas in which there is a cross-over between pedestrian and vehicular movement.
Waterfront	Greenways and other public space along rivers and lakes can not only create areas for people to gather and hold events, but also bridge connections to water transportation and recreation.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Perception	Perceived safety may temporarily be lower because of the lack of traditional space separation.
Investment	Permanent shared spaces require the reconstruction of the street.
User Responsibility	All users of shared space must observe the rights of other user groups to ensure safety.
Resistance	Projects aim to make streets less auto-friendly and may be met with upfront resistance.

TACTICAL SITE INTERVENTIONS


Fig. 1 Sidewalk Widening


Fig. 2 Road Closures


Fig. 3 Parklet Program


Fig. 4 Curb Elimination

One of the biggest barriers to implementing a project of this scale is users' preconceptions of how a street should look and function. Figures 1-3 are interim tactics that can be temporarily used. These temporary projects allow users to experience shared streets while the organizers and designers can learn from behavior and responses. Short-term sidewalk widening (Figure 1) can be implemented by simply putting up barriers in the road to create more space for pedestrian traffic. Temporary road closure is another tactic that gives pedestrians and cyclists more access to streets and roadways. This type of event could help raise support and awareness for shared streets and spaces. Parklets are another project that can be used as a temporary or permanent installation to alter space usage. In contrast, curb elimination (Figure 4) is a more lasting tactic that opens the space to multiple uses and blurs boundaries between traditional roads and sidewalk surfaces.

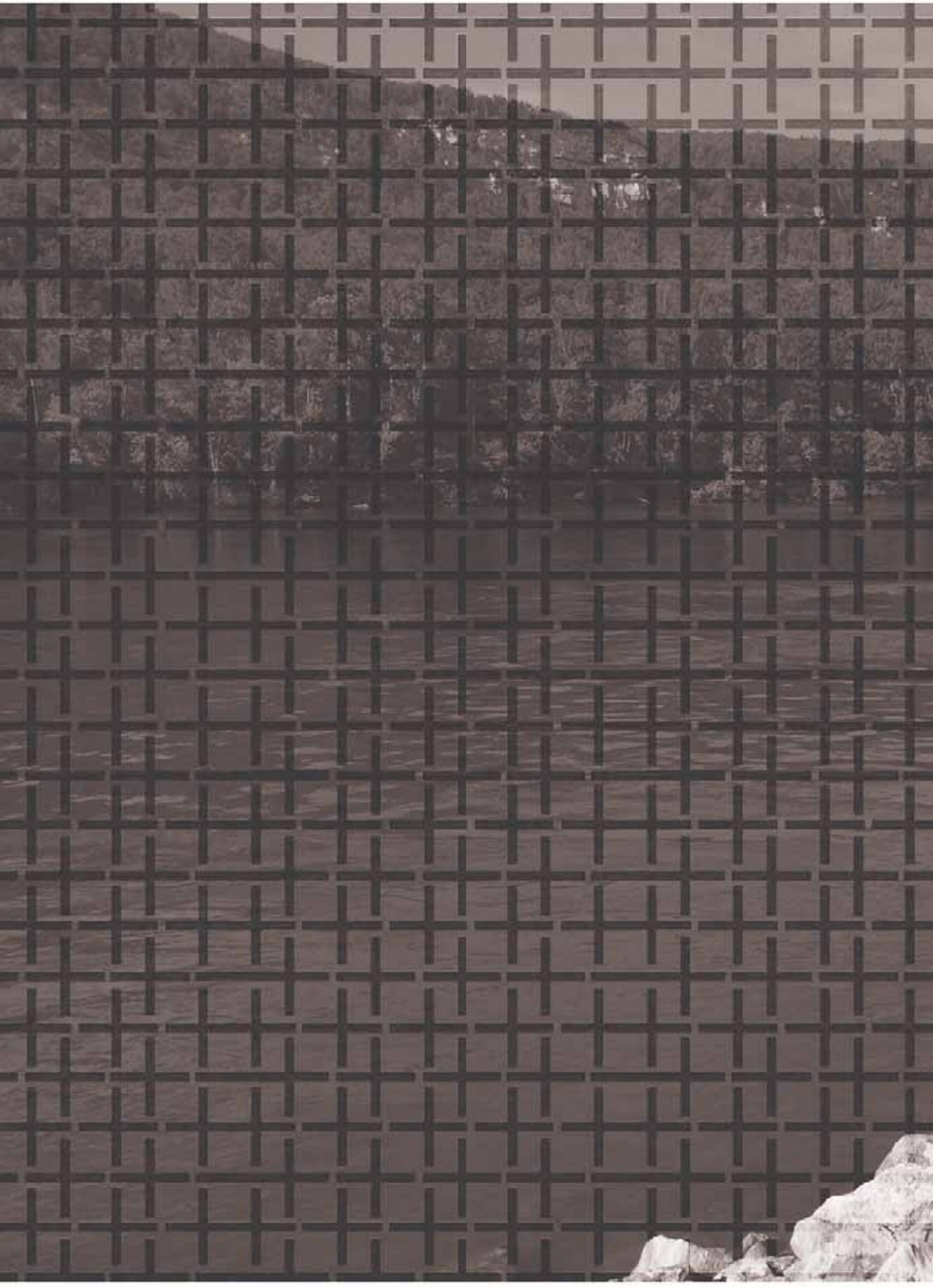
PRECEDENTS

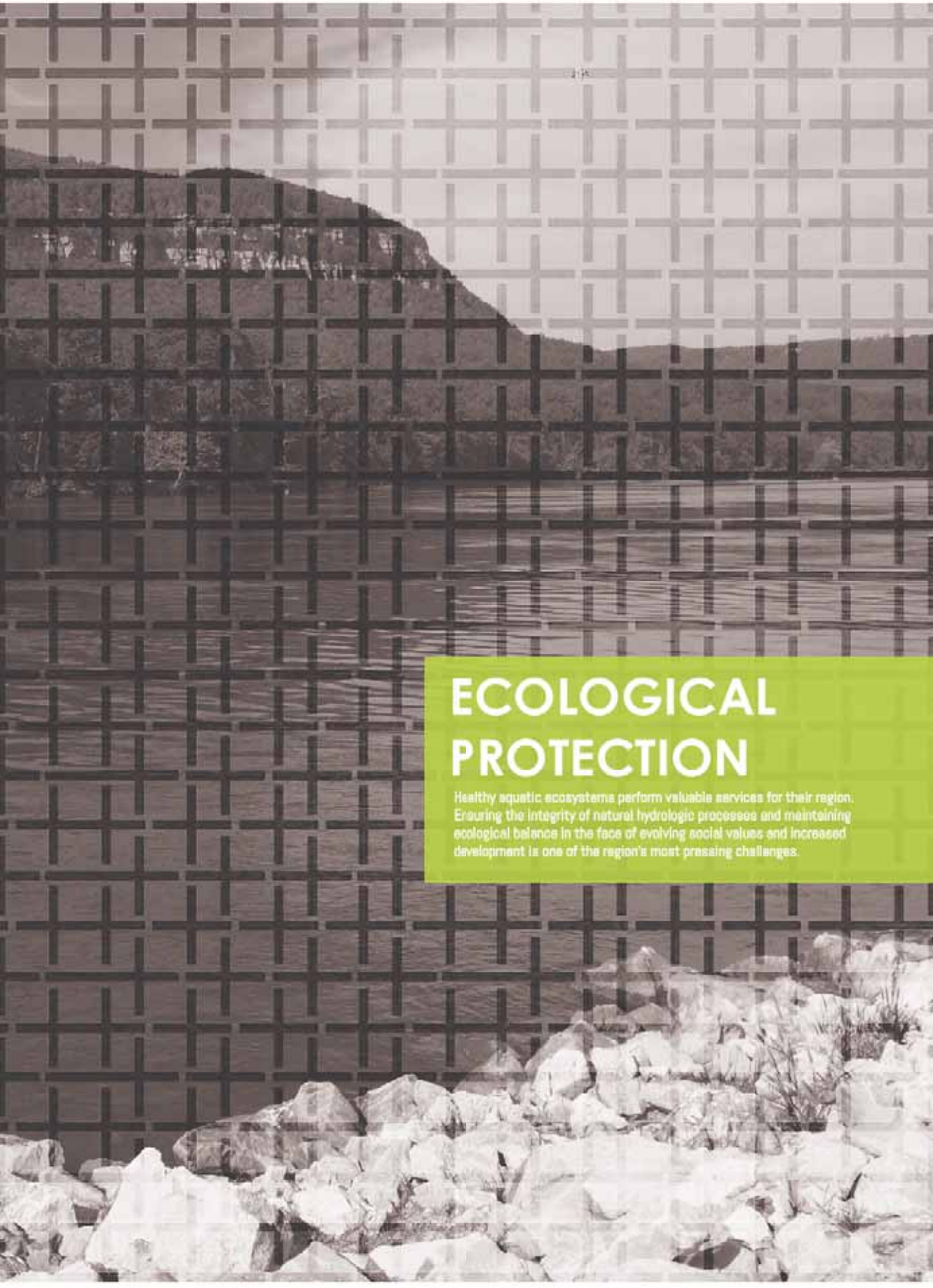
Argyle Street
Chicago, IL
2016

The project involved converting three blocks of this busy street into a shared street that prioritizes walking. The road was elevated to eliminate the curb and pedestrians are allowed to cross freely at any point. This even level allowed the entire space to become wheelchair accessible. A new ordinance has also given pedestrians the right-of-way above motorists.

Downtown Eugene
Eugene, OR

Woonerfs are living spaces that give priority to pedestrians and cyclists. Projects such as this one in Oregon are the opposite of most traditional streets in America. The street is meant to function without the delineation of spaces. Users are forced to be aware of their surroundings and of other users.





ECOLOGICAL PROTECTION

Healthy aquatic ecosystems perform valuable services for their region. Ensuring the integrity of natural hydrologic processes and maintaining ecological balance in the face of evolving social values and increased development is one of the region's most pressing challenges.

A tributary from Georgia feeds into Nickajack Cove on the Tennessee River near the Georgia-Alabama-Tennessee line.

ECOLOGICAL PROTECTION

An ecosystem consists of living plants, animals (including humans), and microorganisms, the physical environment that they inhabit, and the interactions between them. The biotic life within an ecosystem serves different yet interrelated functions such as production, consumption, decomposition and pollination. These functions are foundational to regional agricultural productivity and natural water and air filtration. The integrity and health of the physical environment, which includes the atmosphere, weather and climate, the soil or geologic substrate, and water resources such as creeks, streams, rivers, lakes, wetlands and aquifers, is inextricably connected to the health of an ecosystem.

EXISTING CONDITIONS

The Southeast Tennessee District is a mosaic of naturally-formed landscapes and culturally-formed, developed environments. The region's mountain ranges, karst features, ridges and valleys, waterways, and fertile floodplains have enabled the settlement of urbanized communities, rural and agricultural land, and infrastructural reservoirs. This dynamic landscape yields a diverse tapestry of ecosystem types that continue to sustain and benefit the region socially, economically, and environmentally.

Access to healthy ecosystems is a cornerstone of the region's robust tourism economy and the highly sought-after quality of life available to Southeast Tennessee's residents and visitors. The region's reservoirs, rivers, streams, and forests are recreational venues for active lifestyles and adventure

opportunities that appeal to residents, entrepreneurs, and tourists alike. They also support a diversity of aquatic wildlife that is unrivaled by other North American river systems.[63]

These resources and the quality of life they provide are sought after by savvy businesses seeking to maintain and attract a skilled, productive workforce, thus driving business (re)location decisions. This quality of life was cited by executives as a deciding factor in Volkswagen's 2008 decision to locate its newest North American operation in the SETD region, bringing with it thousands of jobs and opportunities for supporting businesses.[64] The health of ecosystems and water resources also affect the region's ability to provide low-cost, safe drinking water, affordable material inputs to commercial and industrial processes, and otherwise absorb new economic development. Healthy water quality also supports rafting, fishing tournaments, regattas, and other water-based recreation events and the communities that host them.

Ecosystems, their environments, and the behaviors of actors within them complement, influence, and sometimes threaten the health and resiliency of one another. Often the nature and extent of the threats posed by these relationships is most evident in the health of the region's water resources.

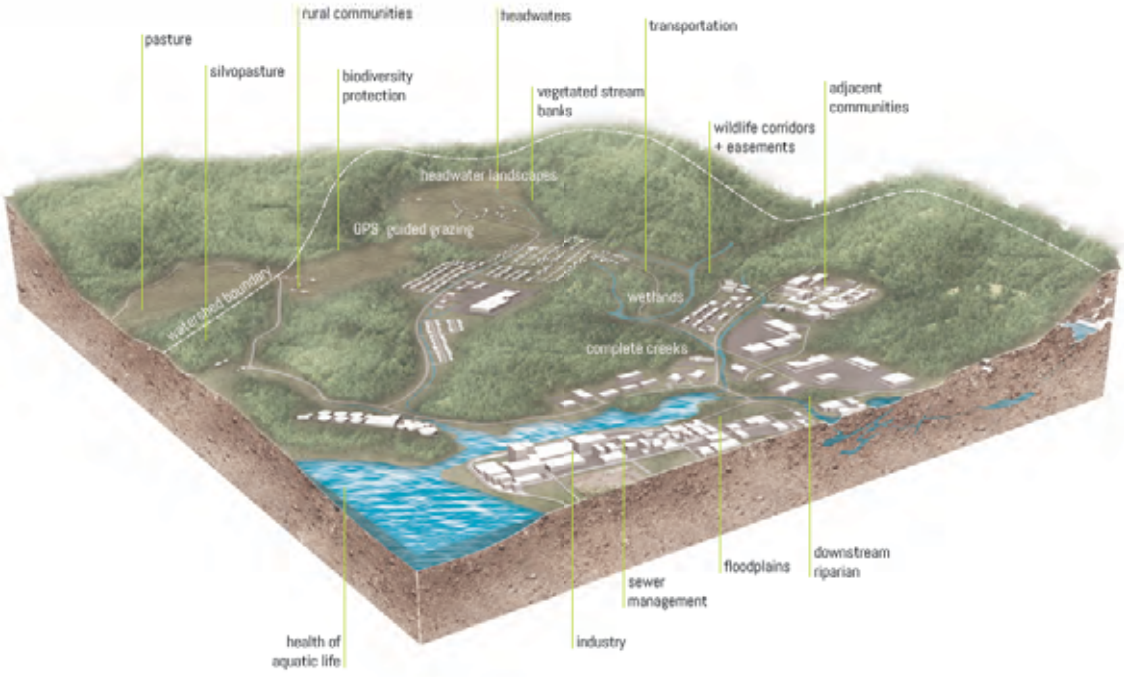
Nonpoint source pollutants from urban and rural land uses conveyed by stormwater aggregate in regional streams, rivers, and reservoirs. Sediment from construction sites, agricultural landscapes, timber and mining operations cloud waters, reducing visibility for sight-feeders and inhibiting plant growth on stream and river bottoms. Water temperature is influenced by industrial effluent, infrastructure tailings, urban runoff, climate dynamics; the loss of riparian canopy reduces life-sustaining oxygen levels; permitted discharges from point-source pollution compromises the stability of aquatic ecosystems. Excess nutrients from animal waste and mismanaged fertilizers trigger vegetative blooms that rob water bodies of oxygen and outcompete other native species for limited resources.[65] Wetlands and flood plains, an environment's natural defense against water quality and quantity threats, are routinely impacted, drained,

filled, or otherwise consumed in the path of economic progress, often mitigated with man-made wetlands that rarely achieve the same level of sustained ecological performance as their indigenous counterparts.[66] However, one example of a local successful restoration project is of the Oostanaula Creek in Athens, Tennessee.[67] The attention to healthy aquatic environments within a developed area have resulted in a better-functioning hydrologic system.

APPROACH

Ensuring the long-term health of the region's natural treasures — including water resources — was recently identified as one of four priority initiatives in Thrive 2055. By recognizing the relationship between healthy ecosystems and environments and the region's capacity for growth, economic development, and quality of life, the communities in the SETD will be positioned to advocate for water resource stewardship initiatives that ensure the environment's long-term ability to self-regulate and recover from disturbance and climate dynamics.

Though communities within the SETD region can boast successes in this regard, new technologies, multi-scalar cooperative approaches and contemporary conceptualizations of the value of ecosystems and the services they provide can further inform the region's attitude towards traditional behaviors, infrastructure approaches, and development patterns. Such innovation and recalibration can steward the economic, social, and environmental assets that drive the region's future. These ideas are at the foundation of the strategies for change proposed within this section.



The territories identified above include those landscapes where the following water quality improvement strategies may be implemented.

WHAT GUIDING PRINCIPLES

1

ECOLOGICAL FUNCTION: Regenerative Region

- To address pollution at the source of the region's waters
- To protect the natural territories and hydrologic processes that power ecosystem services at multiple scales

2

NETWORKS: Natural and Urban

- To plan for efficient urban expansion alongside natural territory
- To recognize ecological interconnectivity within and between urbanized, rural, and undeveloped watersheds

3

RESEARCH: Synthesis and Innovation

- To engage with the environment as a living laboratory
- To lead new, progressive methodologies of data management and environmental understanding

4

EQUITABLE ASSETS: Inherent Valuation

- To prioritize water quality in areas previously neglected
- To share knowledge of water stewardship that promotes the socio-economic health of all communities

HOW STRATEGIES FOR CHANGE

PROTECT HEADWATER LANDSCAPES

Stewardship of regional water bodies' origins protects diverse ecosystems and mitigates pollution levels being conveyed to downstream water resources and communities

a

PROTECT, RESTORE, + CONSTRUCT WETLANDS

Protecting these threatened landscapes ensures their ability to provide benefits such as pollutant filtration, habitat creation, and flood control

b

DEVELOP COMPLETE CREEKS

The concept of Complete Creeks designates waterways that will provide socio-economic benefits while supporting river physiology and aquatic ecosystem health

c

GUIDE VIA GPS COLLARS

Using smart systems to manage livestock's use of streams can reduce contamination, stabilize stream banks, and ensure ecosystem function

d

WHAT GUIDING PRINCIPLES

1 ECOLOGICAL FUNCTION: regenerative region

Respecting the multi-scalar character and structural complexity of ecosystem networks reveals the dynamic, value-added functions they perform as they transform energy and metabolize nutrients. Preserving the integrity of these relationships and mitigating urban impacts on the landscape will ensure the ecological health of the region's water bodies, their ability to regenerate from historic challenges, and their capacity for resiliency to future threats.

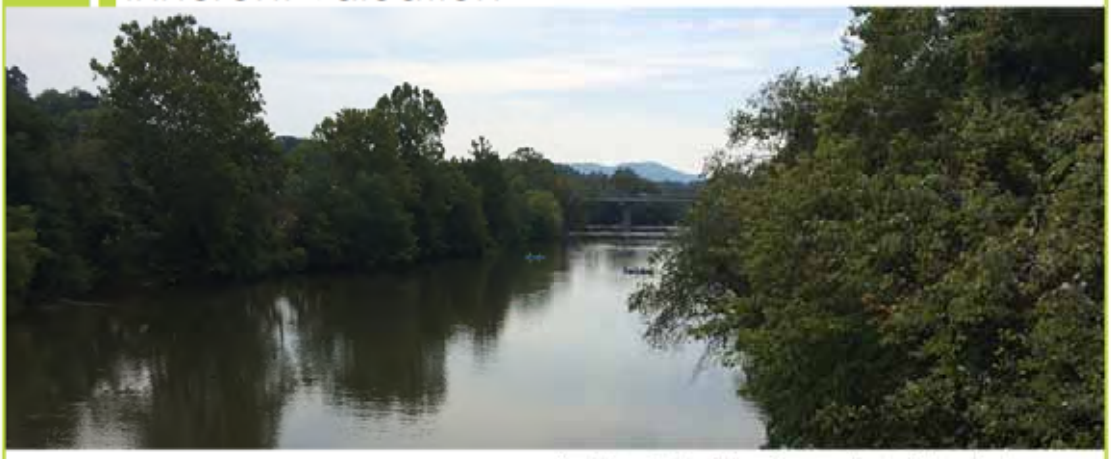
2 NETWORKS: natural and urban

A new narrative of interconnectivity between natural landscapes and urban territory has emerged. Through spatial planning, urbanized communities now seek to incorporate ecological systems that were previously distinguished as separate territories with competing interests. This blurring of boundaries unlocks the productive value and potential of open space and living systems as integral parts of communities and urban infrastructures.

3 RESEARCH: synthesis and innovation

Scholars, non-profits, and industry in Tennessee and the SETD region continue to advance monitoring methodologies and invent new, more efficient tactics for preserving and regenerating the health of aquatic ecosystems. By leveraging regional capacity and continuing to support and collaboratively synthesize these past successes, the region can lead the state and the nation in water resources management, research, and innovation.

4 EQUITABLE ASSETS: inherent valuation



Watershed stewardship interventions have inherent values that affect the entirety of the region regardless of the cultural or socio-economic context in which they are implemented. Water quality initiatives and investment priorities should be driven by needs in the region and their potential to maximize benefits to regional water resources. This enables an equitable distribution of capital resources and expertise, delivering value-added projects to rural and urban communities alike.

CONNECTING
PRINCIPLES & STRATEGIES

	a PROTECT HEADWATER LANDSCAPES	b PROTECT, RESTORE, + CONSTRUCT WETLANDS
1 ECOSYSTEMS	Protecting spring-fed streams and creeks and other waters at their source establishes a higher standard of water quality and aquatic ecosystem health that benefits downstream waters and communities across the region.	Ensuring the presence of wetlands, one of the most biologically fragile and diverse ecosystems, promotes natural water filtration for improved immediate ecosystem function that extends to surrounding habitats.
2 NETWORKS	Regulating downstream ecological impacts of pollutants from households or industrial processes restricts the spread and accumulation of pollutants to connected landscapes throughout the region.	Ecosystem services provided by wetlands — preserved, restored, or constructed — benefits natural landscapes, rural communities, and urban centers, necessitating consideration of their conservation and incorporation into community planning and design.
3 RESEARCH	Monitoring the ecological health of this critical water body type leads to pursuing new methodologies of preservation, protection, and regeneration.	Sensitive and dynamic wetland processes can be maintained through monitoring programs, existing as living laboratories for new ecological discoveries and innovations.
4 EQUITABLE ASSETS	Technology and capital investment may disadvantage some rural headwater communities, but acknowledging their equal stake in water impacts and protection reprioritizes and empowers these areas.	Disregarding negative cultural context of wetlands enables promotion and protection of these ecosystems for their natural filtration processes and sustenance to wildlife.

C DEVELOP COMPLETE CREEKS

Enriching vegetative stream buffers while incorporating foot, bike, and boat traffic in a minimally invasive way reduces transportation pollution, encourages natural ecosystem dynamics, and raises awareness and protection of stream ecosystems.

Stream corridors extending between urban, suburban, and rural locations create ecosystem connectivity for improved wildlife navigation, ecological function, and non-carbon transportation benefits/access across landscape types.

Implementing new strategies such as Complete Creeks is a necessary step in progressing best management practices and understanding anthropogenic-ecological thresholds.

Recognizing the ecological benefits of waterways highlights their importance. Drawing people to them educates the community about this resource and takes advantage of a natural navigable path.

d GUIDE VIA GPS COLLARS

Finer control over cattle grazing will allow users to identify and conserve specific ecological areas, which function in reducing headwater pollution that ultimately accumulates in larger water bodies.

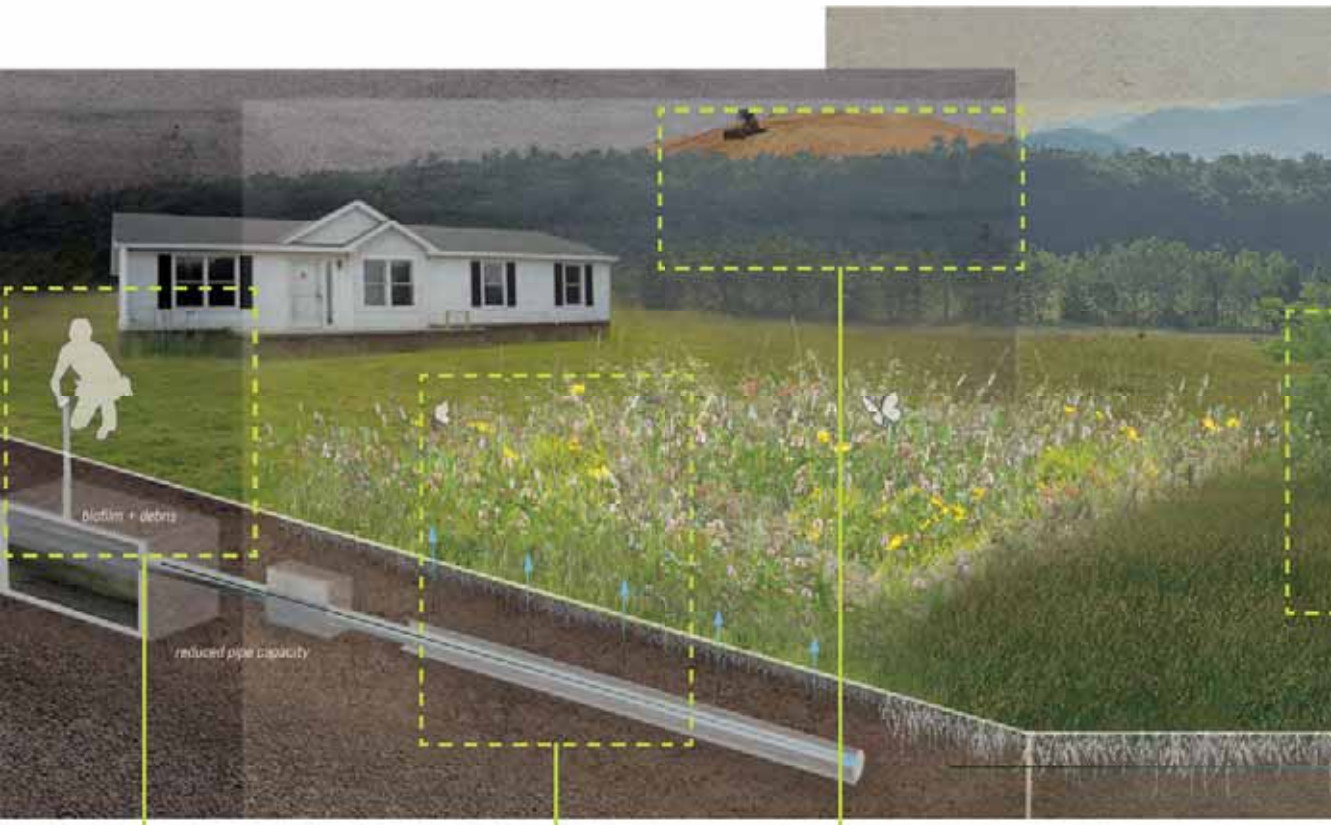
Protecting rural agricultural stream ecosystems across the region improves the health of urban areas to which they are connected.

Monitoring water quality at known sources of pollution advances preparedness and standard protocol.

Combined impact of individual farms adopting this practice leads to watershed-scale water quality, technological, and socioeconomic effects.

HYDROLOGIC BENEFITS

Controlling household, agricultural, and industrial waste pollution in headwater areas protects local quality of life and mitigates downstream environmental damage. Investment in riparian buffers, site development guidelines, and waste infrastructure maintenance programs in headwater communities stewards local resources and initiates multi-scalar benefits.



SEPTIC MAINTENANCE

Old septic tanks must be reassessed and maintained. Septic system components degrade over time and threaten ground and surface water resources.[68] It is the responsibility of the owner to monitor failing systems and prevent untreated human waste from escaping into the environment.

SEPTIC PLANTINGS

Shallow rooted planting can prevent erosion over undisturbed soil and uptake liquid from the ground, enabling the septic system to function efficiently.[69] Planting native wildflowers will create a new habitat for wildlife and support neighboring ecosystems.

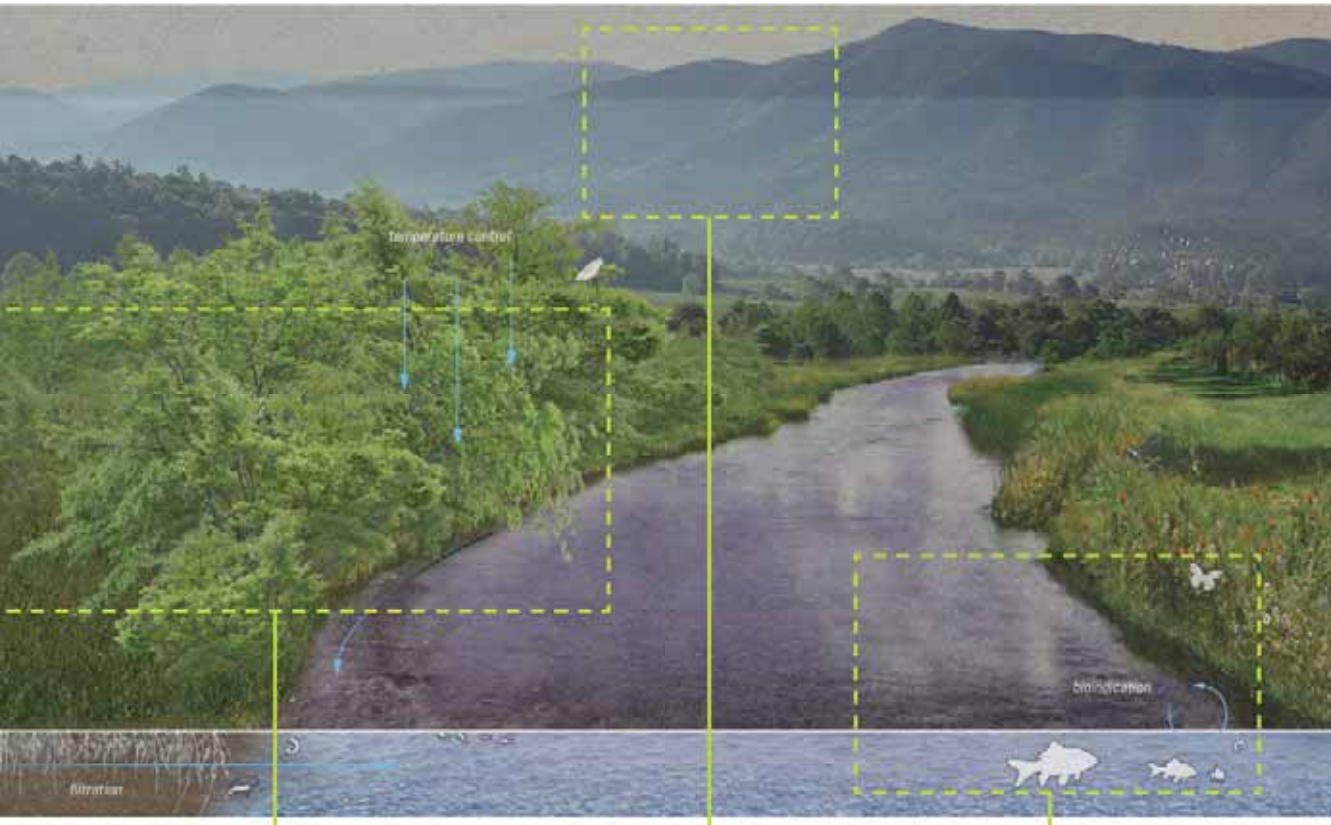
RIDGETOP DAMAGE

Construction and mining have long impacted the region's mountainous landscape. These practices have many negative consequences on downstream water resources, including increased runoff volume, sedimentation, and toxic contamination.[70] Though new regulations and best practices are in place, proper enforcement and maintenance are required to avoid ongoing water quality degradation.

PROTECT HEADWATERS + RIDGES

a

The state of Tennessee has roughly 18,500 miles of streams that are the origins of surface waters, which supply public drinking water systems. Over 50% of their volume comes from ephemeral or spring-fed headwater streams.[71] These ecologically-rich water bodies aggregate to become the major river and lake systems around the region. Headwater streams are commonly located in remote areas with topographically challenging terrain, making it difficult monitor their health. The communities in which they are located may not have the capacity, technical knowledge, or political leverage necessary to properly steward them. Mapping, assessing, and supporting initiatives and planning frameworks to steward these landscapes is a critical maneuver that can protect the economic viability of these waters as quality of life resources for local communities and reduces downstream impacts. By continuing to refine mining, forestry, residential and agricultural waste management, as well as site development practices on ridges, hillsides and other headwater landscapes, the impacts on vulnerable streams can be minimized and managed.



RIPARIAN BUFFER

A forested riparian buffer captures excess nutrients, harmful contaminants, and sediment from creeks and streams.[72] These channels are further maintained by the water's temperature regulation from leafy shade and banks held by strong root systems.

RIDGETOP GUIDELINES

Stronger planning and regulation ensures that any development, resource extraction, or industrial practices conducted on ridgetops and other remote landscapes do limited damage to the area's sensitive ecosystems and the water resources they support.

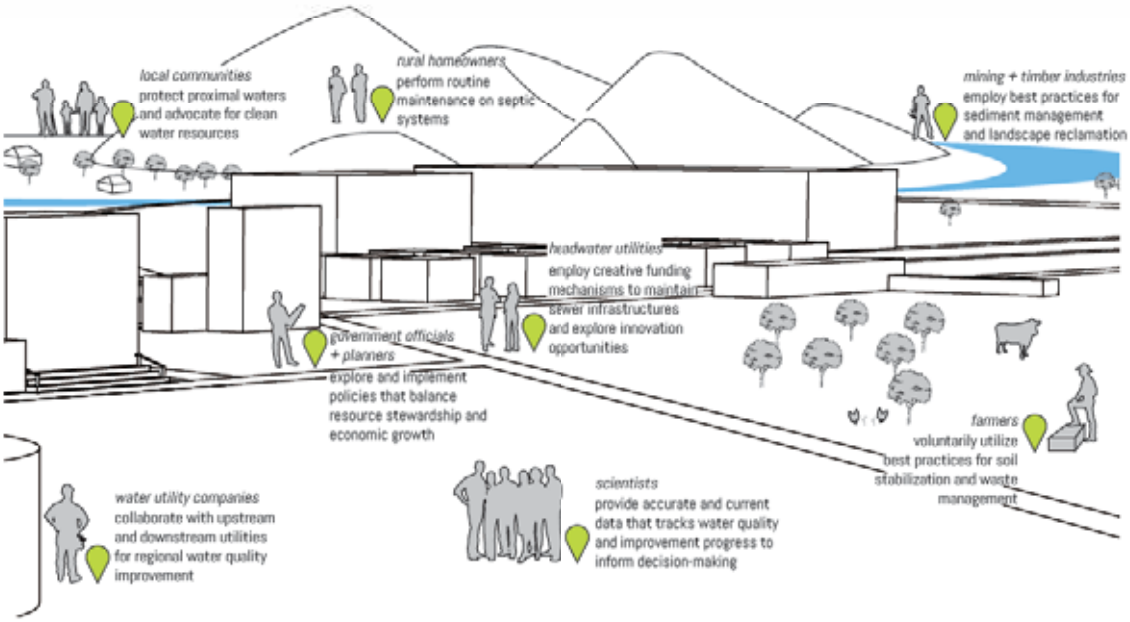
AQUATIC ASSESSMENT

Aquatic macroinvertebrates maintain headwater health by consuming detritus, controlling sedimentation and supporting larger lifeforms as food. These species are often the first to perish from fluctuations in climate or toxicity levels.[73]

IMPLEMENTATION TERRITORIES

Farmland	Though contemporary farming practices can reduce the water quality impact of agriculture, their voluntary nature creates an abundance of improvement opportunities on farmland near headwaters.
Headwater Communities	Stormwater and sanitary sewer infrastructures in headwater communities are especially vulnerable to leaks and failures due to challenging economic conditions and municipal budgets.
Downstream Riparian	Regularly testing the health of waters downstream can reveal contaminant releases or leaching further upriver.
Rural Households	Rural homes that rely on septic tanks would benefit from better access to the technical and financial assistance to maintain and when possible, upgrade their systems.
Large-scale Site Disturbances	Major site disturbances from mining, timbering, and community development activities destabilize soils, triggering erosion and sedimentation, ultimately disrupting natural hydrologic processes.[74]

STAKEHOLDERS



ANTICIPATED CHALLENGES

Scale	Scale of headwaters can be intimidating, making impacts uncertain and discouraging action.
Investment	Scrutinized investments must be justified and sustained to realize long-term benefits.
Topography	Steep slopes complicate landscape access and infrastructure implementation.
Enforcement	Remote locations and scale of landscapes can make guideline enforcement difficult and inefficient.

TACTICAL SITE INTERVENTIONS


Fig. 1 Locate Communities


Fig. 2 Composting Toilets


Fig. 3 Field Plantings

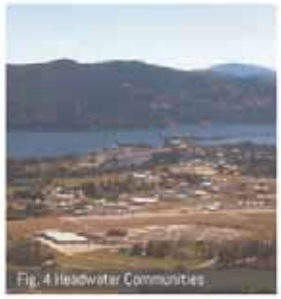


Fig. 4 Headwater Communities

Headwater streams and their contributing watersheds are vital to the health of communities and downstream water resources. Many interventions are preventative, such as effective planning and monitoring of development in these landscapes, but there are ways to address communities that may be most at risk. Developing a criteria for locating these communities can help focus mitigation efforts (Figure 1). In rural locations that depend on septic systems, composting waste systems can reduce the possibility of groundwater and surface water contamination by maintaining an aboveground, isolated system[75] (Figure 2). Shallow root plantings in septic fields (Figure 3) are another way of helping septic systems perform at their best.[76] It is important that headwater communities (Figure 4) receive technical and financial assistance to ensure that their infrastructure does not threaten the health of pristine, local water resources or the broader regional water system.

PRECEDENTS

Soque Project
Chattahoochee River, GA
1998

This program emphasizes the importance of maintaining healthy streamside zones. A collaboration of organizations such as the EPA, Soque River Watershed association, and private landowners, the project has been successful in restoring eroding portions of the river. The goals of the project include preventing erosion along the river and demonstrating the cost-efficiency of prevention versus repair.

Rio Grande Restoration
Rio Grande Watershed, CO
2001

The Rio Grande Headwaters Restoration Project began after a study on the river revealed the deterioration of the river system. Projects typically included interventions such as streambank shaping and the creation of stabilization structures to alleviate sediment loading. The RGHRP has worked with over 60 landowners on fifty different sites to successfully stabilize 11 miles of streambank.

HYDROLOGIC BENEFITS

Wetlands are particularly vulnerable ecosystems because of their interdependency on the broader biophysical region. Safeguarding these landscapes via mapping, spatial planning, construction regulation, and regeneration will ensure their ability to filter excess nutrients from the surrounding environment, reduce harmful sedimentation, and mitigate flooding.

WETLAND PROTECTION

Site analysis, project design, and construction should avoid wetland impacts and minimize runoff to nearby sensitive aquatic ecosystems. Wetlands vary in scale and environmental performance, but even small ephemeral pools contribute to overall watershed health. Conservation efforts and thoughtful site planning protect these valuable landscapes.

SITE DISTURBANCE

Road construction and urban development require soil compaction that causes excessive runoff near wetland systems. Sediment loads entering wetlands due to unmanaged runoff from construction sites or agricultural land uses can degrade wetland habitats, smother biologically-active plant and debris surfaces that otherwise metabolizes contaminants, and reduce a wetland's flood storage capacity.[77]

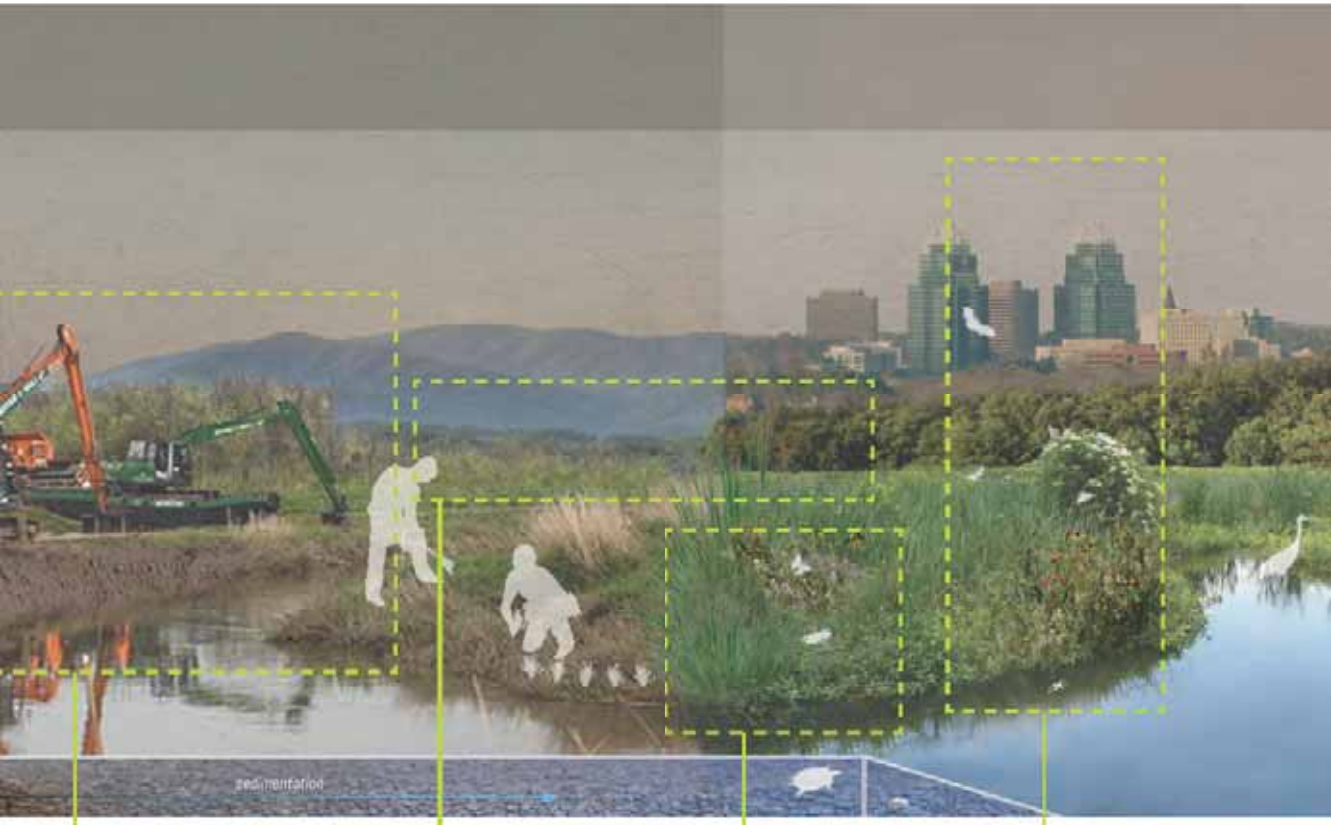
UNINTENDED CONSEQUENCES

Even projects that include wetland protection can cause unintentional impairment. Disrupting a wetland system's physical connection and unseen relationships to its surrounding environment can lead to acidification, eutrophication, and terrestrialization.

PROTECT, RESTORE, + CONSTRUCT WETLANDS

b

Wetlands include a number of habitat types with shallow, continuously-inundated areas that support aquatic life. They are some of the region's most dynamic, diverse, and fragile ecosystems. These landscapes are valued for their resiliency to periodic flooding and their capacity to filter runoff. Historic approaches to river management, development, agriculture, mining, and dam construction have consumed more than half of the Tennessee's total wetlands through permanent flooding, draining, filling, and contaminated water inputs.[78] These water bodies have recently been acknowledged as critical habitats nationwide and are now protected by the Clean Water Act, though Tennessee currently has no water quality standards specific to wetlands, and mitigation programs rarely result in healthy, performing wetland ecosystems.[79] Efforts by organizations like the Tennessee Wildlife Resources Agency can enhance the effectiveness of existing anti-degradation standards, but new strategic partnerships with landowners that prioritize wetland preservation and incentivize restoration initiatives, in addition to the construction of multi-functional wetlands in urbanized landscapes and other novel territories will contribute toward the recovery of the region's wetland resources.



WETLAND RESTORATION

Restoring the ecological structure and function of damaged wetlands enhances their ability to provide water quality improvement, flood attenuation, and recreational opportunity. However, the protection of existing wetlands is much more cost effective than restoration or the creation of a new system.[80]

MITIGATION BANKING

Banking allows for the compensation of negatively impacted ecosystems in other areas. While this is one way for individuals to offset unavoidable environmental damage, it is an artificial exchange that can be bureaucratically abused, and restored or constructed wetlands rarely achieve the same level of sustainable ecological performance as preserved wetlands.[81]

IMPROVED BIODIVERSITY

The ecological and physical characteristics of wetlands are complex and multi-variable. Each site will pose different challenges,but it can ultimately improve water quality through attracting wildlife and combating the negative effects of habitat degradation or destruction.[82]

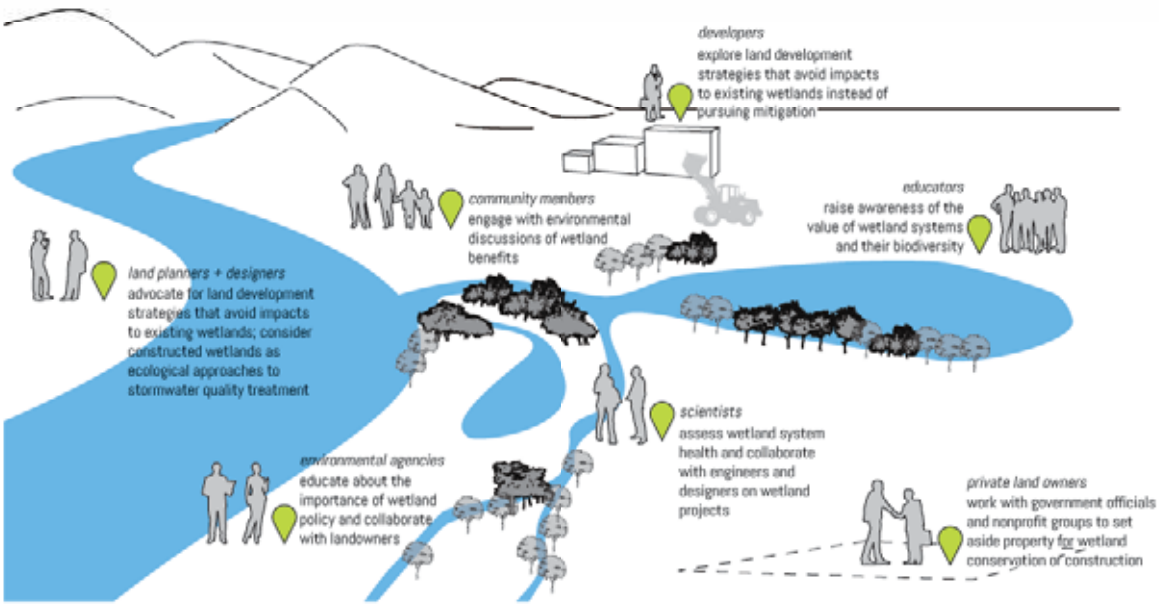
CONSTRUCTED WETLANDS

The ecosystem services of wetlands can be harnessed in urbanized landscapes and other novel territories as part of stormwater management systems and other water quality improvement initiatives.

IMPLEMENTATION TERRITORIES

Streams + Riparian Zones	Maintaining the health of streams and riparian zones protects their natural drainage patterns that support the formation and flood mitigation capacity of ephemeral pools and wetlands.
Existing Wetlands	The ecological performance and diversity of naturally-occurring wetlands that have evolved and stabilized over time are both difficult and costly to replicate in artificial systems.[63]
Private Land	Degraded or underutilized land under private ownership presents opportunities for acquisition and wetland conversion.
Abandoned Mines	Innovative wetland applications can mitigate drainage from abandoned mines contaminates proximal water bodies with sediment and toxin.[64]
Local Communities	Working with local communities near regionally-significant wetland resources can encourage comprehensive, site-specific wetland management and planning.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Funding	A shared investment may be necessary rather than relying on federal funds.
Valuation	Tennessee has no wetland water quality standards nor established evaluation system.
Prioritizing	Regulation compliance may create unwanted costs despite ecological benefits.
Education	Tennessee currently has no outreach or education programs specific to wetlands.

TACTICAL SITE INTERVENTIONS


Fig. 1 Avoidance


Fig. 2 Private Land Conversion


Fig. 3 Demonstration Wetland


Fig. 4 Reserve Easement

One simple intervention to protect wetland boundaries is avoidance. Figure 1 shows a utility line alternatively routed to mitigate wetland impacts. Figure 2 looks at the management of private land and the potentials of enhancing underutilized property. Figure 3 emphasizes the need for a demonstration wetland as an educational tool for the public. There are many federal and state programs that require physical mitigation for threatened environments. Figure 4 illustrates the use of a wetland protection easement whose water body cannot be leveled or drained until the agreed contract expires. Wetland easements are federal agreements through the US Fish and Wildlife Service that compensates property owners for wetland protection.[65]

PRECEDENTS

Hatchie River Wetland
Haywood County, TN
2007

After a mitigation bank was established, 685 acres were restored. This area was returned to the wetlands that were previously lost to agricultural production and urban development. Restoration efforts included the removal of levees and reforestation of the area. The property will be transferred to the TWRA to become a public wildlife management area.

Bartley Gravel Wetland
Portland, Maine
2011

Constructed in 2011, the subsurface gravel wetland allows water to pool and infiltrate on site. Land was excavated to allow for more water collection in an area where water already naturally pooled. Drainage pipes and gravel were put in place beneath the pool areas. Immediately, this wetland provided habitat and encouraged native vegetation.

HYDROLOGIC BENEFITS

The Complete Creek concept strategically co-locates multiple uses and functionalities to enhance and protect the region's waterway networks. The flood plains and buffer zones that are protected or restored as a result of Complete Creek planning not only filter and absorb water for a complete hydrologic system, they also promote healthy use of these waterways and the adjacent land for all community members.

UTILITY CORRIDORS

Adequate buffers between utilities and waterway edges must be planned and maintained to allow for natural meandering over time without damaging utility infrastructure.

HEALTHY CORRIDOR

Converting waterways to Complete Creeks offers a healthy corridor for walking, biking, and running within and outside the city for use as transportation and recreation. Greenways also help to increase property values and catalyze new economic investment.

BANK RESTORATION

Reestablishing proper stream bank geometry and soil stability permits the restoration of riparian vegetation along the banks of streams. This vegetation filters runoff from adjacent landscapes, supports habitats and recreation, and moderates stream water temperature.[86]

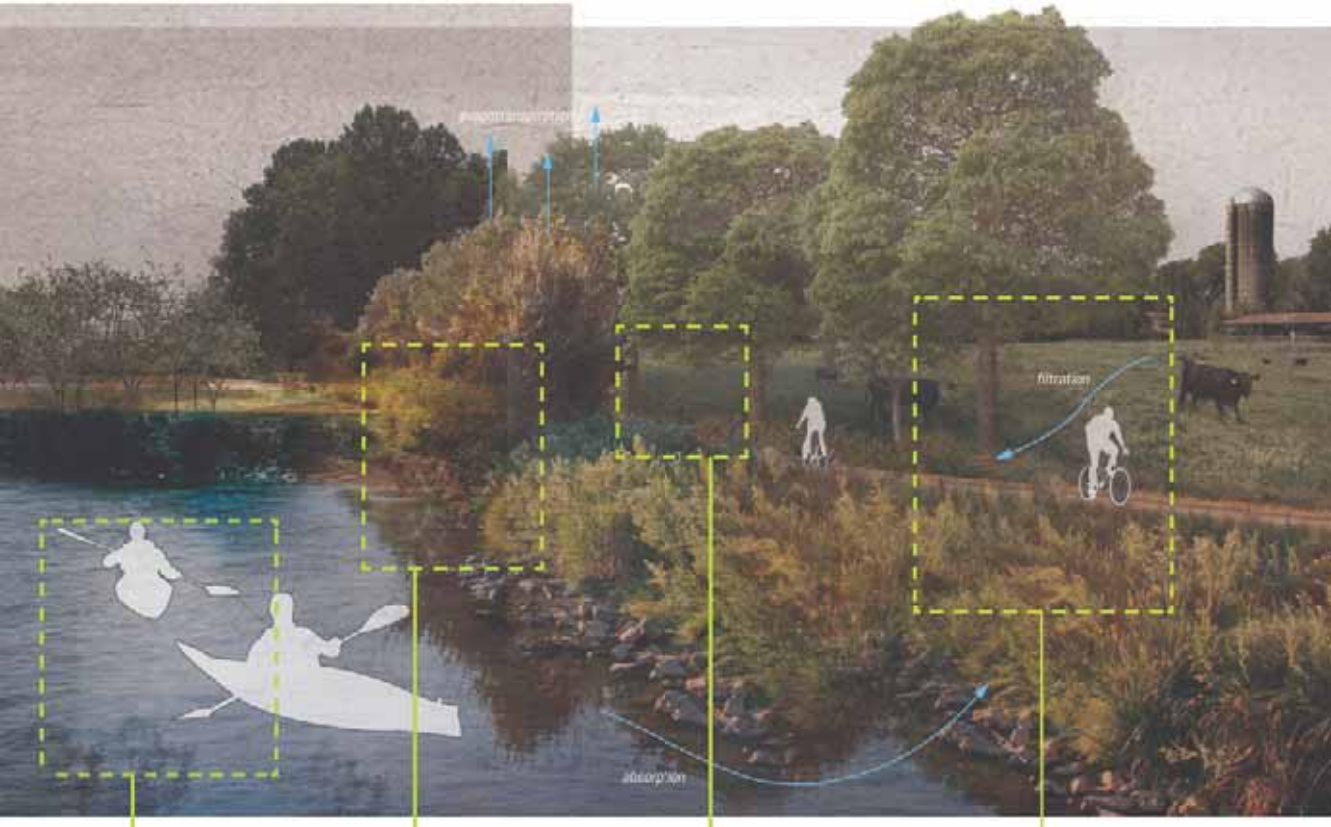
DAM REMOVAL

The removal of obsolete low head and mill dams reveals a previously inundated flood plain with new potential for habitation, recreation and flood water storage while also restoring connectivity of aquatic habitat.

DEVELOP COMPLETE CREEKS

C

The concept of Complete Creeks is a reconceptualization of riparian corridor planning and design to efficiently accommodate a range of uses, users, landscapes, and infrastructures. The linear nature and gentle topography common to these corridors have historically made them logical pathways for gravity sewer systems and other infrastructures. Creek movement and bank erosion caused by high volumes of rapidly-concentrated, fast-moving urban stormwater compromise the integrity of these systems, triggering leaks and necessitating infrastructure enhancements. Utility renovation projects may catalyze stream restoration initiatives, providing an opportunity to strategically reorganize riparian corridors as shared rights of way. Renegotiation of existing easements, agreements for public access through private riparian buffers and flood plains, can enable the region's hydrologic systems to become multi-modal transportation, recreation and ecological networks. This maneuver can stimulate pedestrian and wildlife movement between and within urban, suburban, and rural landscapes. This multi-functional approach to riparian corridor planning helps regenerate the ecological health, water quality, and structural integrity of streams in developed areas while also proactively buffering territories in undeveloped landscapes from future development pressures.



BLUEWAYS

Accessible waterways can provide a new route of transportation or recreational opportunity. Buffering these waterways from runoff and pollution ensures healthy water for such activities.

STREAM BUFFER

In addition to runoff protection and edge stabilization, vegetation along banks provides shade, maintaining the health of many aquatic communities and mitigating flood risks.[87]

FLOODPLAIN FUNCTION

Protecting floodplains from development pressures helps mitigate flood damages and enables river and stream systems to naturally replenish surrounding landscapes with nutrient-rich, alluvial soils.[88]

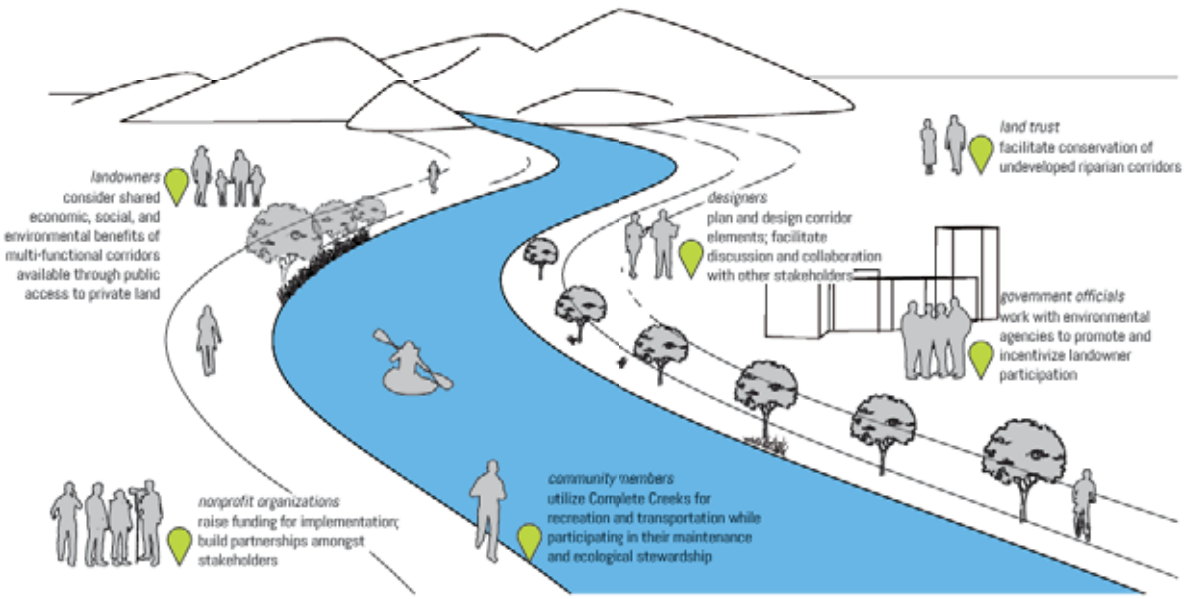
TRANSPORTATION ACCESS

Since streams flow throughout the region, this thoroughfare can connect urban, suburban, and rural areas, reducing carbon-heavy transit.

IMPLEMENTATION TERRITORIES

Urban Centers	Waterways in densely urbanized landscapes stand to benefit from restored hydrologic functions, regenerated habitats, and mobility networks possible through Complete Creek strategies.
Rural Communities	An increase in accessibility and the fostering of a stronger regional identity can strengthen the connection between urban and rural communities and can catalyze agricultural buffer investments.
Public Lands	Existing public lands provide opportunities for initial investments in Complete Creek infrastructures, catalyzing network connections, and value recognition on adjacent private land.
Floodplains	Alternative transportation and recreational systems can stretch through the region's floodplains and hydrologic networks.
Education Systems	Addressing water quality stewardship and alternative development practices within the educational system can provide early exposure and ownership of nearby creek zones.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Community Trust	Comprehensive network establishment may require use agreements for private land.
Alignment	Topography, urbanized stream corridors, and stream morphology may complicate routes.
Time	Shared use negotiations can complicate permitting and extend project time-lines.
Liability	Liability and user safety are perceived risks associated with shared use of private land.

TACTICAL SITE INTERVENTIONS


Fig. 1 Community Attitude


Fig. 2 Assessment of Potential


Fig. 3 Community Walk

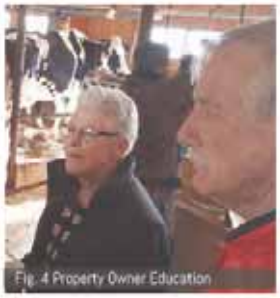


Fig. 4 Property Owner Education

The elements of a Complete Creek can be implemented in phases. Individual communities can choose tactics that best suit their needs and the environment of their waterways. Developing a Complete Creek design includes acquiring access to land that is typically owned by private parties. Approval and land easements may be difficult to come by and so it is important to gauge the community attitude towards this type of development (Figure 1) in lieu of preconceptions about community acceptance levels. One strategy is to identify existing networks and public use areas that are the most readily available (Figure 2). Education is important for gaining support. Community walks (Figure 3) through potential areas can help to educate the public on the importance of keeping creek zones intact. Similarly, doing informative tours (Figure 4) with private land owners can help alleviate concerns and discuss potential benefits of having Complete Creek zones running on their land.

PRECEDENTS

Mill River Park
Stamford, CT
2013

Mill River sits in the heart of downtown Stamford, CT. Efforts to restore the urban segment of the river have been on-going for the past century. The goals of the city were to restore the ecological value and hydrologic dynamics of the waterway, providing buffers to limit future impacts while offering recreational opportunities for the residents of Stamford.

Sand Creek Greenway
Commerce City, CO
2001

Sand Creek ran through a heavily industrialized portion of Commerce City. The ecological significance of the site was little known until efforts to restore the area began. The overarching goal of the restoration effort was to transform the creek back into a diverse habitat and into a recreational resource for residents.

HYDROLOGIC BENEFITS

Limiting cattle access to streams enables vegetated stream banks to flourish, which filter and absorb agricultural runoff. Since many cattle farms are located upstream from critical waterways, such as drinking, recreational, and industrial water sources, addressing this impact at its source reduces the cumulative effects of water pollution for better quality downstream.

STREAM ACCESS

Cattle require cool, clean water which is available in freshwater streams prevalent in Tennessee.[69] However, allowing steam access can cause an accumulation of waste and sediment downstream due to cattle entering and exiting waterways. This causes erosion of the stream bank.

PHYSICAL FENCING

Fencing is a common method used to keep cattle out of streams. The necessity to place such a fence outside of a stream's floodplain to avoid recuring damage and expenses reduces a pasture's grazeable area, a significant issue for smaller farms common to the region.

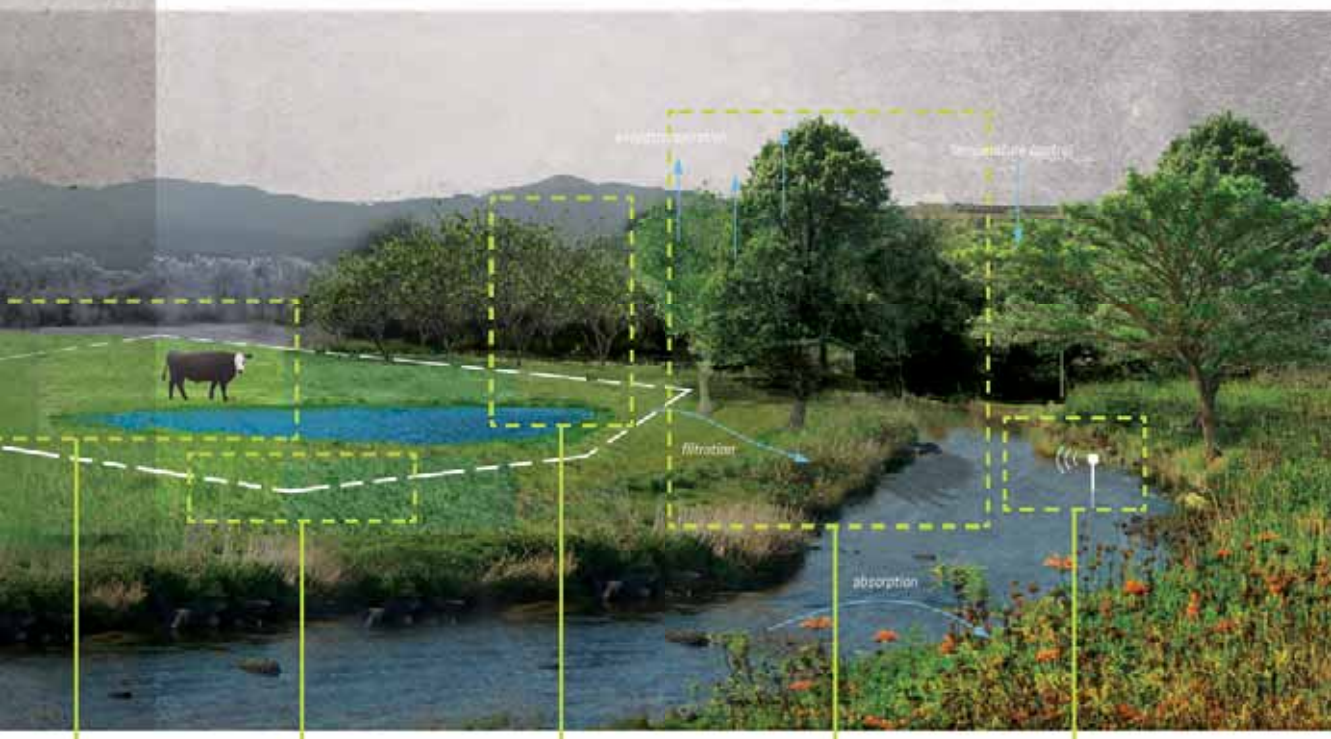
GPS-CONTROLLED PADDOCKS

Using GPS tracking collars, farmers can manage virtual paddocks remotely via a mobile app. This system maximizes a pasture's grazeable area near waterways and allows for easier movement of cattle, thus enabling more frequent rotation and more biodiverse and healthier fields. This app will also connect to water quality monitoring up and downstream to inform the farmer about threats to the farm or impacts the farm may be having on water resources.

GPS-GUIDED GRAZING

d

The undulating karst landscape of the SETD region includes springs and streams woven throughout its mountains and hills, making it an ideal location for livestock production, including beef and dairy cattle. This production and other agricultural land uses are leading sources of *E. coli*, excessive nutrients, and sediment pollution in the region's streams due, in part, to cattle wading and runoff from areas used for waste management and livestock handling.[90] Fencing off streams is a common best practice to contain livestock, which reduces *E. coli* contamination and enables the regeneration of vegetated buffers that filter and absorb runoff. However, fencing limits access to cool watering sources and is often installed directly in the floodplain, necessitating costly repairs following flood events. When located outside of a floodplain, fencing may significantly reduce the farm's grazable area. GPS collars reduce the need for a physical fence by utilizing a virtual fence set up by GPS coordinates established by the farmer. When cows reach this boundary they will hear an audible alert from the collar. Cows adjust their behavior according to this signal, enabling farmers to maximize their grazable area and manage their pasture using virtual paddocks, thus allowing more frequent and flexible herd rotation. Such technology can enable compliance with stream protection regulation and can also be used by farmers and agencies to gather and monitor data, contributing to a physically healthier herd, a more vigorous pasture, a more stable stream buffer, and a more biologically diverse, resilient stream ecosystem.



ALTERNATIVE WATER SOURCES

Without stream access, cows need new sources of water. Pumped water dispensers and ponds are viable options and can be incentives for utilizing the GPS system.

INTENSIVE ROTATION

Rotating cows throughout a pasture more frequently, or in conjunction with other animals, improves pasture health, resulting in deeper root systems and greater biodiversity that reduces erosion of pastures and increases flood capacity.[91]

SILVOPASTURE

Cows can graze not only in open fields but also in forests, which have the added benefit of cooling shade and protection from the elements as well as erosion reduction and flood control.[92]

REGENERATED STREAM BUFFER

Restricting cattle from walking down the banks can improve the vegetation along the stream, reducing erosion, filtering runoff, absorbing floodwaters, and providing shade for healthier aquatic communities.[93]

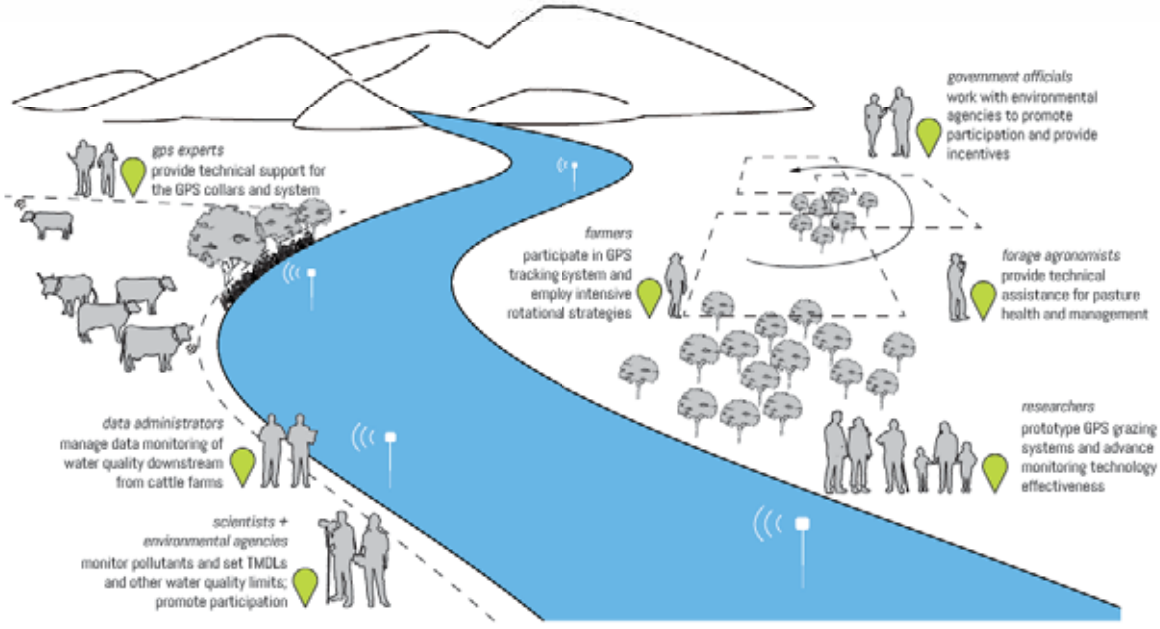
MONITORING

Active data collection of water quality conditions helps to manage the system and determine where there are extreme pollution issues or other concerns.

IMPLEMENTATION TERRITORIES

Pasture	Owners of pastureland that is in reserve or currently used for cattle can be informed about alternative grazing practices that do not sacrifice available grazing land.
Headwaters	The quality of headwater streams and rivers can benefit from enhanced buffering from adjacent grazing areas and reduced livestock contact.
Wetlands	Wetlands are sensitive ecosystems that quickly signal changes in the environment and larger water bodies.
Downstream Riparian	Measuring specific points along riparian corridors can help pinpoint areas vulnerable to point source pollution.
Adjacent Communities	Downstream communities should be made aware of outbreaks of *E. coli* and the release of excessive nutrients in their water resources.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Equitable Access	All operations may not have resources to invest in new technology infrastructures.
Participation	New technology takes time to penetrate target markets and realize measurable results.
Tech Support	Adequate support networks will be necessary to overcome typical tech challenges.
Demonstration	Up-front proof of concept and risk mitigation will be needed for mainstream adoption.

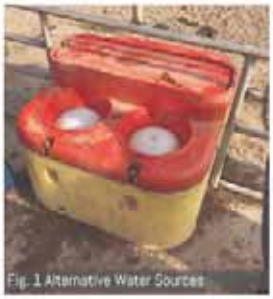


Fig. 1 Alternative Water Sources

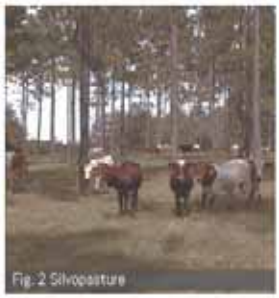


Fig. 2 Silvopasture


Fig. 3 Vegetated Stream Banks

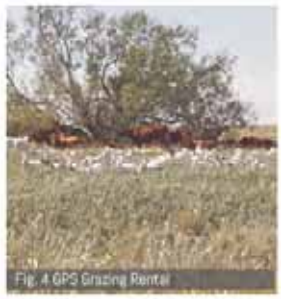


Fig. 4 GPS Grazing Rental

Figure 1 shows a drinking well that keeps water cool and comparable to the water from a stream. Alternative watering sources keep livestock out of streams by providing containers of water for the animals located elsewhere on the property. Other interventions may involve changes in grazing and land management practices. Silvopastures that combine forestry and grazing practices provide multiple benefits, including reduced rate of evapotranspiration from pasture soils and provision of shade for the animals.[94] A vegetated stream bank (Figure 3) provides a natural barrier to block the livestock from stream access. Rental GPS grazing kits (Figure 4) could be a low-pressure, low cost way of introducing people to GPS grazing.

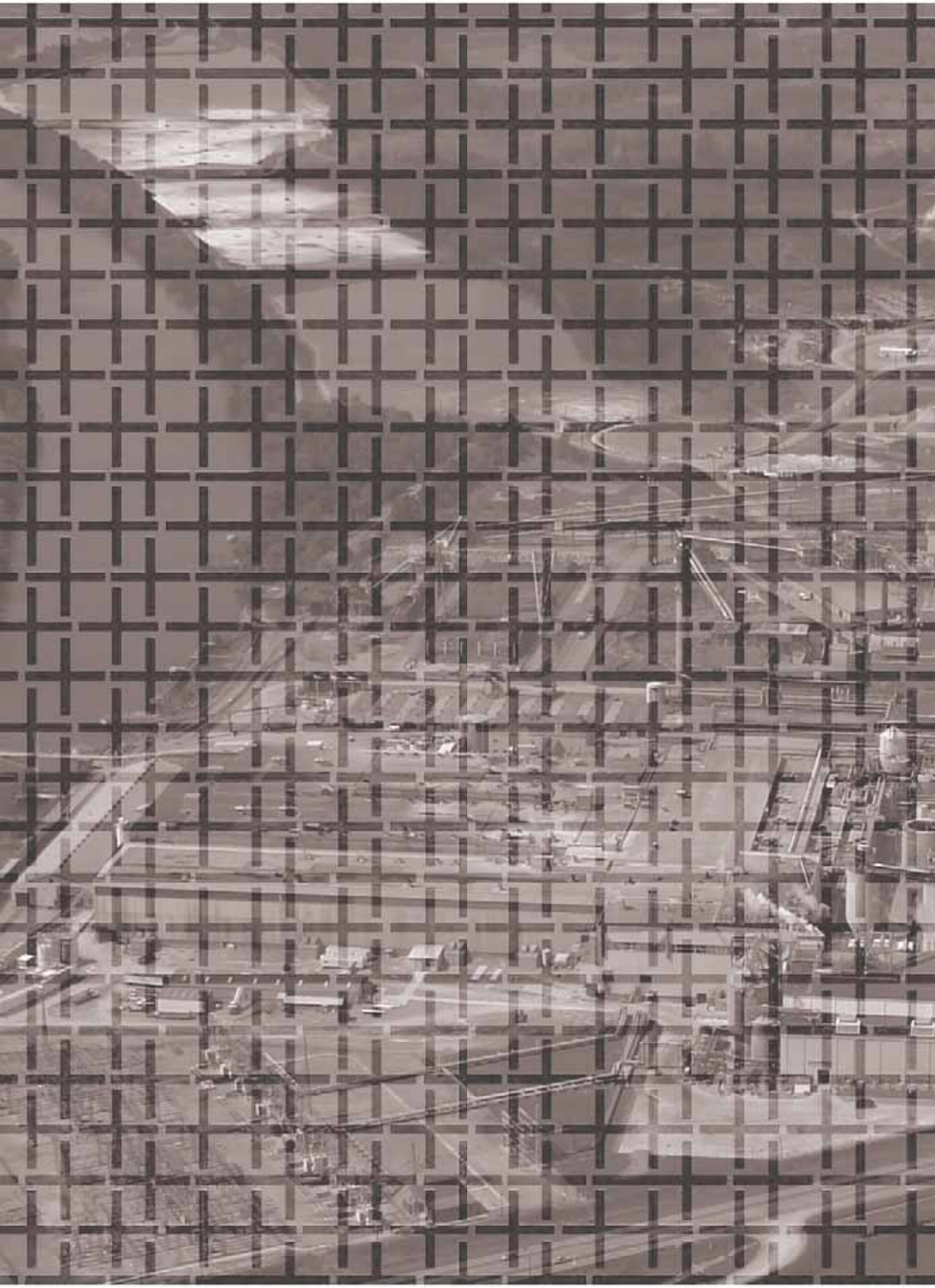
PRECEDENTS

Multi-Species Grazing
Stone Barns
2011

The Stone Barns Center for Food and Agriculture focuses on sustainable and resilient farming methods that facilitate regeneration of the ecosystem. One practice is the rotation of multiple animals through one pasture every few days. This helps to keep fields rich and biodiverse by taking advantage of the unique feeding strategies and nutrient waste of each species.

GPS Collars
USDA Agriculture Research
2006

USDA researchers have developed multiple iterations of GPS collars that provide a way for farmers to set paddock limits via GPS coordinates. Another model goes over the ears and is charged by solar panels situated on the top of the cow's head. In both models, the cows are given an audible alert, which will deter them from the boundaries.



WASTE MANAGEMENT

Rethinking the flow of waste fosters new economies, products and strategies that contribute to water quality stewardship. Current regulations try to control waste release and mitigate environmental damage, but new tools and approaches can help keep up with contemporary waste cycles.

Chattanooga's Moccasin Bend Wastewater Treatment Plant processes solid waste into biosolids that are recognized by the Environmental Protection Agency and the Tennessee Department of Agriculture as a soil amendment.

WASTE MANAGEMENT

Waste is an unavoidable outcome of modern society, economic activity, and population growth. Waste is generated throughout supply, production, distribution, consumption and digestion cycles in the form of industrial byproducts, animal and human effluent, biomass, and discarded consumer products. These materials are commonly disposed of in landfills, discharged at permitted levels to receiving waters, or dispatched to other centralized repositories without regard to their potential reuse, while industry and agriculture wrestle virgin materials from the landscape in order to bring their goods and services to market. As the region becomes increasingly attentive to the finite nature of these resources and the water resource impacts of conventional material extraction and traditional waste management approaches, opportunities for new technologies, networks and economies emerge.

EXISTING CONDITIONS

Modern consumerism and the industry that fuels it has reached an unsustainable level of waste production, and the environmental legacy of past economies and waste management practices that pre-date contemporary regulations are embedded throughout post-industrial brownfields and agricultural landscapes around the region.[65] Before the Clean Water Act, it was common practice for industries to discard their by-products and process waste water directly into nearby streams and rivers. After such practices were prohibited, businesses began stockpiling and disposing of waste products on-site, burying them underground. The legacies of these now-prohibited practices threaten the health of groundwater

resources, linger in sediment deposits in our rivers and streams, and have aggregated in reservoirs and behind dams, sometimes affecting their operation and flood storage capacity. Though NPDES and other contemporary regulation mechanisms have mitigated the water quality challenges from new point-source pollution, our waterways still play an important part in permitted waste management practices — and as such ongoing economic activity and growth — and likewise remain threatened by unpermitted activities and failures of on-site waste management infrastructures.

Examples of environmental catastrophes when waste management infrastructures fail or have been disturbed by natural phenomena are becoming more common. The Tennessee River Watershed is home to the largest coal waste disaster in US history when in 2008, a levee failed at the Kingston Fossil Plant and released over 1 billion gallons of coal ash into the Emory and Clinch Rivers.[96] Animal effluent storage facilities at North Carolina CAFOs were recently inundated by floodwaters triggered by Hurricane Matthew.[97] As similar reports of other infrastructural failures across the nation increase and waste

management facilities become vulnerable to climate dynamics and other disturbances, a more critical eye must be turned towards societal waste flows and management practices.

The last decade has witnessed a surge in interest regarding waste as an economic commodity. Technological and biological efficiencies in solid waste processing produce reusable biosolids of varying grades that possess a range of applications in both urban and rural landscapes. Chattanooga's Moccasin Bend WWTP is already converting solid waste into safe, valuable biosolid fertilizers for the region's farmers and landscape restoration projects. This practice diverts solid wastes from landfills, reduces operating costs, and provides an environmentally-friendly and energy-efficient fertilizer resource.[98] Ash from coal-fueled power plants, that constitutes the largest waste cycle of the region, is beginning to benefit from the same perception change from environmental hazard to kinetic, socio-economic asset. This legacy pollutant has been capped, flooded and piled in various forms that risk leaching into regional water resources, though it is increasingly being safely encapsulated and recycled as a raw material for

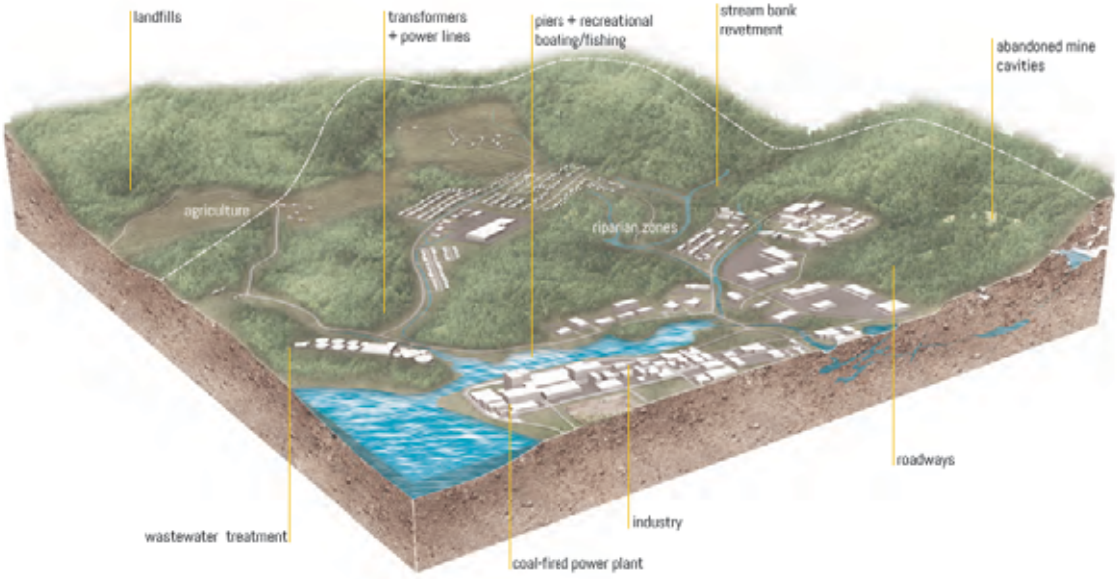
structural grade concrete and other construction products such as drywall and sheet rock.[99] By expanding the region's recognition of human waste and industrial by-products such as coal ash as a raw material resource, new opportunities for the economy and water resource stewardship emerge.

APPROACH

Expanding infrastructures and reuse possibilities for existing material recycling initiatives, and identifying new entrepreneurial waste reuse opportunities, recycling networks, and innovative, on-site management systems are the focus of the visions and strategies for change in this section.

Solid waste recycling strategies exercised at the region's largest wastewater treatment plants (WWTPs) may also be applied in agricultural landscapes and rural residential communities through decentralized facilities or new logistics networks. These approaches can mitigate pollution levels from the region's most wide-spread water resource impairment, *E. coli*, and generate new revenue that may support deferred infrastructure maintenance as well as innovative infrastructure and water resource stewardship investments. Opportunities to expand existing coal ash encapsulation practices into non-structural concrete can create new material resources for productive water resource infrastructures such as stream bank revetments, artificial aggregate for green infrastructure installations and compact-able base material, reducing demand for virgin aggregate quarrying. Similar marketplaces and exchange networks for recycling waste products while reducing landscape disturbance for raw material extraction are also possible in other industries. Innovative in-situ waste water management, waste harvesting and waste reuse networks will also benefit regional water quality by reducing the amount of discharge processed at WWTPs, reducing their operating costs and increasing their capacity to accommodate new economic growth.

Each of the following recommended strategies seek to shift attitudes towards waste management, reduction and recycling by all stakeholders, individual residents and industry alike. A new view of waste management is a necessary step for the future quality and security of the region's water resources.



The territories identified above include those landscapes where the following water quality improvement strategies may be implemented.

WHAT GUIDING PRINCIPLES

1

LOCALIZE ECONOMY: Production Through Reuse

- To reduce raw material extraction and importation by maximizing local waste recycling
- To mitigate legacy pollutants through entrepreneurial reuse of local waste resources

2

REDEFINE INFRASTRUCTURE: Innovate Use

- To continually reassess production within the community
- To analyze the functions of infrastructure based on the value of its products

3

COMMODIFY WASTE: Create New Goods

- To extract usable components for revenue
- To reconsider the life cycle of products for improved efficiency of resources
- To extract usable components for revenue

4

REVITALIZE ENVIRONMENT: Waste for Ecological Benefit

- To restore degraded landscapes with waste products
- To apply usable elements of waste to the environment for healthy vegetation

HOW STRATEGIES FOR CHANGE

RECYCLE SOLID WASTE

Organic matter from solid waste can be converted to safe biosolids for soil nutrification, providing an economic resource while reducing the volume of disposed solid waste and its associated water quality impacts

a

INCORPORATE COAL ASH

Coal ash can be used as an aggregate for various grades of concrete, a product that can then be used in many of the same ways as traditional concrete to produce traditional and novel products

b

REDUCE POLLUTION PRESSURE

Extracted organic nutrients from wastewater and treated greywater can be distributed for productive use and revenue, reducing pressure on pollutant limits of impaired streams and potable water demand

c

MONITOR HOUSEHOLD WASTE

Proper disposal of unwanted contaminants helps to reduce the negative impacts of households on ground and surface water resources

d

WHAT GUIDING PRINCIPLES

1 LOCALIZE ECONOMY: production through reuse

Emphasizing localized waste reuse networks can reduce importation of material inputs to production processes. Mitigation strategies are easier to monitor and sustain when the pollutant sources are located within the region. The region is intrinsically connected to its legacy pollutants and has the greatest capacity to recode their history and leverage them for economic potential through local reuse.

2 REDEFINE INFRASTRUCTURE: innovate use

As technology continues to evolve, assessment and refinement of existing infrastructural approaches and adoptions of new infrastructures present economic, social and environmental benefits. Analyzing the performance of contemporary waste management practices and making strategic, proactive investments position communities and business owners for future infrastructure innovations and efficiencies.

3 COMMODIFY WASTE: create new goods

Tennessee has long fostered a culture of innovation and technological advancement. The region is poised to spearhead a future of waste commodification and new economic opportunities. Reconsidering the material flows and life cycles of industrial and residential by-products of the Southeast can shift perceptions and advance new uses for materials previously conceptualized as waste.

4 REVITALIZE ENVIRONMENT: waste for ecological benefit

The environment benefits from both waste reduction and reuse. Proper disposal of industrial and residential by-products has the potential to mitigate environmental damage while recycled materials can be applied in constructive, ecologically regenerative or restorative ways that steward water resource health.

CONNECTING
PRINCIPLES & STRATEGIES

	a RECYCLE SOLID WASTE	b INCORPORATE COAL ASH
1 LOCALIZE	Processing regional animal and human solid waste into biosolids can create a local nutrient cycling program that promotes healthier landscapes while providing economic gain.	The region's industrial past has stockpiled a dangerous concentration of idled legacy pollutants that continue to grow at exponential rates; however, new cementation techniques address this pollutant as both resource and commodity.
2 REDEFINE	By isolating a step in the process of wastewater treatment and proposing safe reuse, waste can be reconceptualized as a resource and provide a new function to the overall waste reclamation system.	Framing coal waste as a productive resource can shift negative perceptions of the energy industry and its by-products, relieving communities of the fear of nearby toxins and mining the ash until other energy alternatives are available.
3 COMMODIFY	Tapping into existing waste systems can benefit efforts to protect both urban and natural environments while opening new economic avenues of product development and distribution	Certain grades of coal ash have proven valuable components in a variety of applications, but this region is uniquely situated to realize the economic potentials of the resource in its entirety.
4 REVITALIZE	Refined biosolids contain the necessary nutrients to improve living environments or accelerate their function, reinvigorating damaged landscapes, local neighborhoods, and urban centers.	Addressing coal ash and encouraging its safe reuse as construction aggregate or wildlife habitats can simultaneously give life to stagnant energy landscapes and the natural environment.

C REDUCE POLLUTION PRESSURE

Reconsidering the wastewater treatment process aims to extend nutrients to more places within the region and better connects urban and rural communities.

Capturing nutrients and greywater before they reach a water treatment facility breaks the conventional cycle and allows the potential for these resources to be utilized for household applications and irrigation.

In the face of a rapidly growing population, the use of greywater can help reduce the demand on conventional water supplies and pressure on sewage treatment systems.

The combination of a localized source of nutrient fertilizer and established greywater diversions for irrigation can benefit environmental aesthetics and ecological health.

d MONITOR HOUSEHOLD WASTE

Urban, suburban and rural homes have equal responsibility towards safeguarding the region's natural resources and can help by abiding by localized waste regulatory standards.

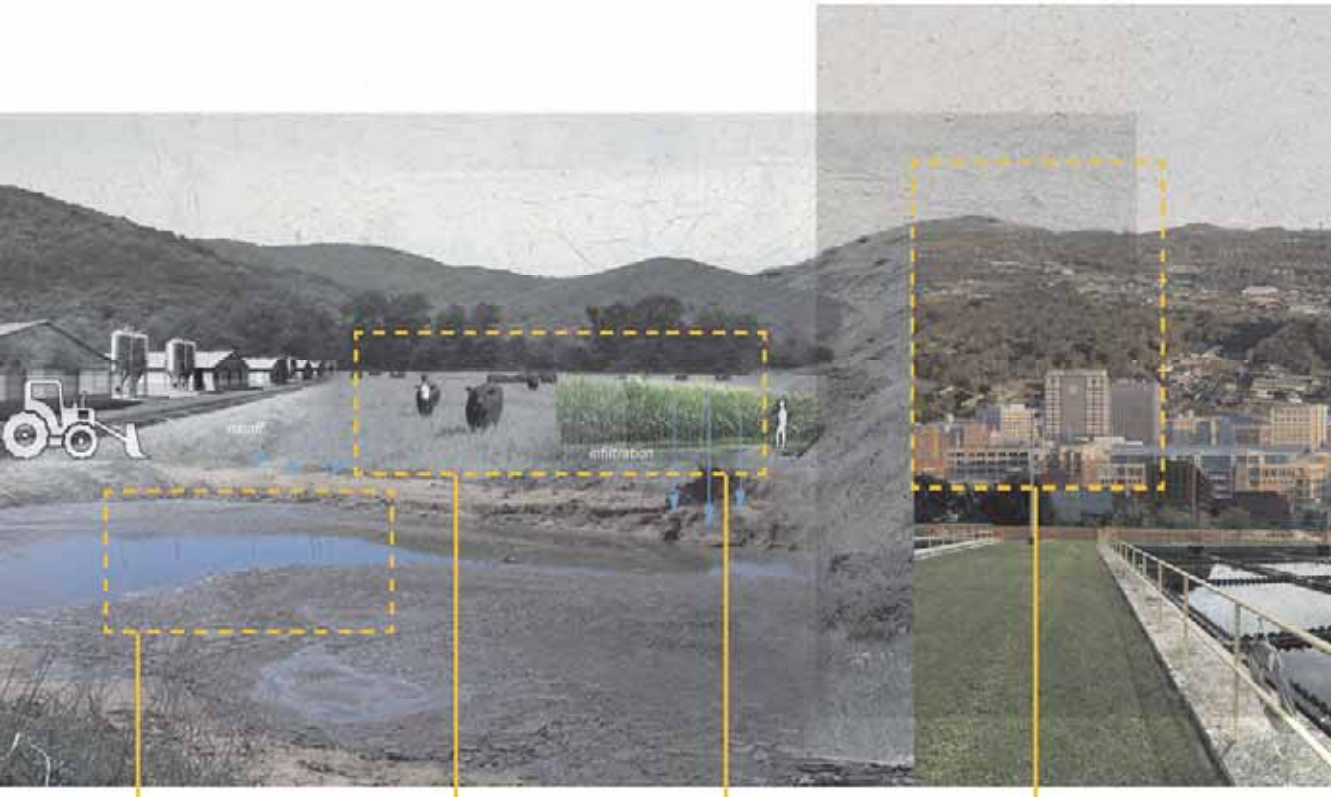
Residents have an unrecognized authority over waste flows and must be conscientious of the environmental repercussions of modern age consumerism.

Stronger demands for environmentally friendly products or recycled materials can influence industrial manufacturing and practice.

Residential zones can benefit from richer natural environments that are devoid of waste effluent and reinforced by recycled materials, reinvigorating local neighborhoods and adding life to urban centers.

HYDROLOGIC BENEFITS

Processing solid wastes as biosolids recalibrates the region's most widespread water quality threat as a valued commodity. Keeping waste within the cycle of production reduces the volume that is embedded in vulnerable, decentralized and loosely-regulated storage facilities throughout the region, reducing leaks and failures and contributing to energy-efficient soil nutrification, stabilization and reduced sedimentation.



ANIMAL WASTE

Solid waste concentrates in storage areas at regional CAFOs (confined animal feeding operations). Developing methods for on-site treatment, processing or sale, and economically transporting waste to central treatment facilities (for conversion into biosolids) can create safe, economical fertilizers and reduce threats to surface and groundwater.

PASTURE HEALTH

The health and coverage of forage crops impacts the quality of nearby water resources. Healthy pastures promote infiltration and reduce the amount of sediment and waste carried by runoff.[100]

FERTILIZER

Waste can be harvested from CAFOs and recycled as fertilizer to improve pasture health. Processed biosolids can be purchased by farmers for use on pasture or crop fields. Per EPA regulations, Class A biosolids are suitable for all landscapes, while Class B have certain restrictions for food crops and grazing.[101]

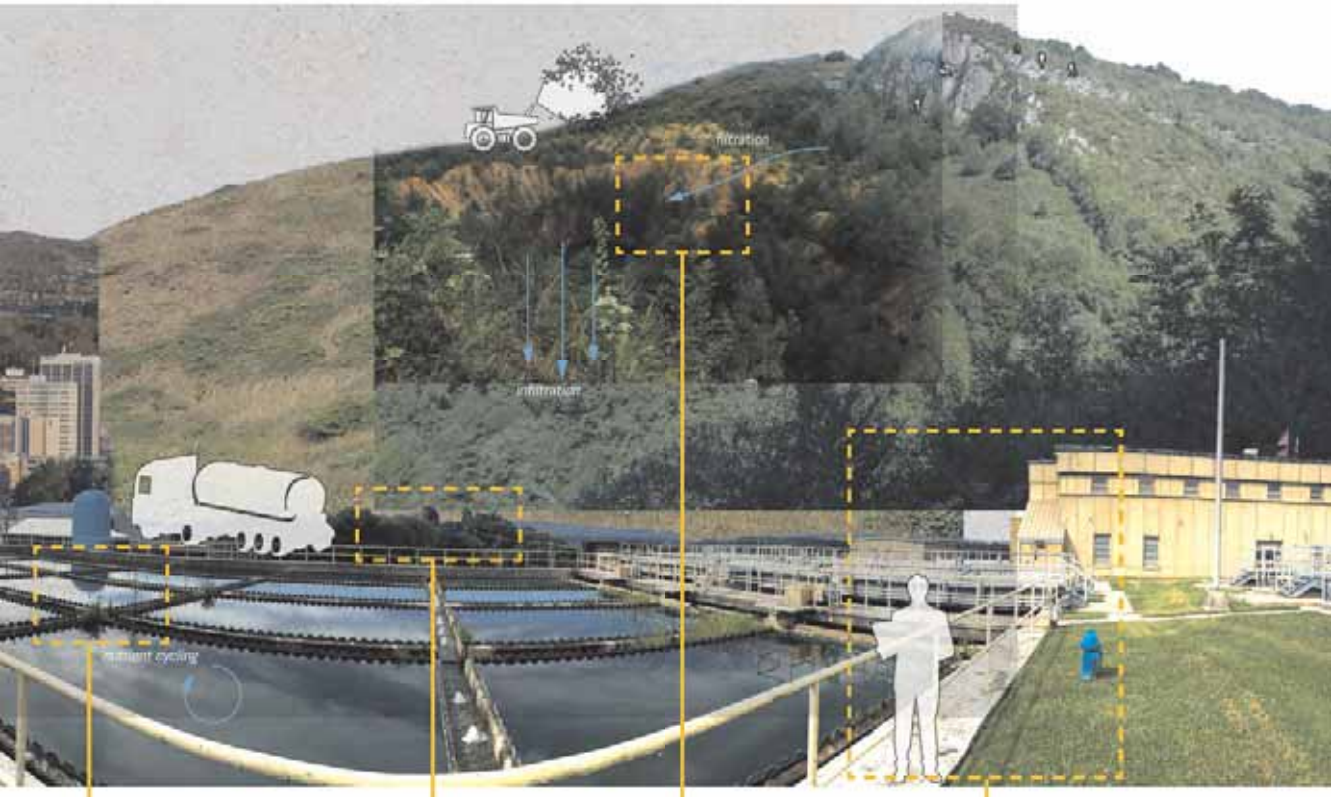
SEWER + SEPTIC

Sanitary sewers convey solid waste to WWTPs where it may be processed into recyclable compost or biosolids. Septic systems can be converted to septic tank effluent pumps that serve as decentralized wastewater treatment, reducing the potential for faulty septic systems. Solid waste in septic tanks can be harvested for centralized processing, stewarding water quality in headwater landscapes.

RECYCLE SOLID WASTE

a

Improperly constructed, operated, and maintained repositories of solid waste from humans and animals (such as CAFO waste stockpiles/lagoons and septic tanks) render the region's ground and surface water resources vulnerable to impairment by biological pathogens and elevated levels of nutrients. Solid waste can be recycled in a number of economically- and environmentally-productive ways. Equipped WWTPs can process solid waste from a range of sources, including CAFOs, septic services, or smaller regional treatment plants, as biologically-stabilized biosolids products. Class A and Class B biosolids can be used as a fertilizer and a soil conditioner for disturbed landscapes that require reclamation and soil regeneration as permitted by EPA regulations.[102] Treated solid waste can also be composted with organic material to produce commercially-viable soil amendments. On- and off-farm uses for recycled animal waste can reduce the size and pollution threat posed by manure stockpiles and lagoons.[103] By considering solid waste as a commodity and a part of a regional nutrient cycle, less overall waste may remain embedded throughout the regional landscape, mitigating threats to water resources while creating local exchange markets and novel economies. Revenues from these exchanges can fund infrastructure improvements and other water quality investments, further compounding the water quality benefits of recycling solid waste.



DIGESTION + PATHOGEN STABILIZATION

Solid waste processed at the wastewater treatment plant undergoes aerobic or anaerobic digestion, processes that break down solid organic material. Methane is a commodifiable by-product of this process of reducing these volatile solids. Additional pathogen reduction and stabilization may be required for safe application to the land.[104]

COMPOST

Processed solid waste can be composted with woodchips or other organic materials to produce nutrient-rich soil amendments.

RECLAMATION

Biosolids applied to former mining sites or other deforested landscapes provide nutrients that facilitate secondary succession and soil stabilization.

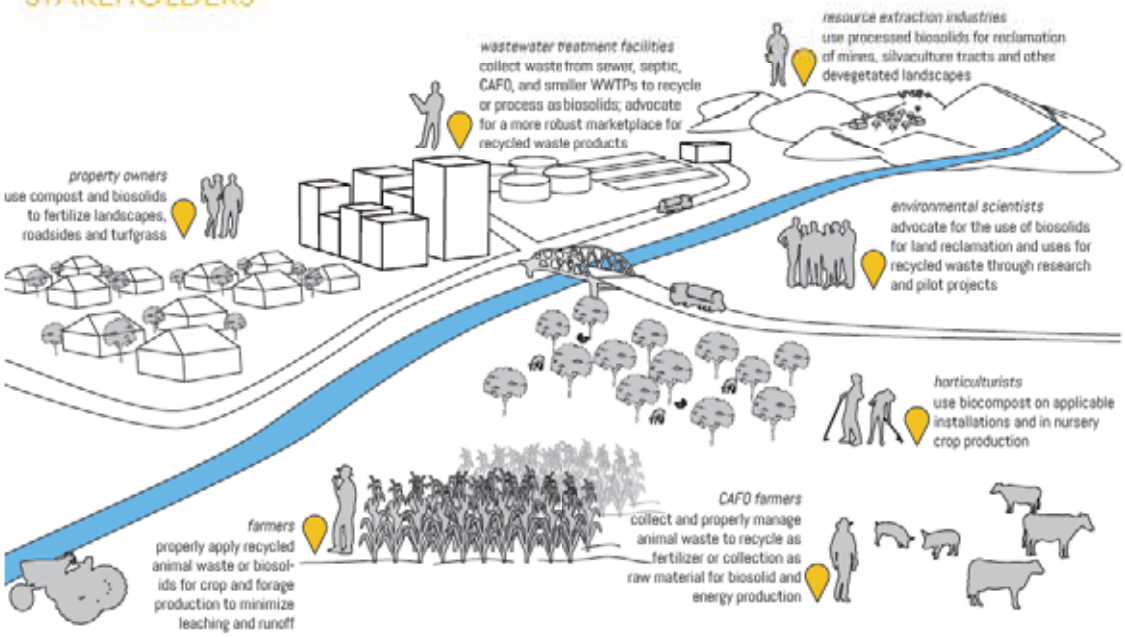
COLLABORATION

Small WWTPs without economies of scale to process biosolids themselves can partner with other regional facilities to achieve efficiencies, generate revenues (that may be used to support sanitary infrastructure repairs or upgrades), and reduce operating costs.

IMPLEMENTATION TERRITORIES

Wastewater Treatment Facilities	Wastewater treatment plants of all sizes can facilitate or participate in solid waste exchange networks for economical biosolids production.
Septic Tank Effluent Systems	These decentralized wastewater systems are viable alternatives to aging septic systems in rural areas that threaten water quality in headwater landscapes.[105]
Agriculture	With the vast acreage of agricultural land in the region, CAFOs can be harvested for solid waste resources while land applications of biosolids offers local nutrient cycling for healthier soils.
Reclamation Areas	Former mine sites and other areas impacted by deforestation can be revegetated or reforested by applying biosolids to reintroduce organic matter and vital nutrition to the soil.
Landscape Plantings + Turfgrass	Class A biosolids can provide a local and inexpensive fertilizer for large areas requiring supplementary nutrients, such as golf courses and cemeteries.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Infrastructure	Increasing biosolids processing may require new or larger facilities.
Transport	Waste transported from rural areas may initially be cost-prohibitive.
Demand	Processing facilities must develop and penetrate markets in order to increase biosolid demand.
Education	The public must be educated on the proper uses of Class A vs Class B biosolids.

TACTICAL SITE INTERVENTIONS


Fig. 1 Demonstration Plots

Fig. 2 Signage


Fig. 3 Reed Beds


Fig. 4 Dewatering Bag

Although biosolids have been available for some time now, many people are either unaware of its existence or concerned about the potential health hazards posed by the use of a commodity derived from wastewater. The biggest hurdle preventing widespread application of biosolids is the perceived risk associated with it. Interventions focused around education and accessibility would be helpful in promoting biosolids as a safe and viable fertilizer option. Demonstration plots like the one shown above in Figure 1 can be used as a tool to teach farmers about the benefits of using biosolids on their crops. Proper signage on participating land plots would provide transparency and direct people to more information on the use of biosolid fertilizer. Figures 3 and 4 are methods that can be used to dewater sludge and improve the economics of transporting the waste to processing facilities, making the system more financially and environmentally efficient.[136]

PRECEDENTS

National Biosolids Partnership
Chattanooga, TN
2016

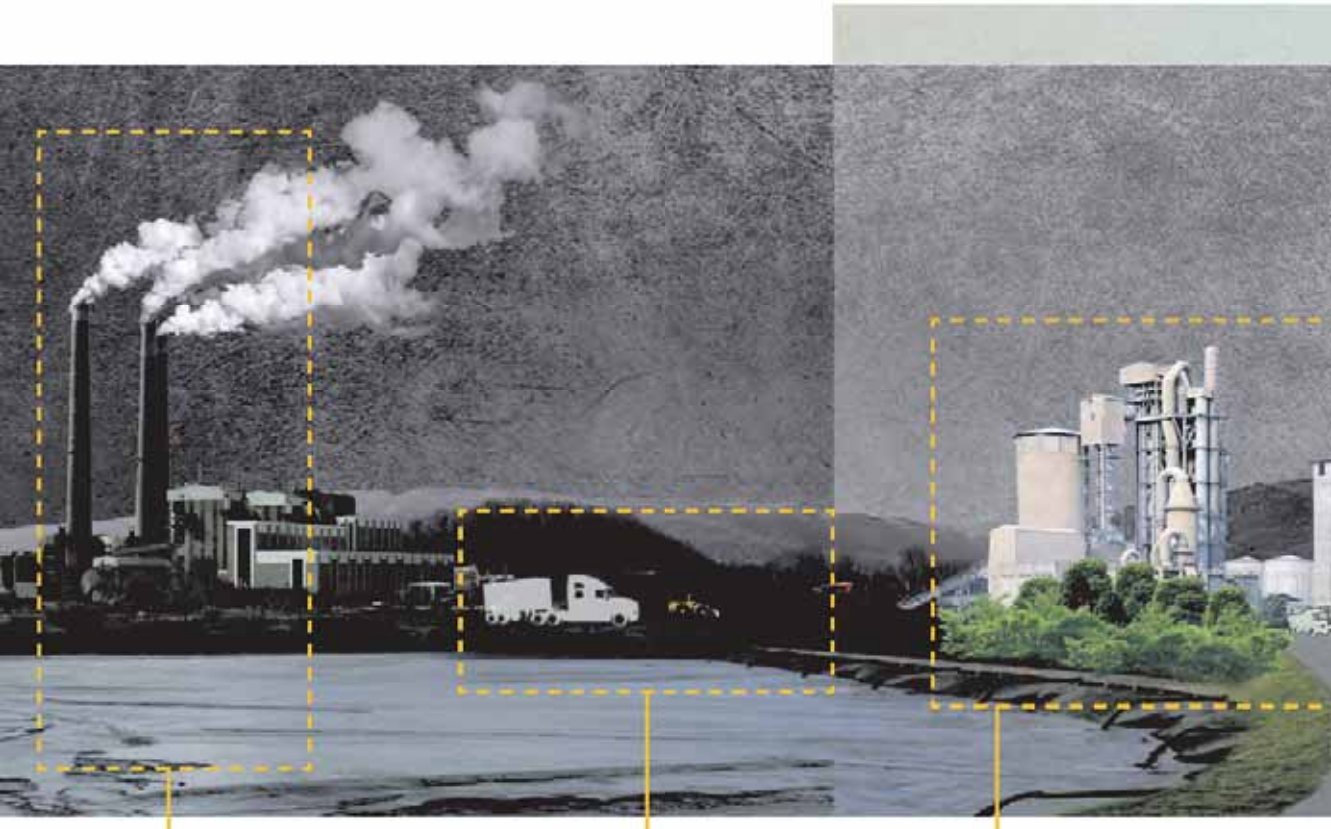
Prior to Moccasin Bend's biosolid land application program, the city was paying to transport and dispose of 100,000 wet tons of biosolids into landfills annually. The program has effectively reduced the amount of waste by producing a safe fertilizer that can be used in various situations for land cover while reducing the facility's operating costs.

Boulder Park Project
Douglas County, Washington
1992

Encompassing more than 75,000 acres of farmland, the Boulder Park Project is the nation's largest farmer-owned biosolids co-op. Boulder Park serves as an on-going laboratory for the study of biosolid use on cropland. Among other benefits, studies have shown that wheat germination and survival rates have increased with biosolids, ultimately improving overall crop yields.

HYDROLOGIC BENEFITS

Shifting the perception of coal ash to that of a valuable construction resource will reduce the amount of hazardous waste stock-piled immediately adjacent to major waterways, as well as encourage fly ash cement use in non-structural concrete for stream bank stabilization and habitat regeneration projects in urban and rural environments, and artificial aggregates, reducing demand for quarried rock.



COAL PLANT HAZARDS

Most coal plants have aging infrastructure that was initially constructed without the safety standards in place today. Broken levees, unlined ponds, and inadequate dry storage have led to a number of devastating environmental catastrophes.[107]

IN-SITU + EX-SITU TREATMENT

In-situ treatment requires less transportation by addressing coal ash at its source. Slurry ponds can be reinforced with geofiber textiles and proper landfills can contain the waste within the landscape. Ex-situ treatment removes the ash from the plant to be processed at other facilities or buried in discrete landfills elsewhere.

CEMENT RECYCLING

By outfitting cement plants with the appropriate technology needed to process coal ash, various cement forms can be manufactured to suit the demands of the city. High grade cement can be applied to roads and sidewalks while lower grade ash forms cement better suited to crush into artificial aggregate.

INCORPORATE COAL ASH

b

Coal ash from fossil-fuel power plants remains one of the largest types of manufactured pollutants in the nation.[108] Tennessee has a rich history of energy production, but has consequently stockpiled dangerous concentrations of this byproduct waste within its landscape. As coal is burned, its non-combustible components fall to the bottom of the incinerator as bottom ash or escapes up the stack as fly ash. Fly ash is incorporated in several EPA regulated cement recycling facilities, but only certain classifications are utilized to produce high quality masonry or roads. The cementation process effectively suspends the toxins found within the waste and makes it safe for human use. However, the majority of this material is not processed because lower-grade ash creates less attractive textures in the resulting cement.[109] While the public may be wary of the material in buildings or bridges, other useful applications, such as the production of artificial aggregates or cast aquatic habitats, can benefit the natural environment without pressures of human inhabitation. The creation of aggregates can localize the crushed stone economy and alleviate mining pressures from regional landscapes. This incorporation of coal ash into broader avenues of reuse opens opportunities for safer regulations of coal plant waste and begin the harvest of this legacy pollutant that currently remains embedded in fly ash ponds and landfills.

RIPARIAN BUFFER

Leveraging rivers as material transport infrastructures, all regional coal plants are located at the water's edge and thus necessitate robust riparian buffers that protect against wet ash leaching and can slow slurry flow in the event of a levee break.

STREAM REVETMENT

Stream revetments and other low-cost cement applications are practical projects that can test the safety of non-structural concrete made with recycled, low-grade coal ash. By proving coal waste can create healthy edge conditions, cities can ensure the safety of consumers in more infrastructural ventures.

AQUATIC HABITATS

Porous cement created by lower grade fly ash is an ideal material to construct wetland habitats.[110] These fly ash blocks will be part of an ongoing research endeavor that seeks to recharacterize coal waste.

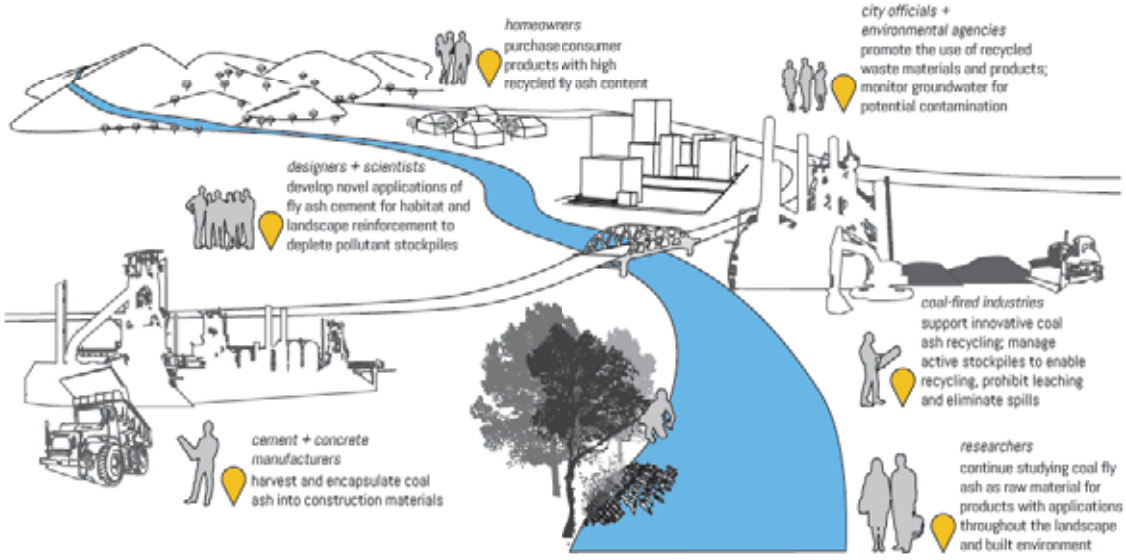
MASONRY

Fly ash bricks are already being manufactured, but cities must foster a larger demand within its consumers.

IMPLEMENTATION TERRITORIES

Decommissioned Coal Plants	Inactive or decommissioned coal plants can relinquish the stockpiles of coal ash waste that are normally stored on site without disrupting the flow of power to the region.
Compromised Capped Coal Ash	Coal ash landfills created before contemporary regulations or the creation of geotextile materials are unlined and risk leaching toxins into nearby water resources.[111]
Urban Parks	Artificial aggregate created from coal ash can substitute typical structural fill material to create new landforms and topography in public landscapes such as recreational areas.
New Road Projects	A number of construction projects have used raw coal ash as structural fill for highways, but artificial aggregate made from coal ash encapsulates the material for safer deployment.
Riparian Zones	New habitat structures and articulated concrete blocks can restore stream banks, control erosion and promote ecological health of creeks, streams and rivers in both urban and rural communities.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Perception	There is a reluctance to recycle potentially hazardous waste even if end products are deemed safe.
Applications	Applications of fly ash materials must be site specific and carefully administered.
Facilities	Outfitting cement plants with infrastructure to process coal ash may initially be cost prohibitive.
Research	Only about 50% of coal ash is recycled commercially. Research is needed to identify more uses.

TACTICAL SITE INTERVENTIONS


Fig. 1 Cement Habitats


Fig. 2 Stream Revetments


Fig. 3 Urban Park Structural Fill


Fig. 4 Cement Research

Low-cost pilot projects in isolated streams can test the safety of recycled fly ash material with little risk for human exposure. Figure 1 illustrates a speculative brick habitat that is perforated and includes surface articulations that suit different aquatic species. New cement revetments, as show in Figure 2, not only reinforce deteriorated stream banks, but also act as aquatic habitat for stream vegetation and wildlife. In more urban settings, small parks can be built using specified coal ash as structural fill. Contaminated soils can be used in urban parks and other landscapes that accommodate public activities as long as the material is properly compressed, as demonstrated in Figure 3, and sealed from contact using geotextile and soil separation layers. Ultimately, the future of coal fly ash waste in cement applications depends on further innovative research and testing. Empirical data that clearly demonstrates the safety of the recycled material will prove its worth within urban and natural environments.

PRECEDENTS

Fly Ash Brick
Boone County, MO
2007

Class F and C fly ash has been used for years in high grade masonry. Though this addition of coal waste as a pozzolan in cement production is more efficient, the process still requires intense heat. EcologicTech's Fly Ash Brick has patented a new method of manufacturing that is able to use ash completely and without heat-firing. This opens new potential for fly ash bricks in construction projects.

Asheville Regional Airport
Buncombe County, NC
2015

In efforts to address concerns about coal waste production and recycling, Duke Energy transported about 4 million tons of coal ash from its Asheville plant to the site of the Asheville Regional Airport for use as fill material. Although this reuse is accepted as a safe and cost-effective disposal of coal ash, this project has had some risks and issues. Encapsulation is a tested a process that would take the reuse another step further.

HYDROLOGIC BENEFITS

Alternative waste streams for nutrient pollutants and greywater reduce the amount of ground and surface water required to support irrigation and fertilizing. By diverting these pollutant loads from impaired streams, water quality is improved. TMDLs can be reduced or more NPDES permits can be issued.

WASTEWATER PLANT

Water is processed at treatment plants and then discharged into surface water or deep injection wells, carrying permitted levels of pollutants based on the other dischargers in the area. WWTP can instead partially treat wastewater and distribute for reuse at other sites.

BIOMASS GROVE

Advanced secondary treated wastewater can be used to irrigate harvestable biomass, reducing pollutants in WWTP effluent and providing revenue for the wastewater facility.

MS4

Cities with MS4 designations maintain permits for discharging pollutants, but decentralizing stormwater management through green infrastructure can lessen the strain on traditional grey infrastructure and TMDL streams.

INDUSTRY

Wetlands or other nature-based filtration systems on site can provide an alternative to traditional process water treatment systems or reduce discharge to WWTPs.

REDUCE POLLUTION PRESSURE

C

Total maximum daily loads (TMDLs) are pollution discharge limits placed on impaired streams to prevent worsening water quality conditions. These limits reflect dilution levels deemed compatible with a waterway's designated uses. Limits are placed on the levels and types of pollutants that industries, cities, and other point sources are permitted to discharge into these waterways. If load limits have been met or exceeded, economic growth may be limited along that waterway or within its contributing watershed.[112] To mitigate the load of pollutants discharged to receiving waters or sent to centralized wastewater treatment facilities, some industries manage process water on-site. Non-point source pollution loads from communities with MS4 designations are also included in TMDL calculations. Decentralizing stormwater management throughout the city using green infrastructure can reduce the impacts to receiving waters. Reclaimed water can be diverted from WWTPs and sold to golf courses, farms and other land owners for landscape irrigation. Concentrated nutrients from wastewater can be harvested, pelletized, and sold as fertilizer. In each case, pollution pressure on receiving waters is reduced, improving water quality and creating space in existing TMDL limits for new economic development.

URBAN VEGETATION

In addition to managing stormwater on site, reclaimed water can be returned to urban landscapes for irrigation.

INFLOW + INFILTRATION

Maintaining sewer infrastructure reduces the amount of stormwater that may be carried to and potentially overburdening WWTP, reducing their treatment capacity.

GOLF COURSES

Reclaimed water and pelletized nutrients from wastewater facilities can be used to irrigate and fertilize golf courses.[113]

LAWNS

In lawns not used for vegetable gardening, reclaimed water and fertilizers can be used for residential maintenance.

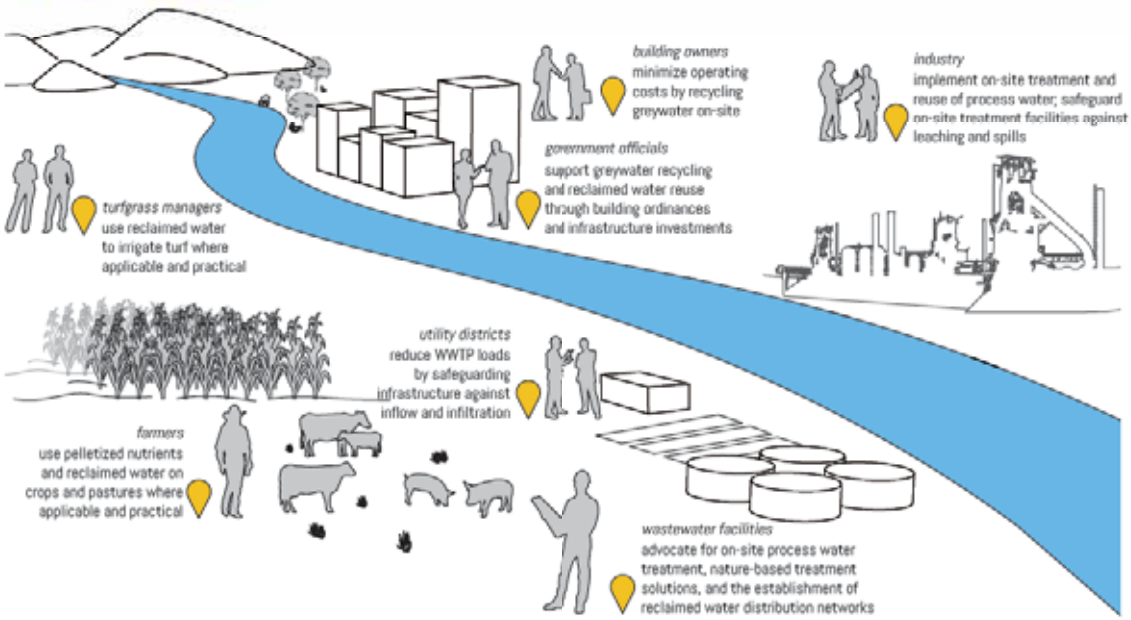
AGRICULTURE

Pelletized nitrogen and phosphorus can be sold to farms for a low cost to farmers, providing revenue for the city. Likewise, reclaimed water can be sold to farmers.[114]

IMPLEMENTATION TERRITORIES

Wastewater Treatment Facilities	Nutrients such as nitrogen and phosphorus can be extracted from wastewater treatment facilities and pelletized through alternate steps in the process of wastewater treatment.[118]
Large Acreage	Cropland, pasture, golf courses, and extensive landscaped areas are landscapes that could benefit from the use of recycled greywater, as well as pelletized fertilizers from nutrient extraction.
Industry	On-site wastewater treatment can reduce the amount of polluted discharge entering surface and groundwater and the resulting greywater can be utilized on-site.
Lawns + Landscaping	Greywater and recycled nutrients reduces the need for fertilizers and potable water, and may be designed as green infrastructures that mitigate stormwater pollutant loads.
Vegetation	Vegetated landscapes help to naturally absorb and filter nutrients and pollutants out of surface water resources.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Transport	Transporting greywater requires new, separate underground pipelines or vehicular transport.
Infrastructure	Pelletizing nutrients into fertilizers requires new processes and machinery.
Filtration	Greywater must have soaps and other toxins removed for safe use in irrigation.
Incentives	Incentives may initially be needed to encourage greywater use for irrigation over municipal sources.


Fig. 1 Alternative Water Sources


Fig. 2 Greywater Recycling


Fig. 3 Biofiltration

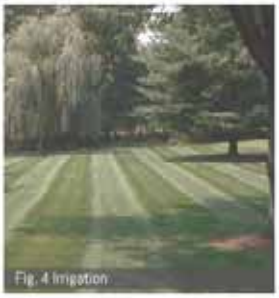


Fig. 4 Irrigation

TMDL limits are set in order to protect the health and ecosystems of streams. To avoid exceeding those limits, waste water that would otherwise be discharged to protected waterways can be treated or reused. Greywater systems (Figure 1) capture used water that can be used for landscape maintenance or to supply water to the lavatories (Figure 2). Vegetation and plantings (Figure 3) can also be used to filter pollutant loads in runoff through a process called biofiltration or to metabolize pollution in industrial process waste water. Facilities that produce a high volume of greywater can also pipe it to nearby locations where water is in high demand or in short supply. Landscapes such as residential neighborhoods (Figure 4) and golf courses may find greywater recycling a more affordable option for irrigation than using potable municipal water supply.

PRECEDENTS

Mayfield
Athens, TN
1950

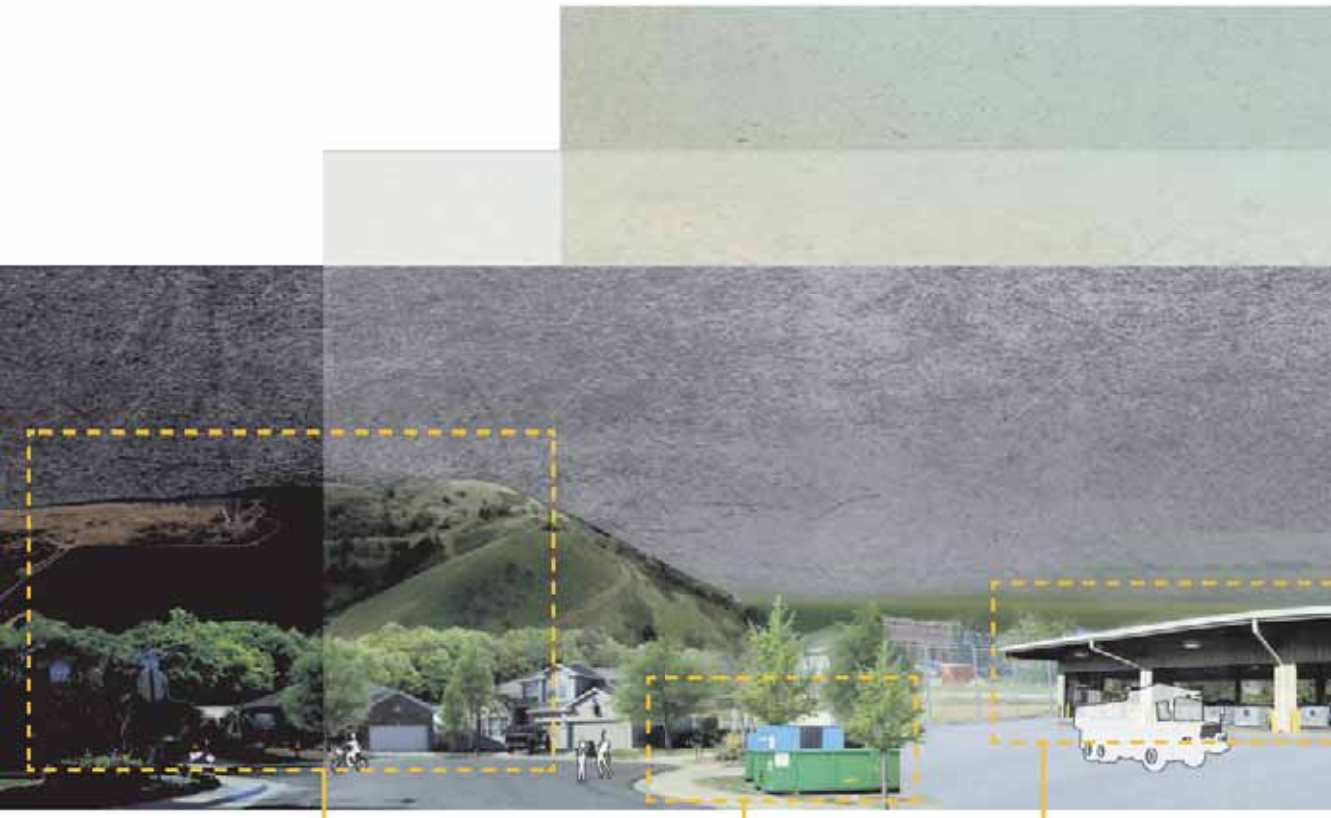
The Mayfield Dairy in Athens, TN uses thousands of gallons of water on a daily basis in their regular processes, including cleaning equipment. The creek where they discharge water is impaired and the wastewater facility has limited capacity. To offset the TMDL in their receiving waters and reduce slug loads to the local WWTP, Mayfield treats some of its wastewater on site and reduces runoff rate with detention ponds.

Poplar Plantation
Woodburn, OR
1999

The City of Woodburn WWTP uses a 84-acre grove of poplars as a nature-based solution to meeting stricter effluent discharge standards. The trees are irrigated with greywater from the plant to protect groundwater sources and reduce nutrient loads discharged to local waterways. Groundwater samples are checked each day before the biomass plantation is watered. The trees are eventually harvested for profit.

HYDROLOGIC BENEFITS

A regional shift in household consumerism and waste is necessary to safeguard the land and waters of the state. By promoting more environmentally conscientious behaviors, residents can mitigate waste flows from polluting local water resources.



LANDFILL PROXIMITY

Neighborhoods in close proximity to large waste-scapes are the target communities for waste reduction strategies. These residents have the most to gain from source reduction and material recycling.

ACCESSIBLE RECYCLING

Ensuring that recycling is available to all residents is key to fulfilling the desire for extended life cycles of manufactured products and develop a culture of total community involvement in waste management and water quality improvement.

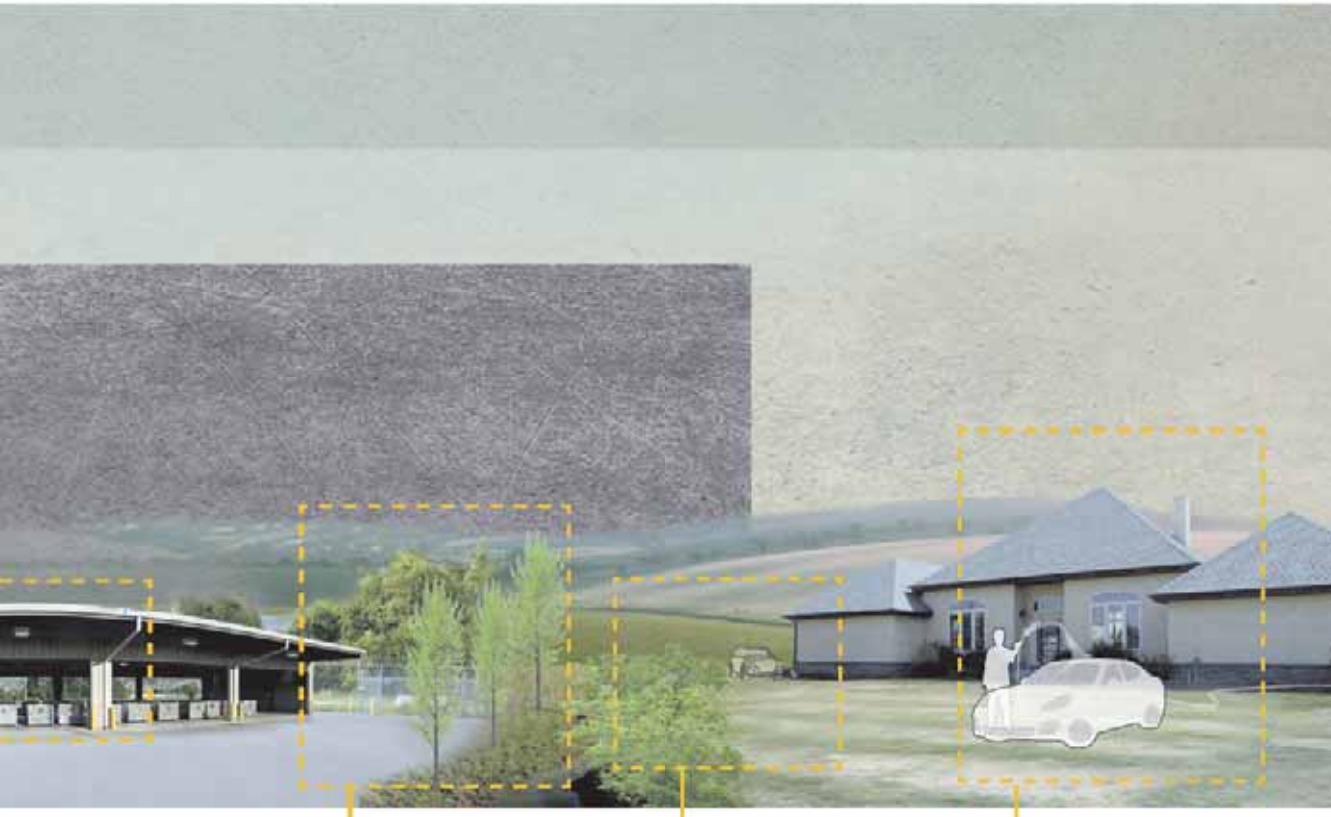
RECYCLING CENTERS

Comprehensive recycling strategies that include single stream recycling and large recycling centers equip residents with the resources to properly dispose of consumer goods including biomedical waste and electronics recycling.

MONITOR HOUSEHOLD WASTE

d

Though waste is often addressed at a city scale, individual neighborhoods and households must also assume the responsibility to control waste flows in and around their local environment. By extending water stewardship principles to urban, suburban and rural homes, all residents are included in the discussion of water quality. The treatment and disposal of solid or effluent waste represents one of the final stages of the wastewater treatment cycle, but source reduction within the consumer sector is an equally critical element. Simple behavior changes such as reducing plastic consumption, using less electricity, and following septic maintenance regimes will reduce the pressures at the industrial scale. Other behavioral adjustments such as proper fertilizer and pesticide storage and application as well as responsible pharmaceutical disposal will also yield water quality benefits. In general, resicents must take ownership of their influence over the market and create the demand for environmentally conscious products and industrial practices. Residential zones can benefit from subsequently healthier natural environments that are void of waste effluent and reinforced by recycling initiatives.



FACILITY PLANTINGS

Peripheral tree plantings serve as bioindicators of stream health, decelerators of runoff and experimental ecosystems for alternative recycled material reinforcements.

RIPARIAN BUFFER

A vegetated boundary is able to prevent groundwater migration and contain waste in the event of infrastructural malfunction.

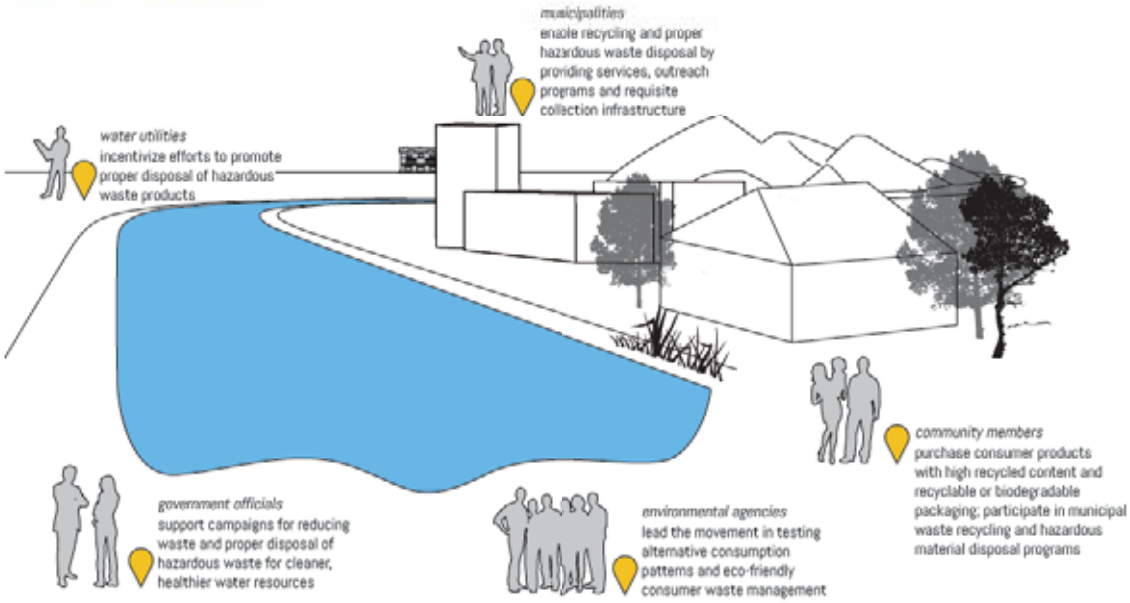
HOMEOWNER MAINTENANCE

Residents should be incentivized to maintain septic systems, reduce plastic goods, set up stormwater and composting facilities, and pursue energy consumption reduction.

IMPLEMENTATION TERRITORIES

Landfills	Diverting or sending less waste to landfills can alleviate the strain on the site's capacity and reduces infiltration of water through waste.
Recycling + Compost	Accessible recycling centers or municipal collection services with clear instructions for disposal of each material can relieve landfills of unnecessary capacity in rural and urban communities.
Homeowners	Educating homeowners in all communities about the proper disposal methods of harmful household waste can help to lessen problems in the wastewater treatment system.
Consumers	Educating consumers about the products they purchase, their packaging, etc. can raise awareness and can ultimately help reduce the amount of waste sent to landfills.
Combined Sewer	Alleviating the amount of stormwater and waste that enters combined sewers reduces the potential for combined sewer overflows.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Incentives	Incentives may initially be necessary to change current household consumption and waste rates.
Efficiency	Efficient collection services or sites may be difficult to implement in rural communities.
Marketing	Promoting waste programs and water quality benefits to dispersed populations requires marketing.
Impact	Individuals may minimize the consequences or benefits of their actions.

TACTICAL SITE INTERVENTIONS


Fig. 1 Educational Material Distribution


Fig. 2 Rain Catchment System


Fig. 3 Rain Barrel


Fig. 4 Prescription Drug Disposal

There are many ways households and individuals can be engaged to help alleviate water quality issues. Education and outreach is an important step in changing behavior and decreasing household wastewater output. Informative fliers or water quality cheat sheets (Figure 1) are useful tools to help citizens make informed decisions about their home water usage. Part of the outreach can include teaching residents about products that help conserve water. Figures 2 and 3 are examples of equipment that help individuals harvest rainwater. Figure 4 addresses the issue of medication disposal. Conventional WWTP systems are not capable of treating increasing concentrations of trace chemicals in found in municipal waste streams that originate from pharmaceuticals.[118] Public programs that collect and dispose of unused medications can help keep the medicine out of the public water supply.

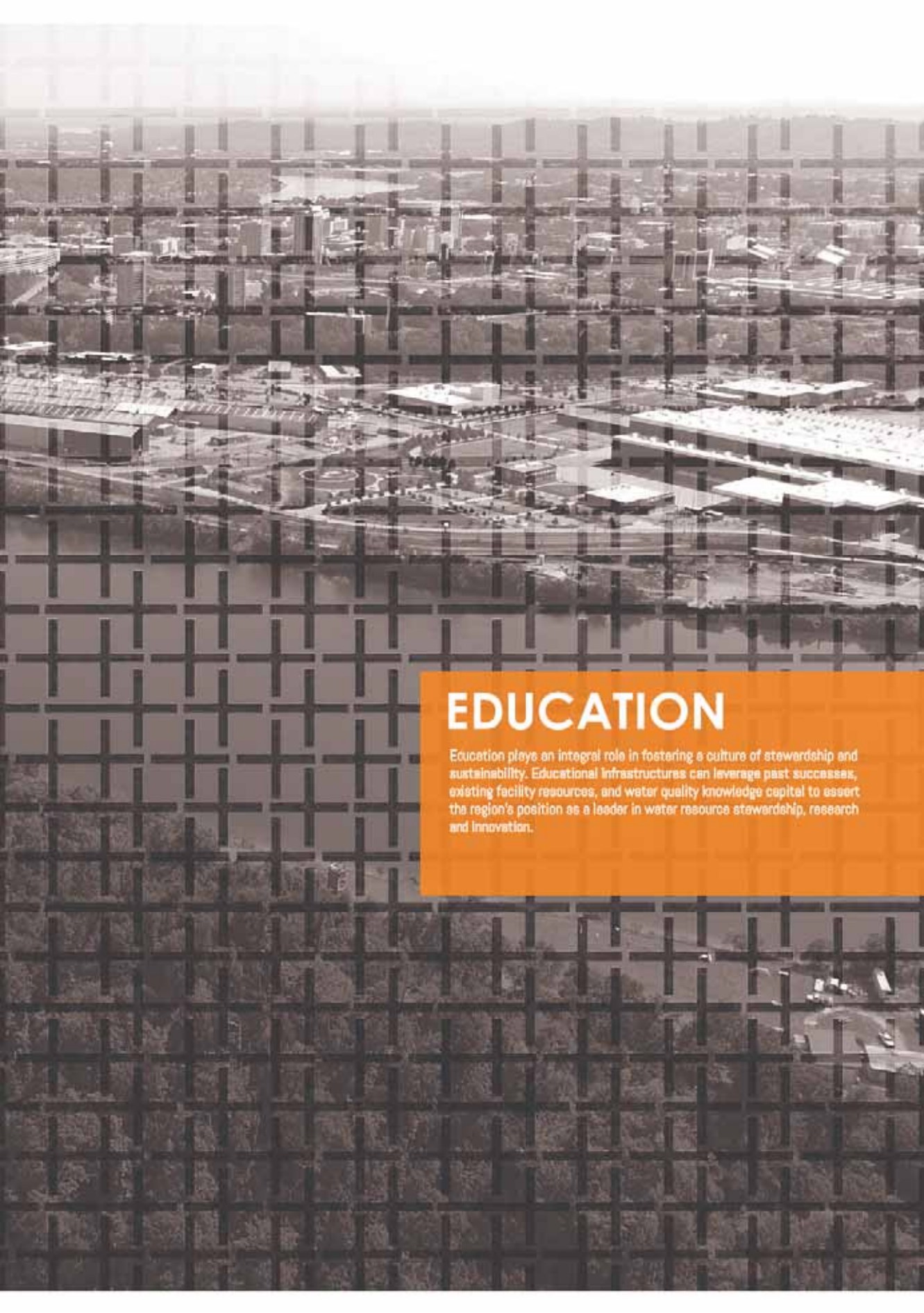
PRECEDENTS

Mobile Hazardous Waste Service
Tennessee
1993 - Present

TDEC's Mobile Household Hazardous Waste Collection Service provides all Tennessee residents a method for safe and responsible household hazardous waste disposal. Residents can check the collection schedule and take their unwanted material to the event in the nearest county. The program has been operating since 1993 and has hosted over 1,000 one-day collections, properly disposing over 20 million lbs of waste.

Unwanted Medication Collection
Knoxville, TN
2001

In addition to organizing medication collection events, the City of Knoxville has a permanent location where citizens can safely to dispose of their unused medicine. This dropbox is located at the Knoxville Police Department's safety building and receives deposits 24/7.



EDUCATION

Education plays an integral role in fostering a culture of stewardship and sustainability. Educational infrastructures can leverage past successes, existing facility resources, and water quality knowledge capital to assert the region's position as a leader in water resource stewardship, research and innovation.

The Tennessee Aquarium Conservation Institute is part of the region's foundation of water resource education and information.

EDUCATION

All stakeholders, regardless of socio-political status and residency in urban or rural communities — from high-level decision makers, property owners and developers, regulatory officials, to ordinary citizens — must be empowered to recognize and engage their role in preserving the future integrity of the region's water resources through contemporary educational initiatives. The focus of this education must include building recognition of the relationship between the health of the region's water resources and economic development, regional competitiveness, and quality of life.

Effective educational initiatives must also suit a contemporary audience, employing experiential, collaborative and technology-based methods of instruction that suit changing learning styles and meet learners where they are intellectually and geographically. Informed and educated individuals are the building blocks of communities willing to support leadership and policy capable of stewarding the long-term vitality of shared water resources.

EXISTING CONDITIONS

The current condition of the region's water resources — its success stories and its enduring challenges and threats — is an outcome of individual and collective choices, the accuracy and comprehensiveness of the information upon which those choices are based, and the level of understanding of the individuals and groups empowered to make and act upon those choices.

The SETD region boasts a legacy of water quality improvement success stories and is home to local and national water resource champions. The City of Chattanooga, once considered the United States' most polluted city, is now a nationally-recognized destination for water-based recreation and is home to multiple water resource facilities and advocacy organizations. The upper reaches of the Ocoee River Watershed has benefited from one of the largest landscape regeneration efforts ever attempted in the world. The City of Athens has established multiple productive partnerships and made strategic investments in education and green infrastructure demonstration projects that continue to yield measurable water quality results.[117]

These are but a few of the many communities and initiatives that have in part been made possible by an elevated social consciousness regarding the value of water resources, by visionary leaders, and by accessible expertise. They have helped build an enduring infrastructure of educational resources,

experience, and proof of concept around effective water resource stewardship. The Conservation Institute at the Tennessee Aquarium has become a robust center for scientific research and thought leadership with a focus on outreach and stewardship of the Tennessee River's unrivaled freshwater biodiversity.[118] The aquarium and the Institute are both a product of and a catalyst for the region's reconnection with its water resources, each coming to existence through some of the nation's best examples of regional planning, urban design, and waterfront revitalization.

These success stories and the infrastructure of experts and knowledge capital built through them will be fundamental to addressing the widespread water quality challenges and threats that persist within these communities and remain largely-unaddressable in smaller communities throughout the SETD region.

Though all communities in the SETD impact regional water quality and have a part to play in their stewardship, not all have the regulatory impetus, knowledge capacity, human resources, information

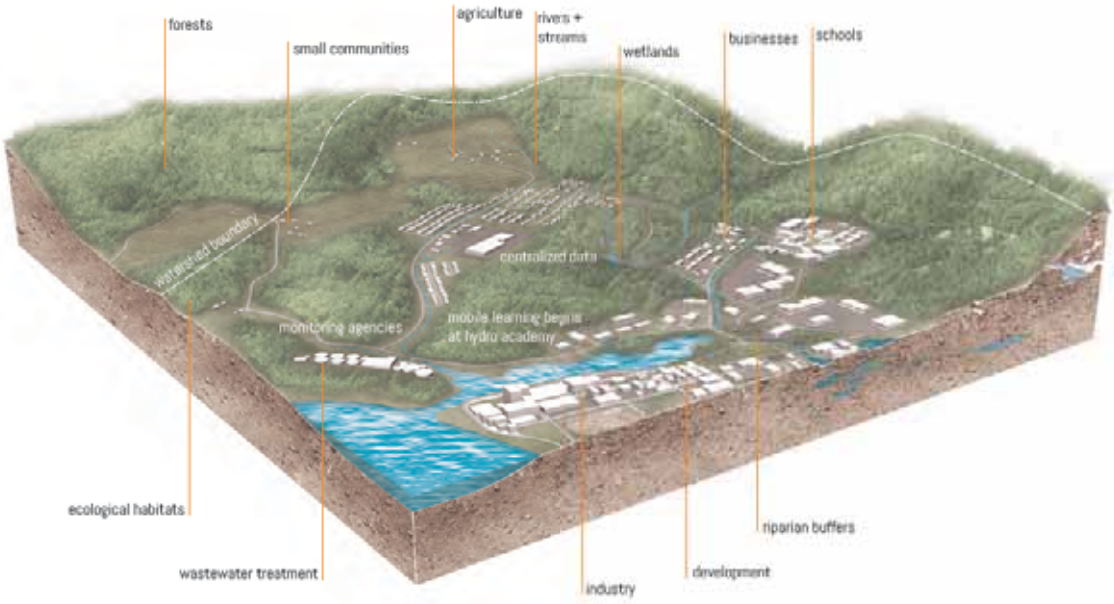
infrastructure, and financial capital necessary to analyze and react to current water resource challenges, to effectively anticipate and understand future threats, and proactively take action to mitigate their potential impacts. Even larger communities with more robust infrastructure and expertise may still lack all of the contemporary resources necessary to address the totality and complexity of the water resource challenges and threats within their physical, financial, and socio-political landscape.

All communities must recognize the value of continuing education, self-critique, and continuous improvement in the evolution of their policies and infrastructures. As the water resource challenges and environmental dynamics that communities face change over time, so too must the policies, approaches and technologies used to address them.

APPROACH

Governments, agencies, and individuals are empowered to make educated decisions about the future of the region, their communities, and their water resources through access to accurate information, a respect for scientific research, and engaging credible experts.

All stakeholders must be empowered to recognize and engage their role in preserving the future integrity of the region's water resources through contemporary educational initiatives, mobile resources, and locally-relevant information. The focus of strategies proposed in this element is to build on past success, to equitably expand the reach of existing resources, and develop new capacity and outreach infrastructures that can become catalysts for ongoing innovation and capacity building. These strategies aim to leverage contemporary technology to collect, synthesize, visualize and share information, and position the SETD region to write new chapters in its legacy of national leadership in water quality improvement.



The territories identified above include those landscapes where the following water quality improvement strategies may be implemented.

WHAT GUIDING PRINCIPLES

1

SCALE: Regional Capacity and Legibility

- To enhance legibility of water quality management and education resources
- To emphasize a regional trans-jurisdictional attitude toward resource capacity

2

RESOLUTION: Hydro-informed Decision Making

- To synthesize existing data into infrastructural and community planning
- To bolster a network of information exchange
- To project a future built on a foundation of multidisciplinary expertise

3

CULTURE: Water Quality Reconceptualization

- To accept water quality and resource health as foundational rights
- To understand connections between water quality and economic development, social health, and quality of life

4

DISCUSSION: Facilitating Cooperative Strategies

- To establish a framework for a database collective
- To elevate responsive educational partnerships between communities and their administration

HOW STRATEGIES FOR CHANGE

MOBILIZE THE CREEK SQUAD

A team of centrally-organized water resource experts that travel to communities in need of water quality consultation and who offer technical support on-demand

a

PILOT MOBILE LEARNING

A diverse fleet of mobile resources deployable across the region capable of providing practical educational experiences to a range of audiences

b

ESTABLISH THE HYDRO ACADEMY

A teaching, research and outreach academy focused on becoming a local, regional, national and global resource on water resource stewardship

c

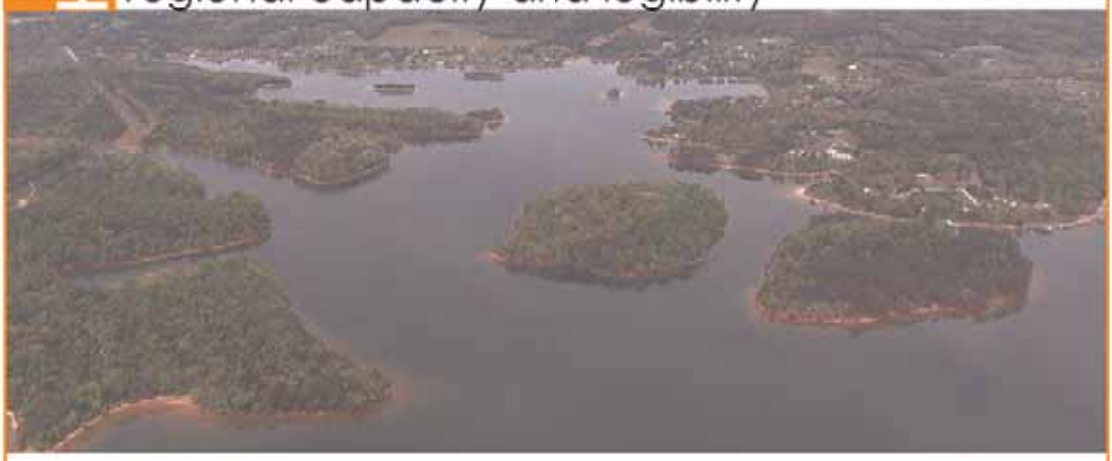
SYNTHESIZE + VISUALIZE DATA

Accessible real-time information systems that coordinate, synthesize, and aggregate otherwise separate hydrologic monitoring data sources

d

WHAT GUIDING PRINCIPLES

1 SCALE: regional capacity and legibility



The region's heavily-populated Phase I and Phase II MS4s (Municipal Separate Storm Sewer System) communities are required to implement regulatory, educational and water quality monitoring programs, enhancing local capacity and infrastructure to steward water quality. Access to similar resources and legible information empowers communities of all sizes to effectively steward local water resources, improving water quality throughout the region.

2 RESOLUTION: hydro-informed decision-making

A watershed's hydrology and water quality affects its capacity to sustain populations and maximize long-range economic growth potential. Planning and land use decisions typically driven by short-term economic opportunity and social need should be informed by their long-term hydrologic impacts and opportunity costs. Communities should be equipped and empowered to put water quality at the forefront of their decision-making processes.

3 CULTURE: water quality reconceptualization

Water resource education and research should extend beyond an environmental focus to more clearly establish water quality's connection to local and regional economies, lifestyle sustainability, and its vulnerability to human impacts and climate dynamics. A coordinated ecosystem of adaptable and engaging educational initiatives enables a more contemporary, widespread and shared conceptualization of the layered values of water quality in the region.

4 DISCUSSION: facilitating cooperative strategies

Transparent dialogue, coordinated data sharing and a spirit of collaboration between national and state agencies, municipalities, non-profits and citizens enables an environment where the capacity, technology, information resources, reach and infrastructure of each can be collectively leveraged to keep water quality information current, easily accessible and accurate, to identify common solutions to shared challenges, and to build a culture of cooperation.

CONNECTING
PRINCIPLES & STRATEGIES

	a MOBILIZE THE CREEK SQUAD	b PILOT MOBILE LEARNING
1 SCALE	Regional technicians can be available on demand to smaller communities that have an equal stake in regional water quality but currently lack the infrastructural or knowledge capacity for effective stewardship.	Portability of high quality educational materials, programming, and facilitators provides equal learning opportunities to urban and rural communities across the region.
2 RESOLUTION	Current, accurate knowledge of water resource conditions throughout the region enables communities and agencies to evaluate initiatives, prioritize resource allocations and make hydro-informed planning policy decisions.	Mobilized programs provide access to information needed to empower citizens to make well-informed decisions on the development that occurs in their communities.
3 CULTURE	Accessible networks of expertise helps to elevate understanding of water resource networks and to establish the understanding of hydrologic health in relation to other aspects of community development.	By spreading education and awareness throughout the region, communities can make decisions based on a more holistic watershed approach.
4 DISCUSSION	A mobile strategy will create a relatable resource that can disperse knowledge synthesized from cooperation between experts in various fields.	Increased awareness facilitates discussion among citizens, agencies, and organizations which leads to the engagement of all stakeholders in choices that affect the watershed.

C ESTABLISH THE HYDRO ACADEMY

This hub of water quality education, research and outreach is home base to the Creek Squad, mobile learning units and other initiatives that offer technical assistance and build capacity within the region's diverse communities.

The Hydro Academy's purpose is to promote water-centric communities and equip them with current information and contemporary understandings essential to decision-making through continuous education and research.

In addition to hydrologists and environmental scientists, experts associated with the hydro academy should include professionals in natural resource economics, business, sociology, and other allied disciplines.

The Academy's infrastructure, network, and notoriety cultivates a community capable of developing relationships, facilitating the exchange of information, and building awareness of opportunities for collaboration and efficiency.

d SYNTHESIZE + VISUALIZE DATA

Mapping and monitoring systems that function on a multi-scalar watershed level provide a regional picture of water resource quality, threats, and relationships that is both comprehensive and current.

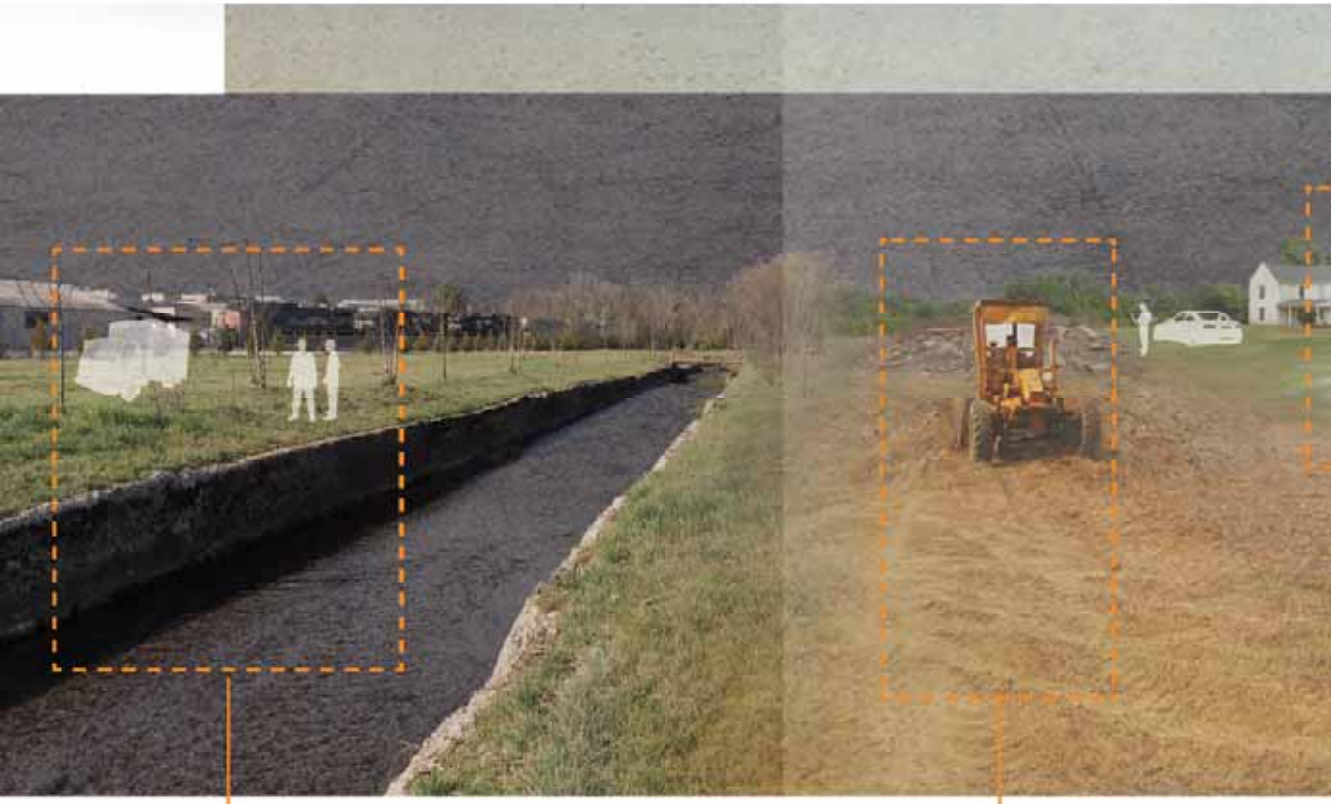
The data gathered through research systems creates the foundation for a legible, customizable, and digital tool that aggregates information by watersheds and prepares a community to make hydro-informed decisions.

A synthetic digital resource can be an essential tool for education initiatives and development of a culture that recognizes relationships between water quality and the built environment, policy, and human behavior within watersheds.

Real-time data relayed from shared monitoring systems will provide all regional stakeholders with the knowledge and impetus to continually pursue water quality stewardship.

HYDROLOGIC BENEFITS

A regional service will have the ability to reach all communities and professional entities that require water improvement and consultation. This centralized team of water specialists works at multiple scales, empowering the region's stakeholders to make more hydro-informed decisions.



STERILE STREAMS

Channelized streams have major ecological consequences on aquatic wildlife and physical water behavior. Consultation can help built monitoring programs, identify vegetation optimization strategies, and novel habitat opportunities for the benefit of nearby water resources that may lead to more robust restoration efforts.

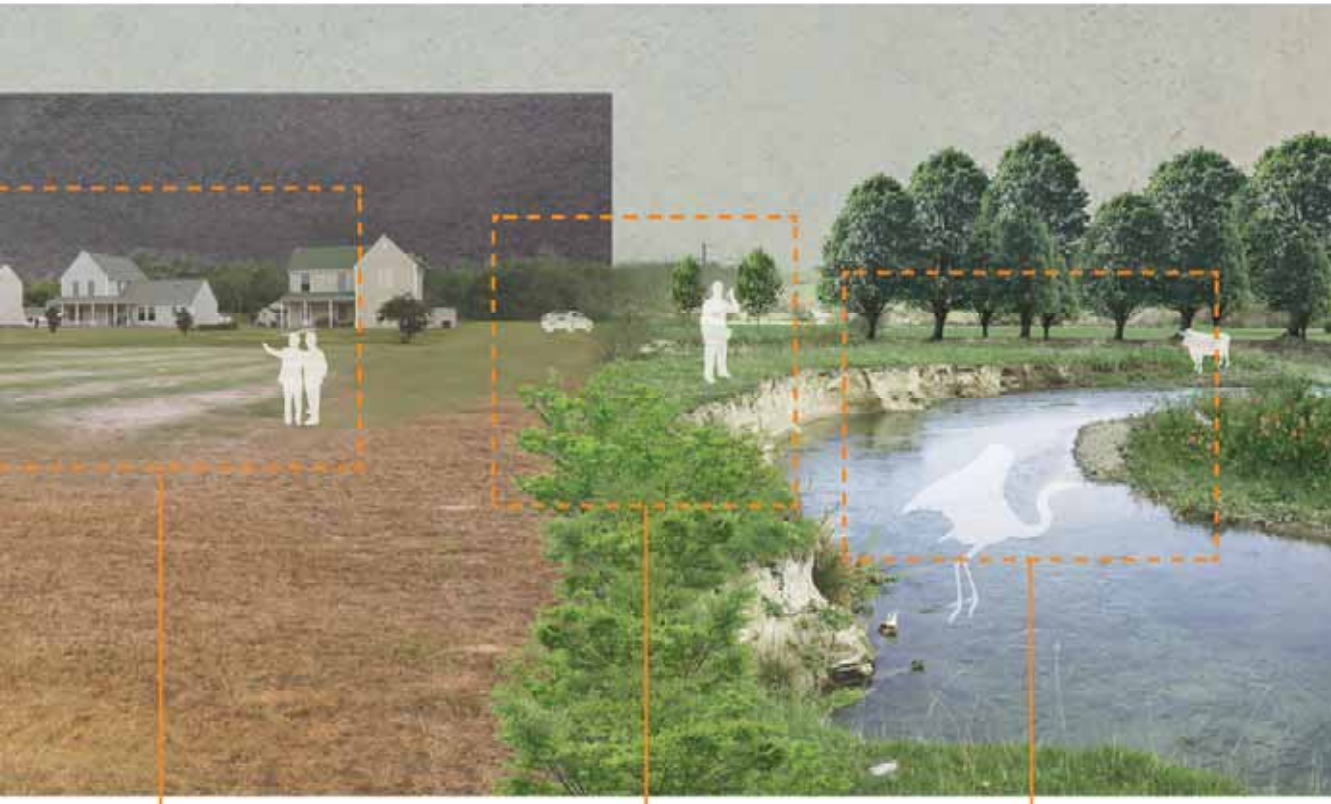
CONSTRUCTION PROJECTS

Land development projects that require major land alterations must comply with regulations to ensure water quality protection from excess sedimentation or rubble contamination. Regular monitoring and an informed consultation can help all parties maintain compliance for shared water resource stewardship.

MOBILIZE THE CREEK SQUAD

a

The Creek Squad envisions a non-profit organization of trained water resource experts that ensures stakeholders around the region have equitable and affordable access to specialized, situation-specific technical assistance. Qualifying communities, business owners, developers, consultant teams, farmers, and homeowners may request assistance from the Creek Squad to help them make informed decisions about protecting their investments and stewarding shared water resources. The squad would be based from a central location and respond to client needs on demand by sending individuals or a team of specialists to assess the situation and offer appropriate recommendations. This mobile resource aims to leave a legacy of enhanced capacity and empowers communities or individuals with limited resources to contribute to broader regional-scale water quality stewardship efforts. Its goal is to become an important human element of the region's water quality monitoring infrastructure, bringing on-the-ground knowledge back to agencies to inform regional initiatives, policy decisions and resource allocations.



SEPTIC FIELDS

Homeowners that depend on septic systems should have access to a water quality technician who can advise on proper system operation and maintenance. A regional squad serving remote headwater communities benefits all downstream waters and ecosystems.

TRANSITIONAL ZONES

Degraded edge conditions have the greatest potential for ecosystem restoration and protection. A mobile resource can inventory urban and rural communities for areas that would benefit from structural, ecological, or aesthetic improvements.

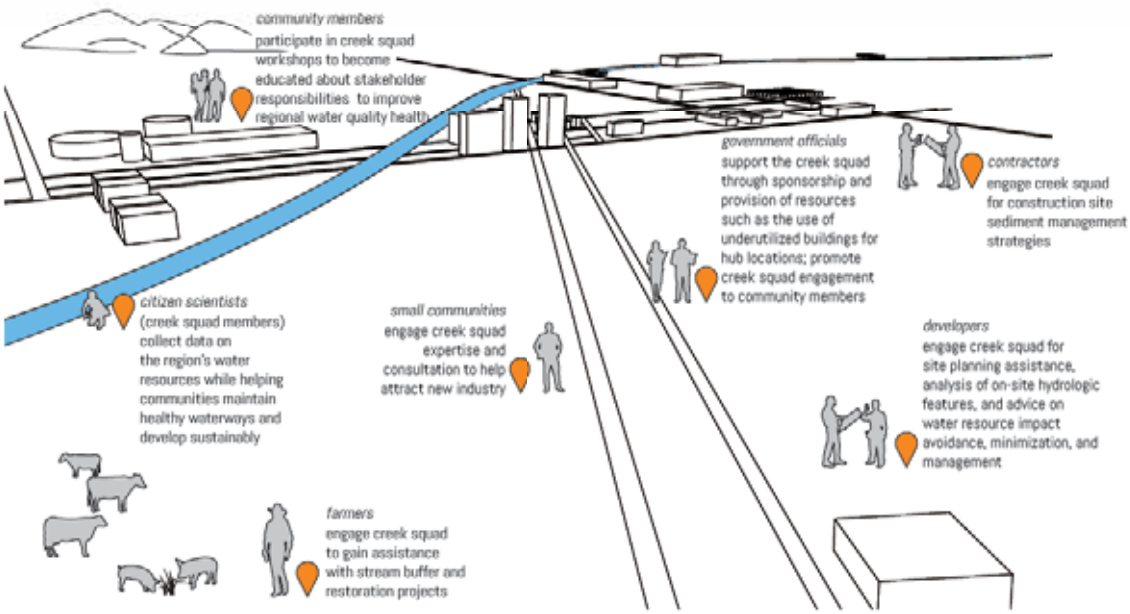
AGRICULTURAL LAND

Farmers have a close relationship with their land, and should have access to a water quality specialist who can supply them with tactical interventions that help balance water resource access need with water quality stewardship.

IMPLEMENTATION TERRITORIES

Septic Systems	As technology advances, the Creek Squad can promote alternatives and modifications to traditional septic systems that enhance system efficiency and reduce incidents of failure.
Development	Creek Squad can help develop innovative compliance strategies and monitoring programs that reduce the impact of development in proximity to critical water ecosystems.
Agriculture	Agricultural practices have had to adjust to changes in environmental policy and regulation; water quality technicians can provide support in maintaining compliance with new laws.
Ecological Habitat	Denuded streambanks, rerouted waterways, inadequate buffer zones are prolific water resource conditions in a range of community contexts that could benefit from on-demand expertise.
Small Communities	Establishing a regional source of hydrologic assistance can help ensure that all communities are included in strategic infrastructure development and understand their benefits.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Non Compete	Consultations should position clients for professional services, not serve in lieu of them.
Funding	Flexible fee structures and creative multi-jurisdictional funding mechanisms are needed.
Synergy	Care will be needed to establish synergy, not redundancy, with existing extension enterprises.
Comprehensiveness	Proper consultation often requires an extensive period of research, analysis and follow up.

TACTICAL SITE INTERVENTIONS


Fig. 1 Survey Demand


Fig. 2 Pro Bono Consultation


Fig. 3 Mobile Application


Fig. 4 Tours and Marketing

The goal of the Creek Squad is to provide assistance to communities of different scales. For smaller townships that may not have the resources to develop their own water quality department, the Creek Squad will serve as consultants to aid in the understanding of effective regulations. In addition to assisting with regulatory compliance, experts will be available to help build knowledge around best management practice implementation, monitoring and maintenance. Surveying demand would help identify which communities are the most in need or interested in the service. The assistance would be available on flexible fee structures and may run on a funding model similar to existing community design centers. Implementing this concept without technicians can be done by offering a self-directing website or mobile app to assist people in troubleshooting their issues or concerns. Factory and farm walks (Figure 4) can also be offered to communities as a low-pressure way of learning more about what can be done (at individual sites) to protect water quality.

PRECEDENTS

HelloTech
Multiple Locations

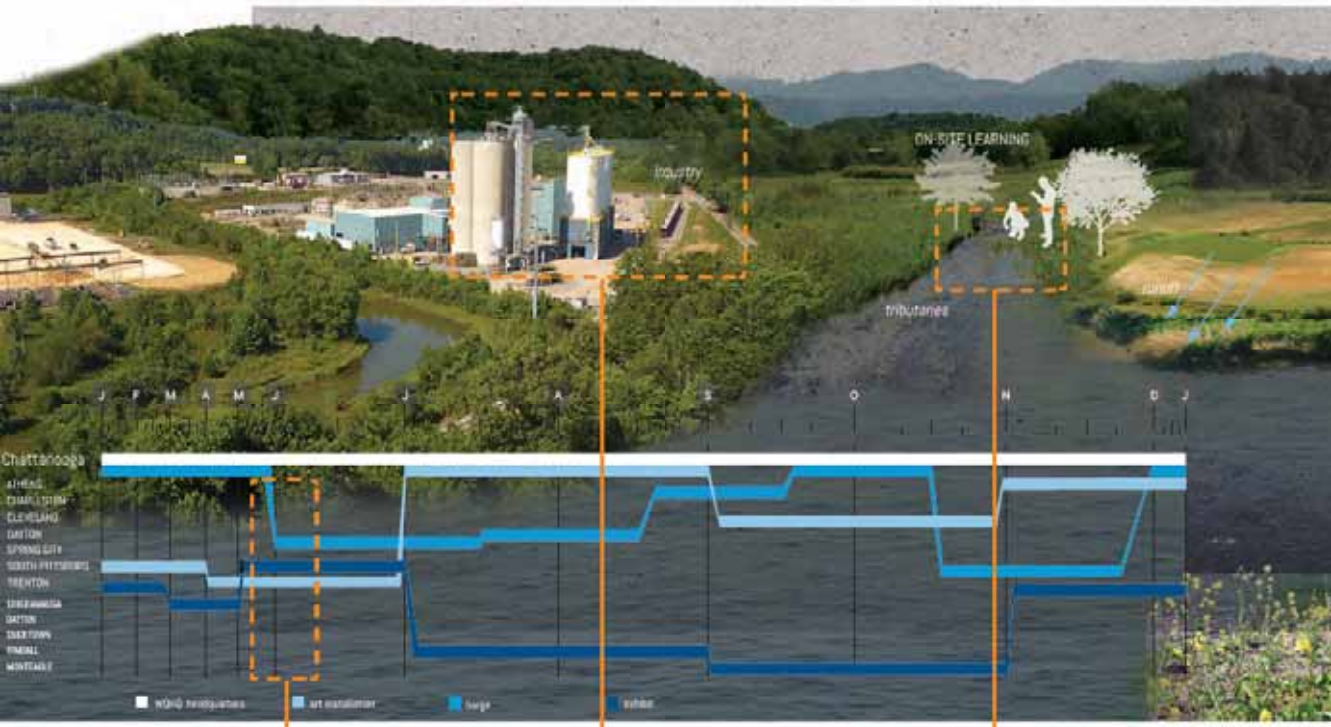
HelloTech has been referred to as the "Uber" of tech support. Their service model makes it simple to share knowledge and expertise. Technicians offer non-proprietary, at-home support to customers in need of various tech support services. This makes them a valuable resource for people that may not have had access to a nearby tech support location.

SETD
Southeast Tennessee

The Southeast Tennessee District was established as a government entity comprised of municipal and county governments. SETD is a shared resource for the region that provides services to communities of varying capacities within its service area. The agency aids in the planning and development of areas that do not have the governmental infrastructure of larger townships.

HYDROLOGIC BENEFITS

Reaching people of all ages and occupations in the community creates a culture focused on improving water quality and protecting water resources for a healthier region. By engaging businesses and local organizations, expertise extends beyond the means of existing agencies for a greater network of partners working toward healthy watersheds.



DISPERSAL

Scheduling stops and programming can help to distribute this education equally throughout the region.

INDUSTRY

Industries across the region can share the innovative ways in which they use and treat water in their processes and how proximity to water is considered in site development.

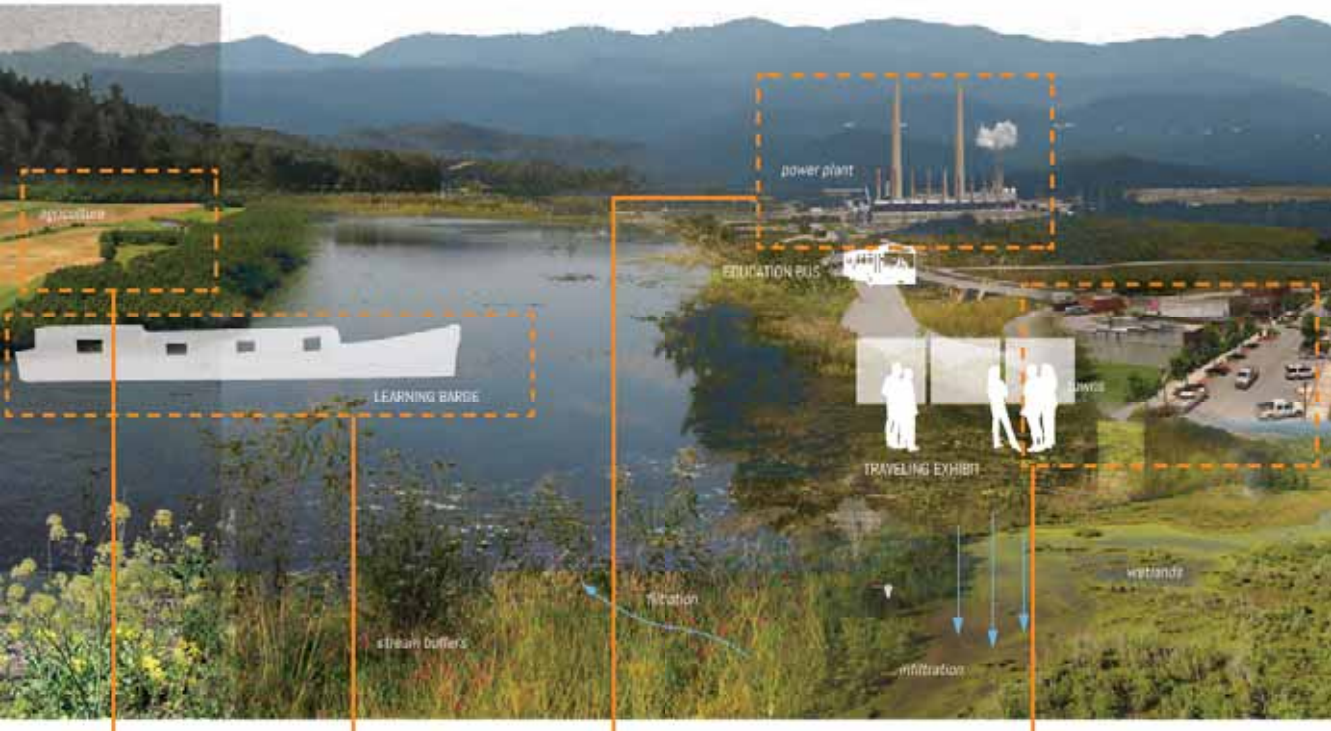
ECOSYSTEMS

Natural environments such as tributaries, wetlands, and forests provide a learning landscape for comprehensive understanding of how wildlife, plants, people, and economies rely on healthy freshwater resources.

PILOT MOBILE LEARNING

b

Mobile learning suggests to bring hands-on education to all communities in the region. Deploying a coordinated and diverse fleet of engaged learning tools may enable its organizers to travel and educate audiences about hydrologic science, water resource value, water quality threats and improvement strategies in a tangible way. Delivery methods may include a river-based learning barge, portable workshops and curriculum modules, traveling libraries, labs, exhibitions and displays, and other site-specific, landscape-based learning opportunities. Stops for any of these educational experiences aim to include healthy and threatened natural and developed landscapes, such as a creek's confluence with a river, a healthy riparian buffer, algae-covered wetlands, urbanized streams, wastewater treatment facilities, and other industries that rely on healthy surface or groundwater resources. The purpose of this system is not only to educate traditional students by supplementing in-classroom curricula, but also inform the businesses, industries, agencies, non-profits and other community organizations. The combined reach within the community at large can provide a measurable impact on the health of the region's water resources.



AGRICULTURE

As one of the largest industries in the region, farms can provide good insight to existing water quality management strategies and become laboratories to develop future innovations.

LEARNING VEHICLES

In addition to providing access to learning landscapes, barges, buses, rail cars and other transportable modules can themselves be designed as mobile laboratories, classrooms and exhibits for water quality education.

POWER PLANTS

The consumption and processing of water in the process of power production, as well as industrial processes and innovative waste management strategies can provide one learning opportunity as a stop for the learning barge.

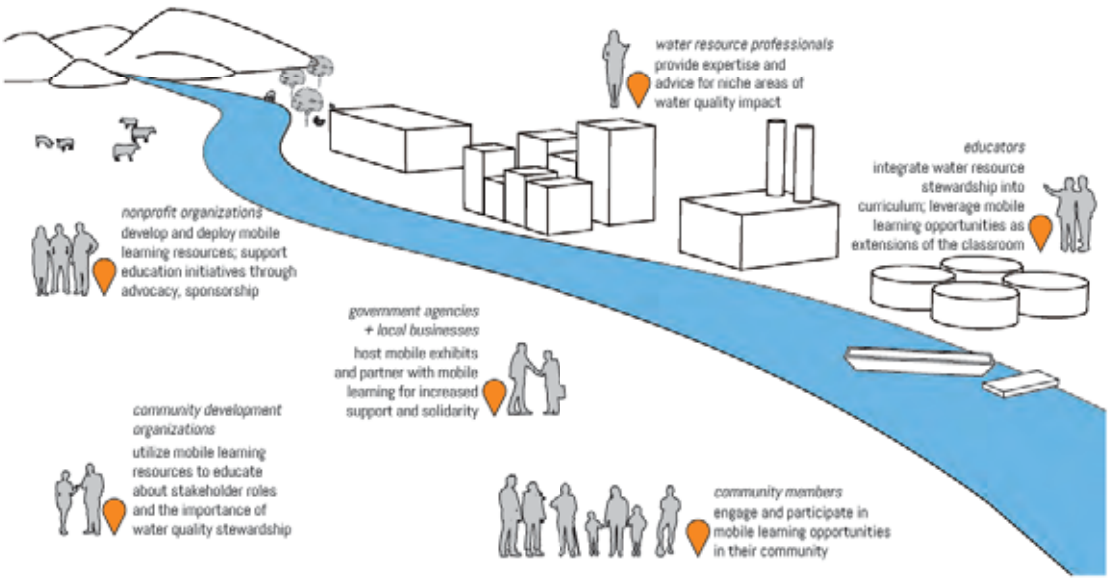
EXHIBITS

Downtowns, schools, museums, and other public places are locations for mobile water quality exhibits and programming.

IMPLEMENTATION TERRITORIES

Public Space	Mobile exhibits and informative events can invigorate plazas, museums, and government buildings to bring awareness to water resources in the region.
Industry + Agriculture	Local and regional industries and farms are valuable partners in educating the public about safe and sustainable water resource practices.
Regional Natural Habitats	Community members can visit natural ecosystems to better understand the function of healthy versus impaired systems that are part of the water cycle.
Rivers	Contact with the region's iconic rivers is one of the most valuable ways to understand its dynamics first-hand.
Schools	Mobile curriculum can bolster standard curriculum in schools throughout the region to aid teachers in water resource education.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Funding	Shared infrastructures required shared investment from multiple communities.
Participation	Even well-designed, well-funded exhibits and mobile classrooms require participant effort.
Methods	Educational traditions must be challenged to meet contemporary learning preferences.
Commitment	Successful educational initiatives require sustained commitments of resources and support.

TACTICAL SITE INTERVENTIONS


Fig. 1 Water Walks


Fig. 2 Mobile Exhibits


Fig. 3 Installations

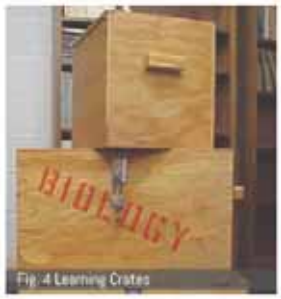


Fig. 4 Learning Crates

Mobile learning can take shape in many different ways. One of the main focuses of mobilized learning is to make education available and accessible to communities all throughout the region. Tactics include low-investment ways for any community to get involved in water quality education. Water walks (Figure 1)can be given as self-guided tours of urban and rural water conditions aided by mobile applications.[119] Participants can learn more about local waterways and begin to understand the relationship between the community and the water system. Traveling exhibits (Figure 2) are educational tools that can be taken from location to location. Temporary installations (Figure 3) call attention to particular areas and can also be taken to various places in and out of the region. Mobile learning can also be mailed to locations. Learning crates (Figure 4) with turn-key lessons and experiments can be sent out to regional schools and organizations.[120]

PRECEDENTS

The Learning Barge Project
Chesapeake, VA
2009

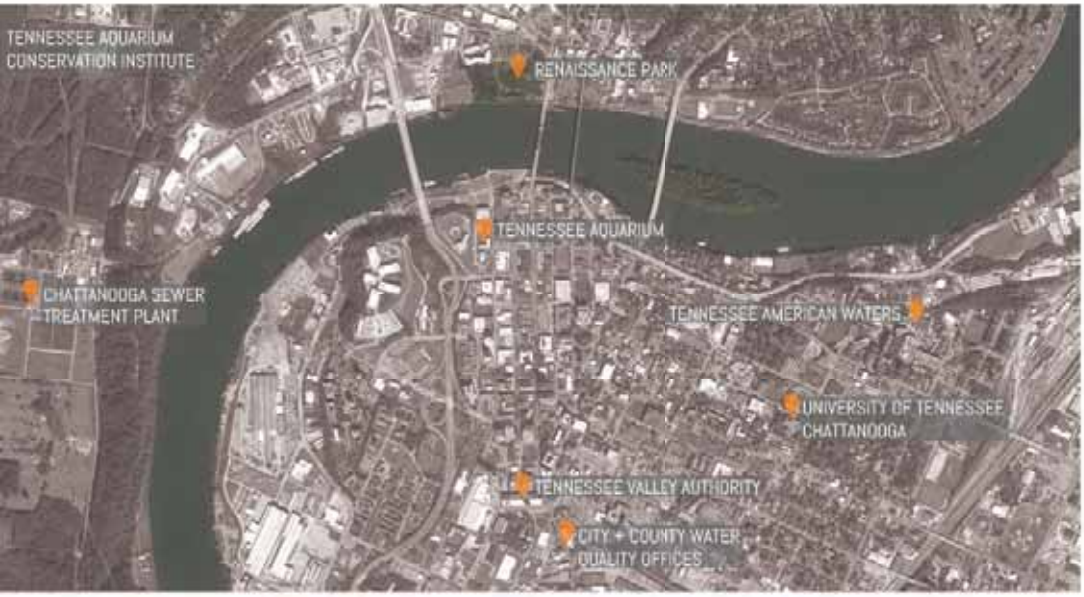
The learning barge was designed by UVA and travels on the Elizabeth River, working to inform guests about the significance of their water systems. Not only is the barge a mobile piece of infrastructure, but it allows guests to engage with the source of water that it is on. This is an unique way of bringing the classroom and subject matter to its audience and to locations in need of stewardship attention.

Water: H2O=Life Exhibit
Multiple Locations
2004

This traveling exhibition serves as a learning tool for all visitors. The installation has been on display at various museums all over the globe. The exhibit's components tell a compelling and engaging story of the importance of water and how it affects every life form on Earth.

HYDROLOGIC BENEFITS

A water quality education system coordinated within a single command center, the Hydro Academy, ensures continuity of information and protocol with water quality strategies. With one agency to pioneer water quality efforts in the region, interventions can be implemented accurately.



LABORATORY

A school founded on water quality provides a unique learning opportunity for children in the region.

MEETING SPACE

This flexible space is used for public programming and meetings of water quality interest groups.

EXHIBIT HALL

On-going exhibits continually educate visitors on the basics of water quality as well as up-to-date research findings from the academy.

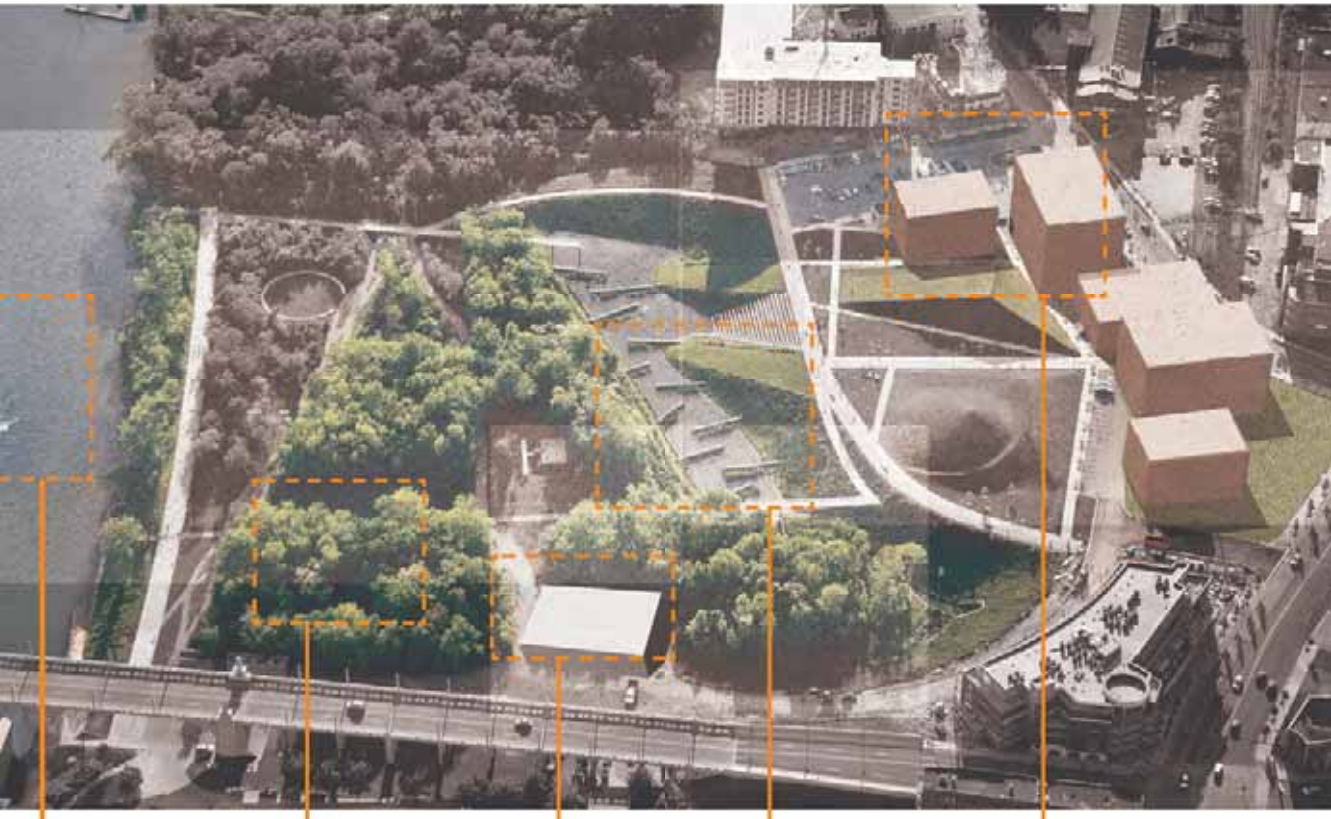
OFFICE SPACE

Permanent and temporary positions at the academy provide professionals from diverse sectors the opportunity to collaborate.

ESTABLISH THE HYDRO ACADEMY

C

The Hydro Academy is a conceptual proposal of a local, national and international center for water quality with a mission to conduct innovative research, increase awareness and capacity through educational initiatives, and catalyze water quality improvement through community engagement. This centrally located hub, shown below on vacant parcels next to Chattanooga's Renaissance Park, would leverage proximity to existing water resource knowledge centers and build on the region's legacy of redefining relationships between communities and water resources. Home to a community of scholars of environmental sciences, economics, planning, design, engineering, and social sciences, the Academy would work across economic, social and environmental agendas while positioning Chattanooga to be to water resources what Oak Ridge is to energy. Its laboratories, meeting spaces, non-profit and business incubator, classrooms, Hydro-STEM school, monitoring capabilities, exhibition spaces, interactive displays, and learning landscapes could create a dynamic campus where multi-disciplinary collaboration, learning and innovation is possible. It would also serve as home to the Creek Squad, a Learning Barge, and other mobile learning initiatives, extending its influence on water quality throughout the region and beyond.



LEARNING BARGE

The hydro academy serves as a home-base for the learning barge, and easy river access makes this is a valuable amenity for the academy.

FLOODPLAIN FOREST

Healthy riparian plant communities and corridors protect water quality and structural integrity of water resources. A demonstration landscape on-site provides a classroom and laboratory for adaptive management practices.

SCHOOL

A STEM academy with a water resource focus provides a unique learning opportunity for students in the region and cultivates a community of professionals.

CONSTRUCTED WETLAND

Wetlands are valuable resources for water absorption and filtration and for carbon absorption from the atmosphere. A wetland on-site provides an opportunity for experiential learning.

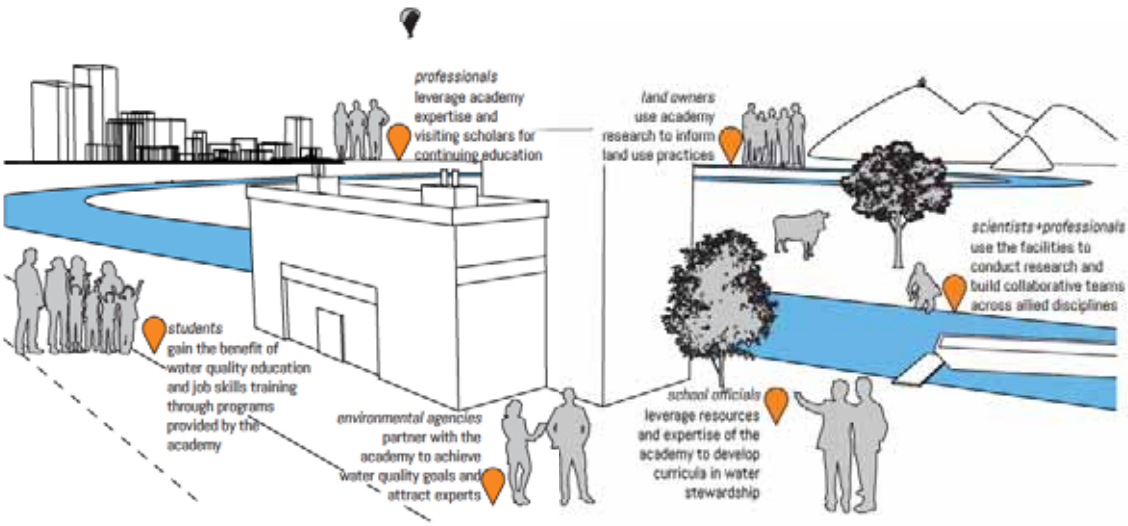
HYDRO ACADEMY

With access to constructed wetlands, the Tennessee River, and other learning landscapes, the Hydro Academy will house labs, classrooms, exhibit halls, and offices to support quality water research and education in the region. Mobile learning and the creek squad will also be housed here.

IMPLEMENTATION TERRITORIES

Learning Landscape	On-site ecosystems that contribute to water quality can provide hands-on laboratory experience for students at the Hydro Academy and for public demonstrations.
Waterways	Adjacency to a major river makes the learning barge accessible and opens up communication with communities along the river.
Riparian Zones	Floodplains and their riparian habitats are critical landscape typologies that contribute to the understanding of the greater river system.
Professional Partnerships	Local and regional partners can provide expertise for a more well-rounded public water quality education.
Centralized Location	The Hydro Academy should be located within a central metropolitan area for the benefits of urban resource networks and transportation access.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Community Trust	A mission of education, job training and value-added outreach must be established and promoted.
Investment	Partnerships will be critical to attracting up-front investment.
Redundancy	Mission and value must be distinct and complimentary to existing centers and resources.
Access	Research and other proprietary activities require consideration of public access limitations.

TACTICAL SITE INTERVENTIONS


Fig. 1 Inventory of Expertise


Fig. 2 Conceptualization


Fig. 3 Location


Fig. 4 Temporary Build

Establishing a water quality center can be achieved by recognizing the concentration of relevant knowledge and infrastructure that already exists in the City of Chattanooga (Figure 1). Conceptualization of the academy's program and design could be explored as an academic exercise by regional design programs, the outcomes of which (Figure 2) can help rally support for the project. Vacant lots at Renaissance Park (Figure 3) are a potential site location that boasts immediate river and stream access, a range of green infrastructure demonstrations and learning landscapes (including a constructed wetland, green roofs and rain gardens), and is itself a demonstration of groundwater stewardship through brownfield reclamation, and green infrastructure as a catalyst for adjacent infill development. Access to existing infrastructure, knowledge networks, and proximity to learning landscapes should be considered when identifying alternate locations. The Academy's branches, remote collaborators and mobile infrastructures expand its reach regionally. Temporary infrastructure (Figure 4) can be utilized as an interim meeting and learning space. This also helps the hosting community visualize a permanent structure.

PRECEDENTS

Oak Ridge National Lab
Oak Ridge, TN
1943

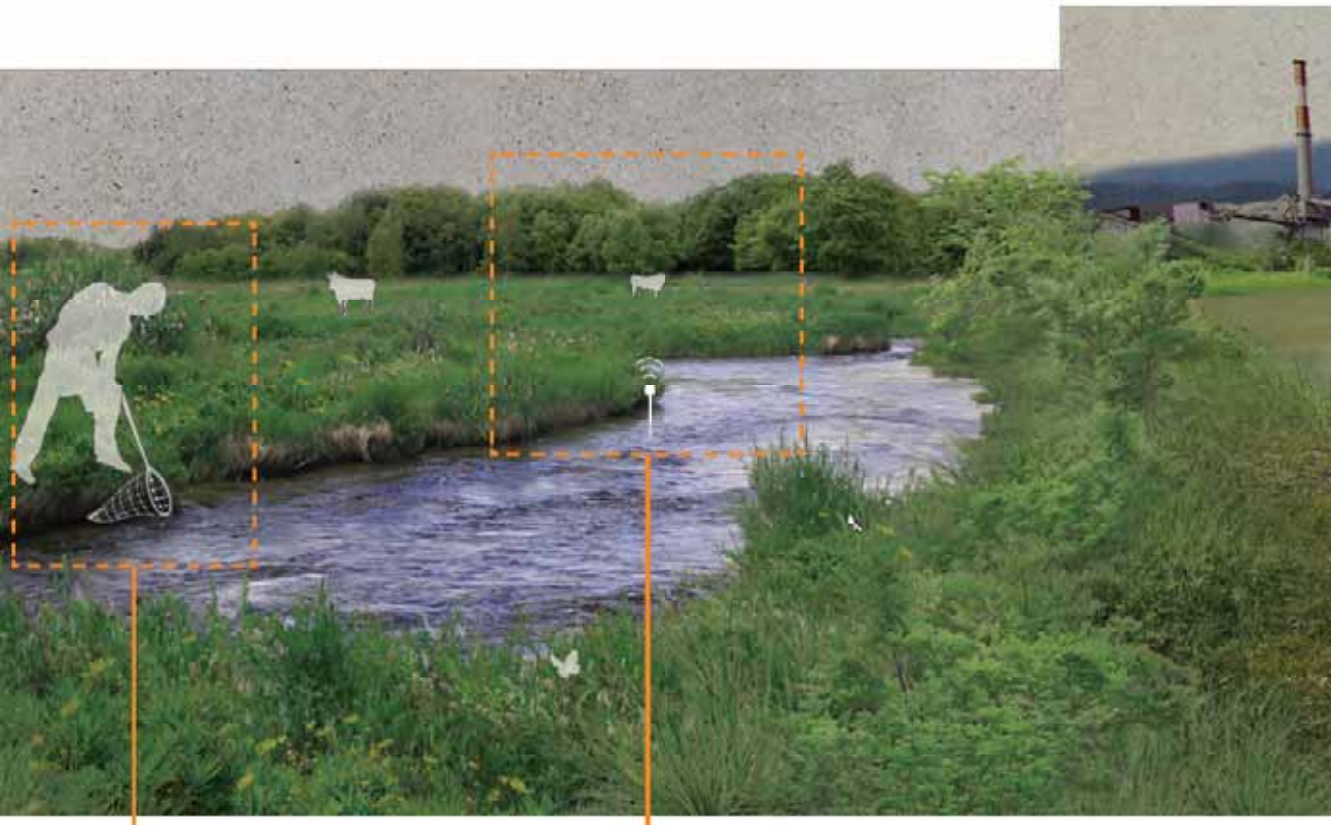
This is the largest energy and science laboratory in the United States' Department of Energy. The laboratory has become a global resource for various scientific findings and has become an authority on energy research. Its community of scholars both leverages and complements other regional partners, including the University of Tennessee, Knoxville.

Salk Institute
La Jolla, CA
1957

The Salk Institute of biological studies is an independently run research facility. The center was a concept dreamed up by the creator of the first safe polio vaccine, Jonas Salk. His hope was to create a collaborative space for research explorations of the basic principles of life. This independent lab has become world renowned for its research in biomedicine, neuroscience, and behavioral science.

HYDROLOGIC BENEFITS

A multi-user watershed analysis tool not only informs and educates the public, but also provides decision making analysis for planning agencies, policy makers and environmental advocates. As many entities, metrics and discrete information systems are used to monitor water quality data, this tool creates a central database that organizes and displays real-time information by watershed boundaries.



BIO-MONITORING

Regular assessments of aquatic bio-indicators will provide a quick assessment of stream vitality. These crowd-sourced evaluations will offer a broader perspective of upstream conditions and regional watershed health.

REAL-TIME DATA

Monitoring systems installed around the region can relay information that will be analyzed in a centralized location. These technological networks will require minimal maintenance and environmental disturbance.

SYNTHESIZE + VISUALIZE DATA

Though information accessibility has increased in recent years, challenges posed by data decentralization and coordination persist. Many valuable data sets that provide information about landscape characteristics, permitted water quality impacts, and real-time water resource conditions are administrated by states, local municipalities or non-profits, posing difficulties to users who seek a complete picture of watershed health and threats. Hydro Perception is a proposed interactive database and visual dashboard that focuses on information coordination, legibility, and synthesis. Centralized sharing of real-time information already available from separate agencies such as USGS, EPA, TVA, and TDEC and locations of permitted water resource impacts would be combined with municipal GIS databases, input from citizen scientists, and other deployable monitoring infrastructures, creating a powerful watershed assessment tool. The design of the dashboard's interface would place a priority on information legibility and user education. Its ability to aggregate and analyze watershed health information from diverse sources at a range of scales aims to empower agency, municipal, and citizen users to consider watershed conditions and threats when making planning, policy, resource allocation, and lifestyle decisions.

INDUSTRIAL WATER

Testing industrial waste waters will ensure that infrastructural standards are maintained and effluent waste does not exceed hazard limits. These monitoring systems and active reports on industry performance will keep nearby communities informed and safe from possible containments.

DATA STREAMS

Existing monitoring and water resource data streams from agencies such as USGS, TVA, and state environmental agencies are aggregated in watershed boundaries and synthesized for comprehensive, real-time assessments of watershed health.

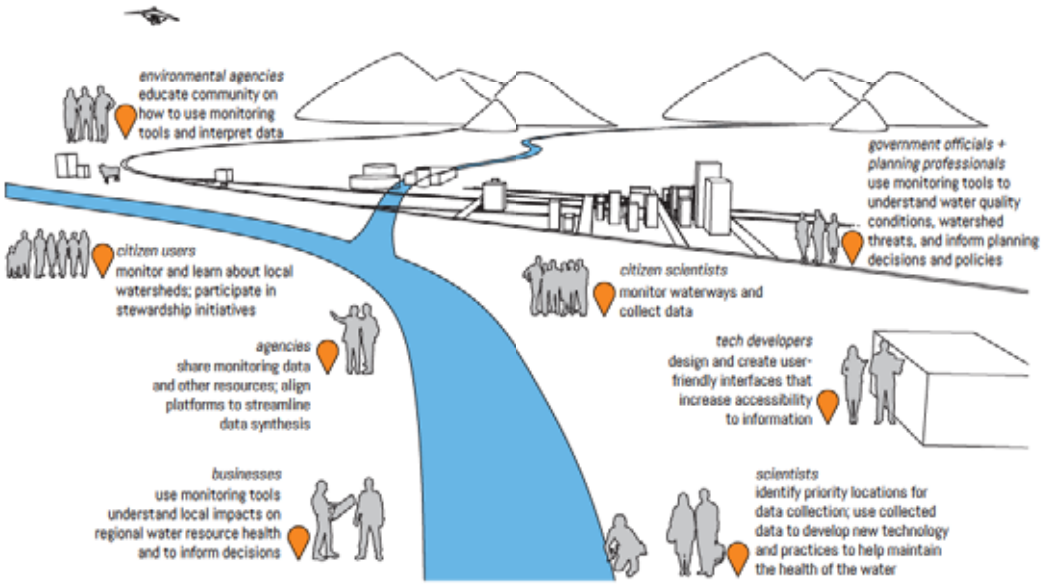
DIGITAL INFORMATION

Administrators, technicians and citizen stewards alike can contribute information and observations to a digital interface that will translate raw data into a legible instrument of hydro-literacy. Hydro Perception will be an interactive tool to understand watershed systems and the infrastructural networks within them.

IMPLEMENTATION TERRITORIES

Stormwater Runoff	New technology allows for the ability to record and calculate stormwater runoff data from varying sources such as agricultural lands, MS4 outfalls, and impervious surfaces.
Development	Distributed monitoring systems can provide supporting evidence for more sustainable development practices and infrastructure approaches.
Hydrologic Features	Data collection from vulnerable locations within water systems can indicate when there are changes in the entire system.
Wastewater	Information gathered from data can prevent future wastewater infrastructure failures and overflows.
Industrial Sites	Industries have an opportunity to minimize the impacts to water resources by using information from new data collection technologies.

STAKEHOLDERS



ANTICIPATED CHALLENGES

Language	Agencies and other monitoring sources may use different data coding languages.
Methods	Differing methods of data collection and analysis by contributors may create synthesis challenges.
Accuracy	Citizen + crowd-source contributors must be educated to provide accurate data.
Processing	Synthesizing and analyzing large data sets in real-time requires significant processing power.

TACTICAL SITE INTERVENTIONS

Fig. 1 Assess Agencies + Data


Fig. 2 Map Areas

Fig. 3 Distribute Kits

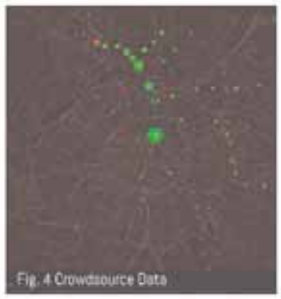


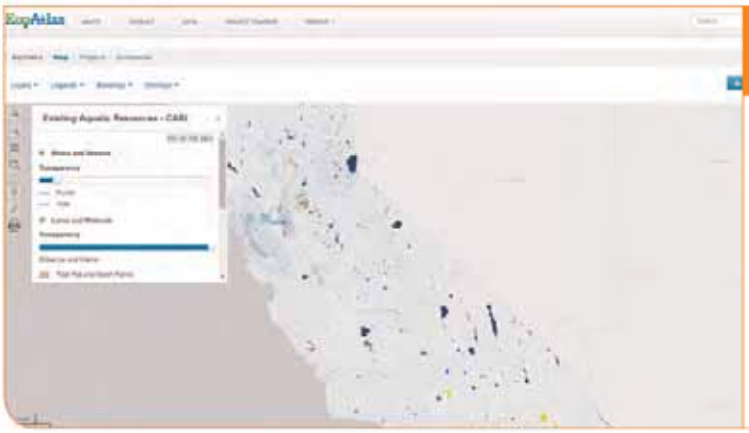
Fig. 4 Crowdsource Data

Multiple agencies and organizations (Figure 1) are in charge of the water quality issues within the region. It is important to assess what agencies have data that can be supplied to the regional index. Inter-agency efforts for mapping (Figure 2) and data collection could help streamline the information and make it more easily accessible. Monitoring is also an integral part of data collection and maintaining healthy waterways. Water monitoring kits (Figure 3) allow interested citizens to take part in collecting samples and data to expand the geographic reach and comprehensiveness of regional water quality inventories and assessment (Figure 4), providing a more complete picture of water resource health and need for improvement initiatives.

PRECEDENTS

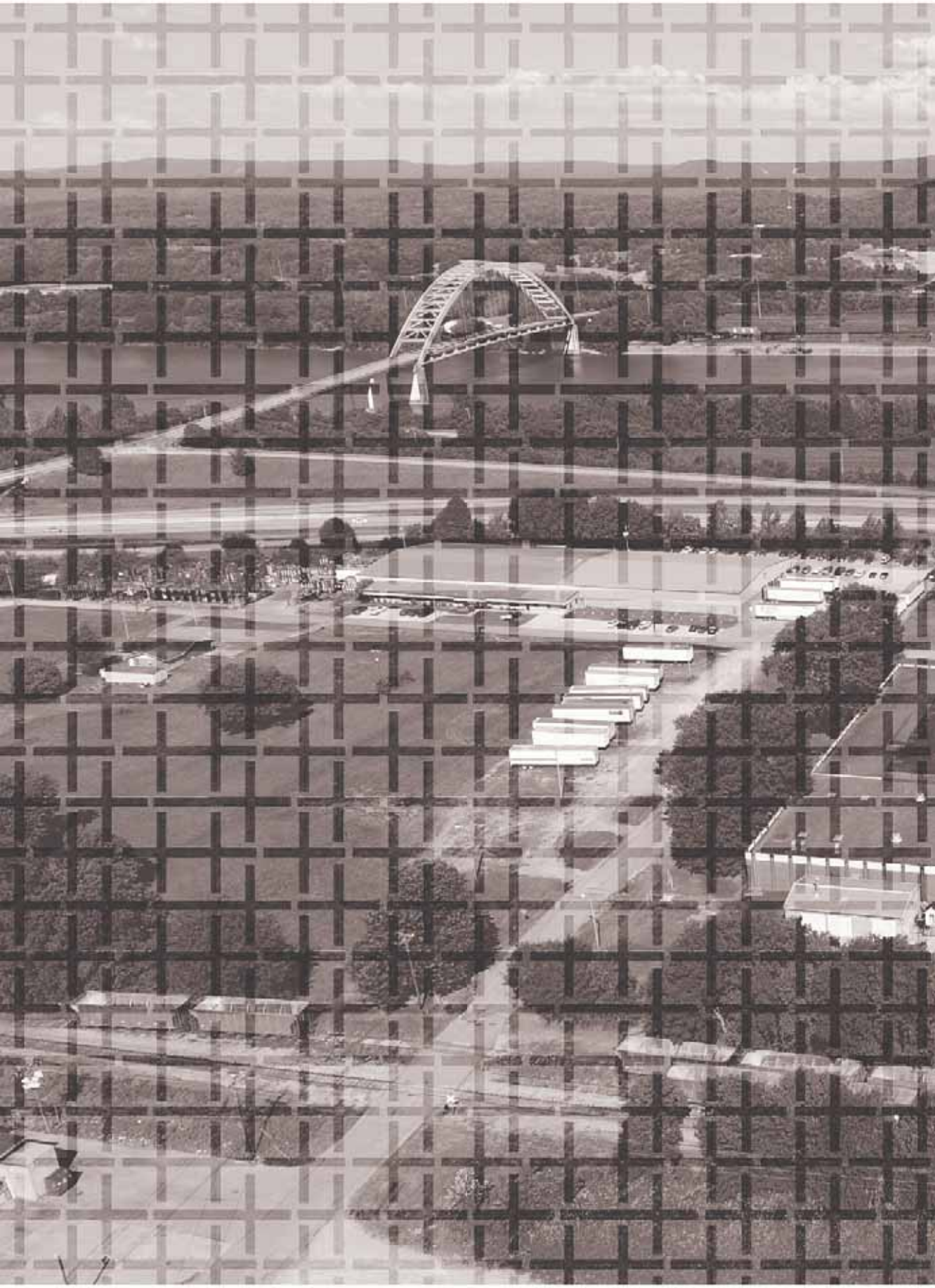
Living Light Structure
Seoul, Korea
2009

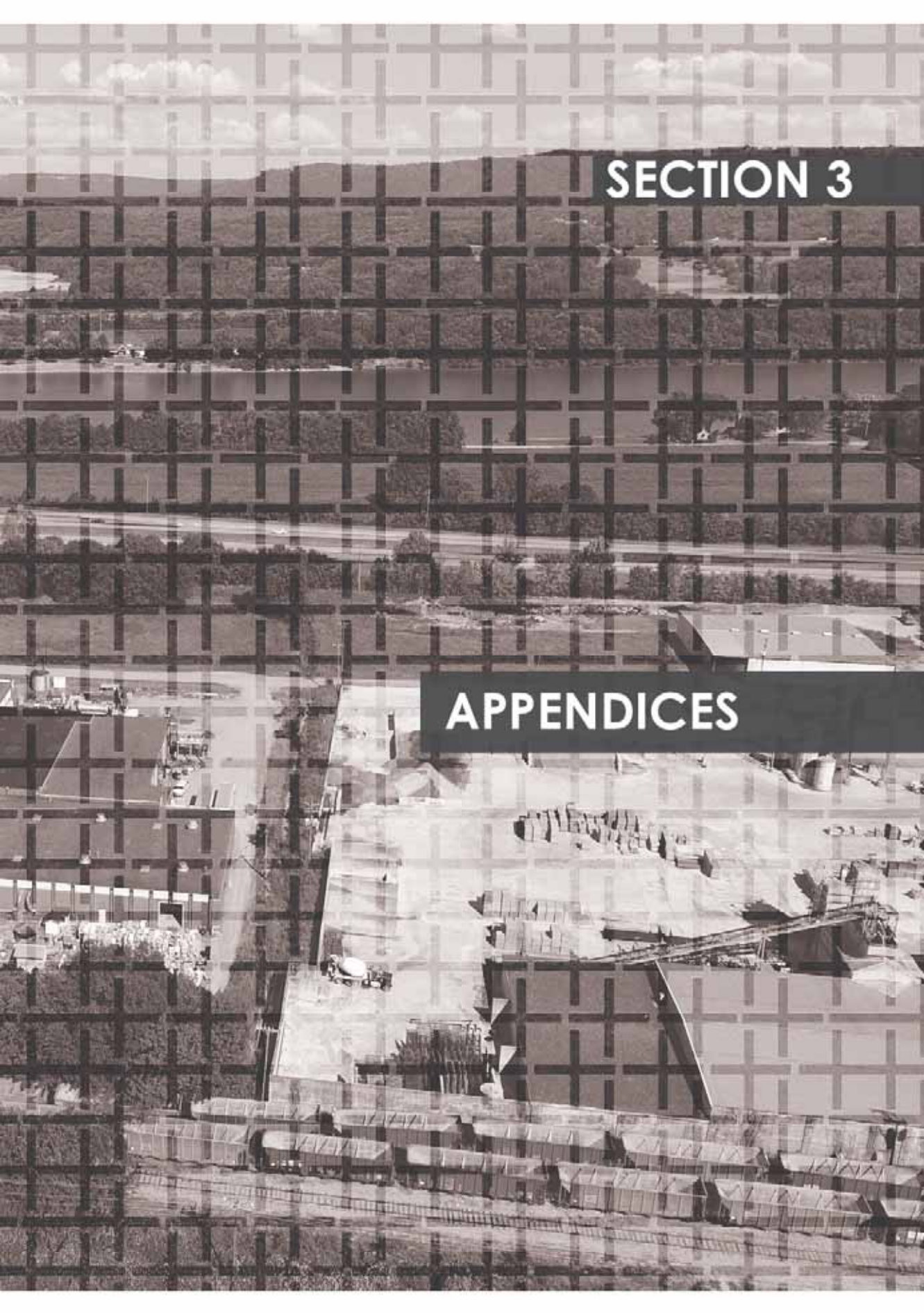
This structure is part of a larger system of real-time air quality display around the city of Seoul. There are 27 blocks that represent the different air monitoring station areas. The map lights up at regular intervals to display the best to worst air quality performers, and also lights up individual blocks when improvements are being recorded. The structure also has an interactive component and responds to information requests by the public.



EcoAtlas.org
California
2010

California's EcoAtlas provides an interactive map that grants free public access to information about California's hydrologic resources. The map features include spatial data, general condition information, and detailed data on specific waterway conditions. This site enables the integration of information in the consideration of the state's hydrology.





SECTION 3

APPENDICES

IMPAIRMENTS[111]

The following are identified by the EPA as impairments to the study area's water resources and are included in the Regional Surface Water Impairments chart in the Introduction of this book (see pg 22). Impairments are listed according to their prevalence in the region as reflected in the chart, beginning with the most widespread impairments at the time this research was conducted.

E. coli

E. coli is a bacterial pathogen that is often spread through feces. It is introduced to surface water resources via sewer overflows and improper disposal of waste, including animal and human waste. It serves as an indicator for other types of bacteria.

Sediment/Silt

Sediment from construction sites, agricultural land and other disturbed landscapes enters waterways via runoff. Sediment is also mobilized by stream bank erosion. This pollutant can restrict proper light infiltration and harm microorganisms that are indicators of healthy streams. Accumulated sediment degrades aquatic habitats. Other pollutants are mobilized in waterways by binding to soil particles.

Altered Vegetative Cover

Removing vegetation from riparian areas during construction or for agricultural use destabilizes stream and river banks, increasing erosion and sedimentation. The result is low oxygen levels and higher water temperatures, impairing the habitat of aquatic life and reducing the water-absorbing capacity of the floodplain.

Dissolved Oxygen

Common causes of low dissolved oxygen (DO) include increases in water temperature, the impoundment of water in reservoirs, and algae blooms triggered by the nutrification of the water by phosphorus and nitrogen. Low DO levels inhibit the health of aquatic life, including fish.

Phosphorus

Phosphorus in water resources often originates from runoff of improperly-applied fertilizer, leaking septic tanks or sewage, or erosion of natural sources. Drinking water contaminated with unsafe levels of phosphorus is especially harmful to infants, causing breathing problems, blue-baby syndrome, or death.

Nitrate/Nitrite

These forms of nitrogen result from runoff of improperly-applied fertilizer, leaking septic tanks or sewage, or the erosion of natural sources. Drinking water contaminated with unsafe levels of nitrate/nitrite is especially harmful to infants, causing breathing problems, blue-baby syndrome, or death.

Physical Substrate Habitat Alterations

Stream flow alteration, artificial banks, wetland infill, and disruption of streambeds can increase sedimentation and water temperature as well as reducing nutrients, dissolved oxygen, and shelter for aquatic life. Changing these habitats can also negatively impact the storage capacity of natural floodplains, potentially increasing incidents of flooding up and down stream, and reduce the quality of recreational spaces.

Low Flow Alterations

Water withdrawals or stream diversion for irrigation, consumption, or industrial use can reduce the amount of water in a waterway, impacting aquatic habitats and their productivity.

pH

Fluctuations in pH can be caused by excess fertilizer and improper disposal of household waste. Increased acidity can lead to chemical reactions that release other toxins into the water. These imbalances interfere with the normal biological functions of aquatic life.

Iron

Iron is a naturally occurring element, making up 5% of the Earth's crust. Precipitation dissolves iron in the landscape and introduces it to waterways, causing adverse taste and color. Private well water may be susceptible to these impacts, though it is not a health concern if consumed at normal trace amounts. Toxic levels of iron can enter water ways through drainage from abandoned mines. Elevated levels of iron in water can be caused by rusting steel. Abnormal iron levels can cause algae blooms, unsafe bioaccumulation in fish, and fish kills.

Manganese

Similar to iron, manganese is naturally occurring and causes changes in odor and color, and though unpleasant, it is not unsafe to drink at normal trace amounts. Well-water users may encounter manganese more frequently. Unsafe levels of manganese in water have been correlated with proximity to ferroalloy production facilities and areas of high vehicular traffic density. Consumption of water with unsafe manganese levels can cause damage to the central nervous system over time.

Eutrophication Indicators

Excess nutrients (nitrogen and phosphorus) can lead to eutrophication, which is a hyper-supply of organic biomass. Increased algae or plant growth and low dissolved oxygen levels are indicators of such conditions. Inattention can lead to toxic water conditions harmful to humans and lethal to fish.

Temperature

Removal of streamside vegetation, heated runoff, industrial discharge, low flow alterations, and dams or other impoundments can raise the average water temperature, facilitating a rise in bacterial and algal populations toxic to humans, wildlife, and aquatic life. Higher temperatures reduce dissolved oxygen and impact fishing and boating economies.

Zinc

Zinc is naturally occurring but also results from improper disposal of metal appliances, industry, mining, and runoff. Prolonged exposure can cause organ damage in humans and impact the lifespan, reproduction, and behavior of aquatic life. Removal of zinc can be costly and thus limit industrial, recreational, and household use.

Aluminum	Aluminum is naturally occurring in the Earth's crust and is used in many man-made products including automobiles, cookware, and deodorant. It is also used in the process of purifying drinking water. Its presence can cause some discoloration of water and is not harmful in trace amounts. Bioaccumulation can be a concern in fish, especially when consumed.
Sulfates	Sulfates are salts that originate from mining, road de-icing, wastewater, and irrigation. Salts are necessary for life in moderation but excess is harmful to human and aquatic life. Removal is difficult, so avoidance is critical.
Copper	Copper is naturally occurring but also enters the environment from mining, corroded plumbing, metal and electrical manufacturing, agricultural and domestic pesticides and fungicides, and brake pads. In the short-term, copper can cause gastrointestinal distress, but prolonged exposed can lead to liver or kidney damage in humans. As with other metals, excess amounts impact the lifespan, reproduction, and behavior of aquatic life. Removal of these metals can be costly and thus limit industrial, recreational, and household use.
Polychlorinated Biphenyls (PCBs)	These organic contaminants originate from electrical transformers, landfills and waste incinerators, and chemical waste. Contact may cause problems with the skin, thymus gland, and immune, reproductive, or nervous systems. They also increase the risk of cancer.
Mercury	Mercury is an inorganic metal that is often released into the atmosphere through the combustion of fossil fuels or enters surface waters through landfill and agricultural runoff. Natural geologic deposits may degrade and erode over time. This element can cause kidney damage.
Polycyclic Aromatic Hydrocarbons (PAHs)	This group of chemicals can occur via natural fires as well as through the degradation of asphalt binders and sealcoat toppings and the anthropogenic combustion of coal, gasoline, wood, and trash. These are known carcinogens and enter water due to leaching through waste storage tanks. Bioaccumulation in consumable fish is a potential risk to human health.

303 (d) list
A list maintained by each State, as required by Section 303(d) of the Federal Clean Water Act, of the water bodies that do not support their designated uses. The Tennessee Department of Environment and Conservation publishes this list every two years: http://tn.gov/environment/wpc/publications/.

aquifer
An underground layer of permeable or porous rock containing or conducting groundwater. Sub-surface rock types commonly containing aquifers include sandstone, conglomerate, fractured limestone and unconsolidated sand and gravel.

basin
A physical facility designed to permanently or temporarily hold stormwater.

best management practices (BMP)
Interventions and cultural practices recognized as an efficient, effective, and practical means of protecting water and soil resources from physical, chemical, or biological degradation.

bioaccumulation
The process by which contaminants accumulate within the tissues of a living organism over time. Bioaccumulation occurs when contaminants are absorbed by a single organism more quickly than they can be metabolized. The contaminants can be passed to larger organisms higher in the food chain, including humans, through a separate yet related process called biomagnification.

biofiltration
The use of microorganisms to filter pollutants from contaminated air or water. The surfaces of biofilter media, including organic and inorganic substrates such as wood chips, soil particles, compost, seashells, pumice, and plastic micro-structures, allow microorganisms to attach, grow, and evolve into a pollutant-metabolizing biofilm. Common biofiltration applications include wastewater treatment, stormwater quality management, and the microbiotic oxidization of contaminants in air.

bioindicator
A living organism whose presence and health can be used to interpret the qualitative condition of the environment that it inhabits.

biological diversity (biodiversity)
The number, variety and distribution of living organisms in a defined study area. Biodiversity includes the number of unique species, genetic diversity within a species and their geographic distribution across a discrete landscape.

biosolids
Solid waste that is treated and processed to EPA-regulated standards by waste water treatment plants. These nutrient-rich organic materials can be applied as fertilizer to improve soil health and to stimulate plant growth.

blueway
Water trails that are developed with launch points for canoeists, paddle boarders, kayakers, and others seeking water recreation.

bottom ash
A coarse, angular ash particle that is too large to be carried up into the smoke stacks so it forms in the bottom of the coal furnace.

brownfield
Real property where hazardous substances, pollutants or contaminants are present or are potentially present.

channelization
1) Hydrologic modification and straightening of a stream's shape that may cause destabilization of its banks and bed;
2) The formation of steep channel walls through erosion or other forces that separate the stream from its primary floodplain.

GLOSSARY

clean water act (CWA)
The primary federal law in the United States governing water pollution. This legislation and its amendments provide the basic regulatory framework for the protection of water quality through control of discharge of pollutants into surface waters, including the management of stormwater runoff. Formally referred to as the Federal Water Pollution Control Act, Public Law 92-500.

coal ash
Also referred to as coal combustion residuals or CCRs, coal ash is produced by the burning of coal, most abundantly by coal-fired power plants. Coal ash includes a number of by-products produced from burning coal, including fly ash and bottom ash.

combined sewer overflow (CSO)
The discharge of the co-mingled of stormwater and sanitary wastewater to a receiving waterbody during storms when the capacity of a combined sewer system to transport or store the increased flow volume is exceeded.

combined sewer system (CSS)
A sewer system that conveys both stormwater runoff and municipal sewage simultaneously with shared infrastructure to a waste water treatment facility.

complete creek
Riparian corridors that are holistically planned, designed, built and maintained to enable the efficient use, shared access, and healthy ecological condition of the water body and its surrounding landscape. Complete Creeks accommodate multiple functions, including utility rights-of-way, pedestrian and bike access, and water-based recreation. The Complete Creek planning construct may be used to rehabilitate impaired water bodies in urbanized areas or as a proactive means to protect water bodies in the path of urbanization.

complete street
Street rights-of-way that are holistically designed, built and operated so as to accommodate a diversity of uses and safe occupancy by users of all ages and abilities, including pedestrians, bicyclists, motorists and public transportation.

contaminant
A substance in a concentration that adversely affects the physical, chemical, or biological properties of the natural environment.

creek squad
A proposed non-profit organization of trained water resource experts that provides equitable and affordable access to specialized, on-demand and situation-specific water resource technical assistance.

developed land
Land that has been altered from its native, undisturbed condition to support human uses and activities.

discharge
The release of water, sometimes contaminated, into receiving waters through permitted or non-permitted activities.

district stormwater management
An approach to stormwater management that allows hydrologically-defined districts to satisfy quality and quantity requirements collectively, alleviating pressure for requirements to be met by individual property owners if they have been offset by runoff avoidance, minimization or management investments elsewhere within the district.

drainage area
The area of a site that contributes runoff; used to calculate dimensions for structural SCMs.

easement
A land use instrument through which the legal rights to access a property are granted to a designated user or group of users, but the legal title of that property remains with the owner of the land.

ecosystem
A discrete, interconnected, and dynamic system of interactions between all living organisms and the abiotic physical environment within a defined area.

ephemeral stream
A stream that has flowing water only during, and for a short duration after, precipitation events. Runoff from precipitation is the primary source of water for ephemeral streams.

erosion
The wearing away of rock and soil due to wind, water, ice, or other physical, chemical, or biological forces. The rate of erosion may be increased by development.

eutrophication
Process by which a waterbody undergoes an increase in dissolved nutrients, often leading to algal blooms, low dissolved oxygen, and changes in community structure. This naturally-occurring process can accelerated by increased nutrient levels in receiving waters due to human activities.

evapotranspiration
The sum of water vapor entering the atmosphere through the evaporation of water from land and water surfaces and the uptake and release of water by vegetation through transpiration.

filtration
Process through which contaminant levels in water are reduced by means of physical removal or chemical decomposition during the movement of water through a medium. Examples of filtering media include soils, root zones, vegetated areas, sand, and gravel.

first flush
Stormwater that runs off an area during the beginning of a rain event. This runoff is widely expected to be more polluted than the stormwater that runs off later during the same event. Generally considered to be the runoff from the first inch of rainfall.

flow rate
A measurement indicating a volume of water per unit of time, most often cubic feet per second. Sometimes used interchangeably with velocity.

fly ash
A very fine, powder-like material composed mostly of silica that is a by-product of the combustion of finely ground coal in a boiler.

global positioning system (GPS)
A system of satellites orbiting the earth that enables the precise location of receivers and other equipped devices to be determined.

green infrastructure
A system of open or green spaces distributed throughout a watershed that provides ecosystem services and environmental benefits, including recreation opportunities, to enhance overall environmental quality and provide utility services. Green infrastructure includes preserved natural spaces and constructed landscapes such as urban parks and waterfronts. As a general principle, green infrastructure uses soil and the natural hydrologic metabolism of plants to infiltrate, uptake, evapotranspirate, and/or recycle runoff.

greywater
Wastewater that may be collected from sinks, tubs, showers, dishwashers, clothes washers, and other non-toilet sources. In communities that permit greywater recycling, it is most often reused for irrigation of non-edible landscapes.

groundwater
Water occurring beneath the earth's surface, typically in aquifers, that supplies wells and springs and is a key source of drinking water.

headwaters
Spring-fed or ephemeral streams that are the origins of a river system and are the tributaries furthest from the river's endpoint or confluence with another water body. Headwaters make up the majority of river miles in the United States and combine with other tributaries to form larger, more recognizable and iconic streams and rivers. The landscape within which these tributary streams are located are referred to as headwater landscapes.

heavy metals
Elements such as zinc, mercury, lead, and copper. These elements can become mobilized in stormwater and are prone to accumulate in urban water bodies due to human activities—mainly automobile use and the decomposition of metal structures.

hydro academy
A proposed local, national and international center for water quality with a mission to conduct innovative research, increase awareness and capacity through educational initiatives, and catalyze water quality improvement through community engagement.

hydrocarbons
Organic chemical compounds made up of solely carbon and hydrogen. Predominantly used as combustible fuel and, in solid state, asphalt; a pollutant of concern in urban areas due to its contribution to ground level ozone and smog and persistence in soil and water.

hydrologic cycle
The continuous movement of water on, above, or below the earth's surface through processes including precipitation, canopy interception, condensation, plant uptake and evapotranspiration, runoff, infiltration/percolation, and storage.

hydrology
The study of the movement and distribution of surface water and groundwater in a system.

hydromodification
Alterations to the natural hydrologic cycle that result from changes to the landscape's physical condition, including soil compaction, canopy or other alterations to native vegetative conditions, stream channelization, and the introduction of impervious surfaces such as buildings and roads.

impaired water body
A water body, or segment thereof, that has been identified as failing to support one or more of its designated uses. See: 303(d) List, Threatened Water.

impervious surface
1) A surface that either prevents or limits the movement of water into the soil as would naturally occur in a pre-development condition; 2) A surface that causes water to runoff in greater quantities than that occurring under natural or pre-development conditions.

infiltration
The movement of water into the ground through air spaces between soil particles.

infrastructure
The basic facilities, networks and systems necessary for the functioning of a community, society, or ecosystem. Traditionally, infrastructure has been thought of as man-made structures such as highways, power plants, and sewer systems. Contemporary conceptualizations expand this definition to also include systems that permit data sharing, the exchange of knowledge, and the movement of wildlife.

land use
The activity that is enabled on a landscape because of the manner in which it has been developed, such as the types and number of buildings, the presence or absence of paved surfaces, vegetation, and supporting or specialized infrastructure. Certain land uses are commonly associated with specific water quality threats, such as hydrocarbons from refueling stations.

low impact development
An approach to site planning, design, and development that seeks to avoid, minimize, and manage impacts to water resources by stewarding and reintroducing natural hydrologic processes into developed watersheds.

mitigation bank
A wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under federal, state or local wetland regulation.

municipal separate storm sewer system (MS4)
A stormwater drainage network (including road drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that is owned or operated by a local government or designated entity (such as a state, city, town, borough, county, parish, district, association, or other public body).

national pollutant discharge elimination system (NPDES)
A regulatory program in the Federal Clean Water Act that prohibits the discharge of pollutants into surface waters of the United States without a permit.

npdes phase 1
Issued in 1990, the Phase 1 regulation requires medium and large cities or certain counties with populations of 100,000 or more to obtain NPDES permit coverage for their stormwater discharges.

npdes phase 2
Issued in 1999, the Phase 2 regulation requires small MS4s in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain NPDES permit coverage for their stormwater discharges.

nonpoint source (NPS) pollution
Pollution that originates from diffuse sources and is often conveyed to receiving waters by stormwater runoff, rendering it more difficult to monitor, manage or regulate than point-source pollution.

nutrients
Substances such as nitrogen and phosphorous that are required by plants and animals for growth. In some circumstances, excessive nutrient additions to surface waters may result in excessive algal or plant growth and, subsequently, the accumulation and decay of increased organic matter. See: Eutrophication.

pathogen
A microscopic organism, such as certain viruses, bacteria, or fungi, capable of causing disease in another organism.

peak flow reduction
Peak flow is the rate of highest stormwater volume that flows during a storm event. Certain SCMs reduce peak flow and decrease the risk of floods, reduce pressure on stormwater infrastructure, and protect stream channels.

permeable / pervious surface
Material or medium that allows the infiltration or passage of water or other liquids.

phytoremediation
The mitigation of contaminated soil, water, or air using plants to sequester, degrade, or remove pollutants.

point source pollution
Pollution that can be traced to a single point or output, such as a pipe at an industrial facility.

process water
Water that is used in commercial and industrial processes including materials fabrication, cooling, product or by-product conveyance, processing and washing, and the cleaning of facilities or instruments.

receiving area
A landscape area designated through a formal Transfer of Development Rights program. Owners of property within a receiving area may purchase development rights from participating owners of property owners in sending areas. Receiving areas are commonly located where existing public services and infrastructures are adequate, or may readily and economically be enhanced, to support additional development intensity and population density.

receiving waters
Any river, stream, reservoir, or other waterbody into which stormwater or other material is discharged.

reclaimed water
Wastewater that has been treated to a regulated, non-potable level at a wastewater treatment facility to remove solids and impurities. Where permitted, reclaimed water may be used to irrigate landscapes and non-edible crops, and to meet demand for compliant residential, commercial and industrial water uses, including conveying waste (toilet water).

right-of-way (ROW)
A type of easement granted or reserved over the land for specified purposes. Common types of rights-of-way accommodate roads and highways, public footpaths, rail transport, canals, as well as electrical transmission lines, oil and gas pipelines, and other utilities. Rights-of-way agreements may be renegotiated and the affected landscapes reorganized to accommodate new uses.

riparian area (corridor)
Waterbodies and their adjacent landscapes whose ecosystems are influenced by the perennial, intermittent, or ephemeral presence of surface or groundwater from the adjacent waterbody. Riparian areas characteristically include both terrestrial and aquatic ecosystems, commonly have high water tables, and are vulnerable to occasional flooding.

river basin
The watershed encompassing all the land that drains to a major river. Water that falls within the river basin flows into the major river via lower order watersheds. See: Watershed.

runoff
Water that runs over the surface of a landscape to a receiving waterbody when the volume or rate of precipitation exceeds the infiltration capacity of the landscape surfaces on which it falls.

sending area
An landscape area designated through a formal Transfer of Development Rights program. Owners of property within a sending area may voluntarily sell their development rights to participating property owners in receiving areas. Sending areas are commonly located where the productive, scenic, or ecological value of the landscape in its current condition or use warrants its preservation.

sediment
Particles of dust, soil, and debris, commonly referred to as suspended solids, that have been moved and subsequently deposited by water, wind, or gravity. Sediment also transports other contaminants that bind themselves to the particles.

shared space
An urban design strategy that seeks to minimize the segregation of motorists, cyclists and pedestrians through the removal of curbs, road markings, traffic signals and signs, creating an environment that shared space advocates suggest is safer due to the traffic calming effects of the resultant proximity of users and a decluttered visual environment.

silviculture
A process through which forested landscapes are managed, harvested, and regrown, resulting in a forest of distinctive ecological structure and physical form.

silvopasture
The agricultural practice through which trees, forages and livestock are simultaneously grown on the same acreage.

stormwater control measure (SCM)
A specific type of BMP that is a permanent intervention, including special management of the soil and vegetation and/or a physical facility such as a rain garden, constructed wetland, or rainwater cistern, that is specifically designed to avoid, minimize or manage stormwater runoff quantity and quality.

stormwater runoff
Precipitation that does not soak into the surface on which it falls, but instead runs along the surface downslope to stormwater infrastructure and/or receiving waters. Generally, the volume and flow rate of stormwater runoff is increased by impervious surfaces such as rooftops, parking lots, roadways, and compacted soils from which deposited contaminants may become mobilized.

surface water
Water collected on the landscape in any waterbody such as a stream, river, reservoir, lake, or ocean.

threatened water body
A water body, or segment thereof, that has been identified as likely to not support its designated uses. See: 303(d) List, Impaired Water.

total maximum daily load (TMDL)
The maximum amount of a specific pollutant that can be discharged to a body of water that if exceeded, the quality of that receiving body of water will be below its articulated water quality standards for the specific pollutant.

transfer of development rights (TDR)
A program that allows landowners within designated sending areas to sell development rights from their land (sending site) to a developer or other interested party who then can use these rights to increase the density of development on a receiving site within designated receiving areas. TRD programs are voluntary and incentive-based.

transit oriented development (TOD)
Development within a walkable distance from a transit station (whether existing or planned) and complementary transportation options that offers a mixture of housing, employment, and shopping opportunities and a density of population adequate to sustain transit service.

treatment train
A series of structural SCMs sequenced to achieve quantity management and treatment of contaminated stormwater runoff.

urbanization
The process through which land use and landscape surface conditions are changed from rural characteristics to urban and sub-urban characteristics; typically associated with an increase in population density and impervious surfaces such as roads and buildings.

water table
The depth at which soil is saturated by groundwater.

watershed
Topographically defined land area within which surface water drains to a single outlet point. Watersheds are designated with Hydrologic Unit Codes (HUC). See: http://water.usgs.gov/GIS/huc.html

wastewater
Water that is used to convey, and is thus contaminated by, solid waste (human and animal excrement). Waste water must be treated through regulated processes and facilities before it is discharged to surface or ground water.

wetland
Landscape areas where the soil is inundated or saturated by surface or groundwater year-round or at intervals during the year. Wetlands may support both aquatic and terrestrial vegetation. The conditions of a wetland favor specially adapted plants capable of living in hydric soils. Wetlands include swamps, marshes, bogs, and similar areas.

Glossary Sources

Definitions within this glossary have been informed by, and have occasionally adopted wording from, the following sources:

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Ludwig, A., J. Buchanan. "Tennessee Storm-Smart Glossary of Terms for Communities." University of Tennessee Extension Service Publication W301. Published 2015. Accessed January 2017. https://extension.tennessee.edu/publications/Documents/W301.pdf.

National Association of City Transportation Officials. "Urban Street Design Guide." Accessed February 2017. http://nacto.org/publication/urban-street-design-guide/.

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United States Air Force. "Frequently Asked Questions." GPS.gov. Accessed February 2017. http://www.gps.gov/support/faq/.

United States Army Corps of Engineers. "2012 Nationwide Permit Information." Accessed December 2016. http://www.usace.army.mil/Portals/2/docs/civilworks/nwp/2012/NWP2012_corrections_21-sep-2012.pdf.

United States Department of Agriculture. "Thesaurus and Glossary." National Agricultural Library. Accessed February 2017. https://agclass.nal.usda.gov/glossary.shtml.

United States Environmental Protection Agency (USEPA). "Terminology Service." Accessed January 2017. https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do.

USEPA. "National Pollutant Discharge Elimination System (NPDES) Permit Basics." Accessed December 2016. https://www.epa.gov/npdes/npdes-permit-basics.

United States Geologic Survey. "Geologic Glossary." Accessed January 2017. https://geomaps.wr.usgs.gov/parks/misc/glossarya.html.

United States Department of Agriculture Forest Service. "Reforestation Glossary." Accessed February 2017. https://www.fs.fed.us/restoration/reforestation/glossary.shtml.

ABBREVIATIONS

BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CWA	Clean Water Act
DOT	Department of Transportation
EPA	Environmental Protection Agency
GDOT	Georgia Department of Transportation
GI	Green Infrastructure
GPS	Global Positioning System
HUC	Hydrologic Unit Code
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
PSRPs	Processes to Significantly Reduce Pathogens
ROW	Rights-of-Way
SCI	Smart Communities Initiative
SCM	Stormwater Control Measure
SETD	Southeast Tennessee Development District
STEM	Science, Technology, Engineering, and Mathematics
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TDR	Transfer of Development Rights
TMDL	Total Maximum Daily Load
TOD	Transit Oriented Development
TVA	Tennessee Valley Authority
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UT	University of Tennessee, Knoxville
WWTP	Wastewater Treatment Plant

FUNDING

The following have been identified by the Southeast Tennessee Development District as potential funding sources for water quality improvement strategies identified in this publication.

AGENCIES

ARC- Appalachian Regional Commission
EDA- Economic Development Administration
EPA- Environmental Protection Agency
FEMA- Federal Emergency Management Agency
HUD- Housing and Urban Development
TDEC- Tennessee Department of Environment and Conservation
TDOT- Tennessee Department of Transportation
TEMA- Tennessee Emergency Management Agency
THDA- Tennessee Housing Development Agency
TNDPA- Tennessee Department of of Agriculture
TNECD- Tennessee Department of Economic and Community Development
TVA- Tennessee Valley Authority
USACE- United States Army Corps of Engineers
USDA- United States Department of Agriculture
USFWS: United States Fish and Wildlife Service

PRIVATE

Lyndhurst Foundation

ADDITIONAL RESOURCES

grants.gov
**Contact SETD for aid in identifying funding for local governments*

ADDITIONAL RESOURCES

The following are sources of general information about planning concepts fundamental to HydroLIT's water quality improvement strategies, as well as detailed information about the specific projects and initiatives referenced in each strategy's precedents and suggested tactical interventions.

DEVELOPMENT

INVIGORATE UNDERUTILIZED LAND

Tactical Interventions:

1. Pocket Park: National Recreation and Parks Assoc.
https://www.nrpa.org/contentassets/f768428e39ae4035ae55b2aeff372617/pocket-parkspdf
2. Pop-up Plaza: San Francisco, http://sfrecpark.org/reservablefacility/union-square/
Boston, http://pavementtoparks.org/plazas/plaza-projects/jack-london-pop-up-plaza/
3. Rooftop Farms: http://www.rooftoprepublic.com/

Precedents:

1. Denso Manufacturing: http://www.densomedia-na.com/news/show/id/598
http://www.makeitinmcminn.org/news/view/34/denso-partners-for-new-ecopark
http://clevelandbanner.com/stories/denso-opens-phase-i-of-athens-ecopark,33342
2. DyeScapes: http://www.dyescape.org

RECLAIM BROWNFIELDS

General Resources:

1. EPA: https://www.epa.gov/brownfields

Tactical Interventions:

2. Pollution containment: http://www.ciria.org/Resources/Free_publications/c736.aspx
3. Development of Profitable Phytoremediation of Contaminated Soils with Biofuel Crops: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=30858
Phytoremediation Crops and Biofuels: http://link.springer.com/chapter/10.1007%2F978-3-319-16742-8_7

Precedents:

1. Brownfield redevelopment: Renaissance Park, Chattanooga: https://landscapeperformance.org/case-study-briefs/renaissance-park

EXCHANGE DEVELOPMENT RIGHTS

General Resources:

1. TDR general resources: http://conservationtools.org/guides/12-transfer-of-development-rights
2. TDR programs resources: http://www.madisonga.com/index.aspx?NID=626
3. TDR Smart Growth America: https://www.smartgrowthamerica.org/app/legacy/documents/transfer-development-rights-policy-toolkit.pdf

Precedents:

1. Chattahoochee Hill Country: https://georgiaplanning.org/student_reports/2007/13--TDR%20and%20Chatt%20Hill/CHC_TDR_report.pdf
2. King County and City of Seattle: http://www.kingcounty.gov/services/environment/stewardship/sustainable-building/transfer-development-rights/receiving/Seattle-tdr.aspx

USE DISTRICT STORMWATER MANAGEMENT

Tactical Interventions:

1. Community Engagement (Oyster tecture): https://www.6sqft.com/living-breakwaters-an-award-winning-project-brings-oyster-tecture-to-the-shores-of-staten-island/
2. Claxton rain garden: http://tntoday.utk.edu/2016/02/05/claxton-rain-garden-completed-part-green-infrastructure-project/

Precedents:

1. Georgia Tech Eco Commons: http://nique.net/news/2016/09/30/eco-commons-to-be-social-space-reservoir/
2. Shoemaker Green at UPENN: http://www.pennconnects.upenn.edu/find_a_project/alphabetical/shoemaker_green_alpha/shoemaker_green_overview.php

TRANSPORTATION

EMPLOY REGIONAL TRANSIT

General Resources:

1. Smart commute: https://www.tn.gov/tdot/topic/smart-commute-ridesharing

Precedents:

1. SETHRA (Southeast Tennessee Rural Regional Transit): http://www.sethratransit.org/
2. Sound Regional Transit: http://www.soundtransit.org/About-Sound-Transit

INCREASE PEDESTRIAN + BIKE ACCESS

General Resources:

1. Bike Infrastructure: http://www.citylab.com/commute/2013/06/10-brilliant-pieces-bike-infrastructure/6009/
2. Small Town and Rural Multimodal Networks Guide: http://altaplanning.com/resources/small-town-rural-multimodal-networks-guide/
3. NACTO Urban Street Design Guide: http://nacto.org/publication/urban-street-design-guide

Tactical Interventions:

3. Open Streets: http://openstreetsknoxville.com/
Open streets project: http://openstreetsproject.org/
4. Community Bike Ride: http://www.newarkpostonline.com/news/article_6afc5c1c-fab3-5cb1-a44a-efb23ecd6668.html

Precedents:

1. Market Square: https://nextcity.org/daily/entry/knoxvilles-market-square-shows-pedestrian-only-spaces-can-work-too
2.Whitwell Multi-Modal: http://www.chattanoogan.com/2015/6/9/302105/East-Ridge-Whitwell-Get-Large-State.aspx

DEVELOP VIA TOD SITES

General Resources:

1. Transit Oriented Development Institute: http://www.tod.org/

Tactical Interventions:

2. Pop-up Markets: http://www.newsobserver.com/living/fashion/article68764432.html

Precedents:

1. Hamilton Springs: http://www.lebanondemocrat.com/Local/2014/03/20/Hamilton-Springs-awarded-1-6-million-grant-for-commuter-rail-station
http://www.tennessean.com/story/money/homes/2016/11/23/nas-re-transit-development-1127/94095276/
2. MLK Rail Station: https://www.austintexas.gov/sites/default/files/files/Planning/Urban_Design/MLK_Jr._Blvd._Final_SAP_Low_Res.pdf

ADOPT SHARED SPACE

General Resources:

1. Redesign cities as shared space: http://www.shareable.net/blog/how-can-we-redesign-cities-as-shared-spaces

Tactical Interventions:

1. Georgetown Sidewalk widening: http://www.georgetowndc.com/sidewalk-widening-october-2015/
3. Parklets: http://pavementtoparks.org/parklets/
http://nacto.org/publication/urban-street-design-guide/interim-design-strategies/parklets/

Precedents:

1. Chicago Argyle Street: http://chi.streetsblog.org/2016/11/05/chicagos-first-shared-street-on-argyle-is-officially-open-for-business/
2. Downtown Eugene: http://nacto.org/docs/usdg/shared_space_streets_cda.pdf

ECOLOGICAL PROTECTION

PROTECT HEADWATERS + RIDGES

Tactical Interventions:

2. Composting Toilets: http://www.letsgogreen.com/how-composting-toilets-work.html
Composting: https://www.epa.gov/recycle/composting-home
3. Leach field plantings VT: https://pubs.ext.vt.edu/426/426-617/426-617_pdf.pdf
Landscaping on septic mounds: http://www.extension.umn.edu/garden/yard-garden/landscaping/landscaping-septic-systems/
Landscaping on septic fields: http://www.clemson.edu/extension/hgic/plants/other/landscaping/hgic1726.html

Precedents:

1. Soque Project: https://chattahoochee.org/our-work/headwaters-regional-office/headwaters-stream-restoration/

2. Rio Grande Headwaters Restoration Project: http://www.riograndeheadwaters.org/

SAFEGUARD WETLANDS

General Resources:

1. Chattanooga Mackey Branch Wetland: http://www.chattanoogaaudubon.org/mackey-branch-wetland.html
2. Renaissance Park Wetland: http://152.874.98/river/neighbors/aug06/wetland.htm

Tactical Interventions:

3. Demonstration wetland slides: https://www.bae.ncsu.edu/programs/extension/wqg/workshop/lwwetland.pdf

Precedents:

1. Hatchie River Wetland: http://www.twrf.net/hatchie-river-wetland-mitigation-bank/
2. Bartley Gravel Wetland: https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/unhsc_gravel_wetland_specs_6_09.pdf

DEVELOP COMPLETE CREEKS

Tactical Interventions:

1. Farm walk/tour: http://www.mssagnet.net/2013/08/12/alabama-farm-tour-sprouts-ideas/
Self-guided river underground tour: http://www.townbranchwaterwalk.com/

Precedents:

1. Mill River Park: http://www.millriverpark.org/aboutus/
https://issuu.com/niarhodesjackson/docs/the_plan_for_mill_river_park_v8_iss
2. Sand Creek Greenway: http://sandcreekgreenway.org/

GPS-GUIDED GRAZING

Tactical Interventions:

1. Alternative water sources for livestock: http://www.vacd.org/field/alternative-water-sources
Artificial/constructed spring: http://www2.ca.uky.edu/agcomm/pubs/aen/aen98/aen98.pdf
Watering Systems for Serious Graziers: https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1144213.pdf
2. Silvopasture: Establishment and Management Principles for Pine Forests: http://nac.unl.edu/documents/morepublications/silvopasturehandbook.pdf1;
General silvopasture information
http://nac.unl.edu/practices/silvopasture.htm
3. Streambank plantings: http://www.ecswcd.org/docs/04-streambank.pdf

Precedents:

1. Alternative Grazing: http://www.stonebarnscenter.org/farm/news/
2. GPS Grazing: http://v-e-n-u-e.com/Invisible-Fences-An-Interview-with-Dean-Anderson

Waste

BIOSOLIDS

General Resources:

NOTE: TDEC and EPA regulate and permit these types of biosolids practices. Biosolids processing and application must be compliant with the federal biosolids rule within 40 CFR Part 503. A guide to this rule can be found at: https://www.epa.gov/sites/production/files/2015-05/documents/a_plain_english_guide_to_the_epa_part_503_biosolids_rule.pdf

1. EPA: https://www.epa.gov/biosolids/basic-information-about-biosolids
2. Biosolids Management Program Manual: http://www.lewwtp.org/Home/ShowDocument?id=7964
3. National biosolids partnership: http://www.weat.org/Presentations/2014Eckenfelder_Moss.pdf
4. Utilizing Biosolids on Agricultural Land: https://msu.edu/~warncke/E2781%20Utilizing%20Biosolids%20on%20Agricultural%20Land.pdf

Tactical Interventions:

4. Dewatering sludge: http://www.tpomag.com/online_exclusives/2013/03/reed_bed_technology_for_biosolids_dewatering and_storage

Precedents:

1. Mocassin Bend Wastewater Treatment Plant: http://www.chattanooga.gov/public-works/interceptor-sewer/biosolids-management-system
2. Boulder Park Project: http://www.kingcounty.gov/services/environment/wastewater/resource-recovery/Loop-Biosolids/Projects/Agriculture.aspx#BPI

INCORPORATE COAL ASH

Tactical Interventions:

2. Streambank Revetment (without coal ash), Lake County, Chicago: http://www.lrc.usace.army.mil/Portals/36/docs/regulatory/pdf/StrmManual.pdf

Precedents:

1. Ecological Tech Fly Ash Brick FAQs: http://ecologic-tech.com/faqs.html
2. Asheville regional airport: http://www.citizen-times.com/story/local/2014/07/09/tons-coal-ash/12435649/

REDUCE POLLUTION PRESSURE

General Resources:

1. Greywater guide AUS: http://www.thegreywaterguide.com/the-2-minute-guide.html
2. Information on greywater usage and composting toilets: http://greywateraction.org/contentabout-greywater-reuse/

Precedents:

2. Popular plantation in Woodburn, OR
http://www.tpomag.com/editorial/2014/07/treatment_with_trees

Household

Tactical Interventions:

1. Water catchment: http://www.wastewatereducation.org/teacher_resources.html
2. Rain Barrel: https://www.watercache.com/education/rainwater-harvesting-101
3. Proper Drug Disposal: http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm101653.htm

Precedents:

1. Mobile Hazardous Waste Services https://www.tn.gov/environment/topic/sw-mm-household-hazardous-waste-program
2. Unwanted Medication Collection: http://www.knoxvilletn.gov/government/city_departments_offices/public_service/solid_waste/unwanted_medicines_collection

EDUCATION

CREEK SQUAD

Precedents:

1. HelloTech: https://www.hellotech.com/
2. SETD: http://www.sedev.org/www

PILOT MOBILE LEARNING

Tactical Interventions:

1. Town Branch Water Walk: http://www.townbranchwaterwalk.com/news.html
2. VODA:WATER: http://www.mgml.si/en/city-museum-of-ljubljana-377/city-museum-of-ljubljana/future-exhibitions-523/water/
3. Amphibious Architecture: http://www.environmentalhealthclinic.net/xooz/projects/amphibious-architecture/
4. Biology in a Box: http://biologyinabox.utk.edu/

Precedents:

1. The Learning Barge: http://www.arch.virginia.edu/learningbarge/
2. Water: H20 Exhibit: http://www.amnh.org/exhibitions/water-h2o-life/

ESTABLISH THE HYDRO ACADEMY

Tactical Interventions:

3. Renaissance Park: http://www.hargreaves.com/work/chattanooga-renaissance-park/
4. BMW Guggenheim Lab: http://www.bmwguggenheimlab.org/what-is-the-lab/architecture

Precedents:

1. Oak Ridge National Lab: https://www.ornl.gov/
2. Salk Institute: http://www.salk.edu/

SYNTHESIZE + VISUALIZE DATA

Tactical Interventions:

3. Water Quality Monitoring Kit: www.carolina.com/environmental-science-water-quality/lamotte-green-water-quality-monitoring-kit/652567.pr
4. Combining Big Data and Crowdsourcing to Build a Smart City: http://www.newcitiesfoundation.org/combining-big-data-crowdsourcing-build-smart-city/

Precedents:

1. Living Light Structure: http://www.livinglightseoul.net/
2. EcoAtlas: http://ecoatlas.org/

OTHER RESOURCES

1. Small Town and Rural Design Guide: http://ruraldesignguide.com/
2. Strong Towns: http://www.strongtowns.org/journal/2017/1/3/five-low-cost-ideas-to-make-your-city-wealthier?utm_content=buffer4d3ee&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer
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5. North Chickamauga Creek Conservancy: http://www.northchick.org/
6. Green|Spaces: http://www.greenspaceschattanooga.org/
7. The Urban Design Studio: http://www.chattanoogastudio.com/
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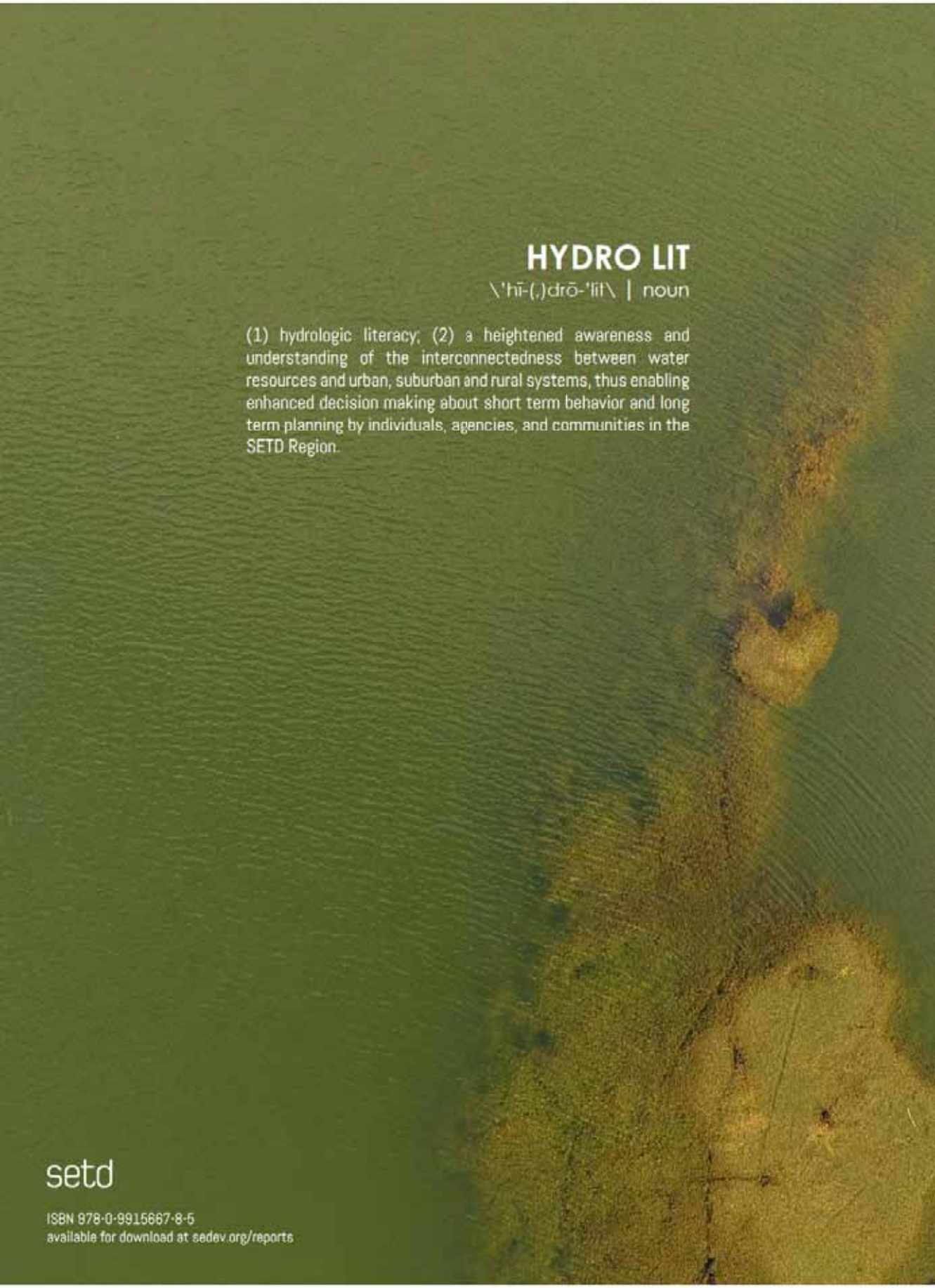

HYDRO LIT

\'hī-(,)drō-'lit\ | noun

(1) hydrologic literacy; (2) a heightened awareness and understanding of the interconnectedness between water resources and urban, suburban and rural systems, thus enabling enhanced decision making about short term behavior and long term planning by individuals, agencies, and communities in the SETD Region.

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ISBN 978-0-9915667-8-5
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