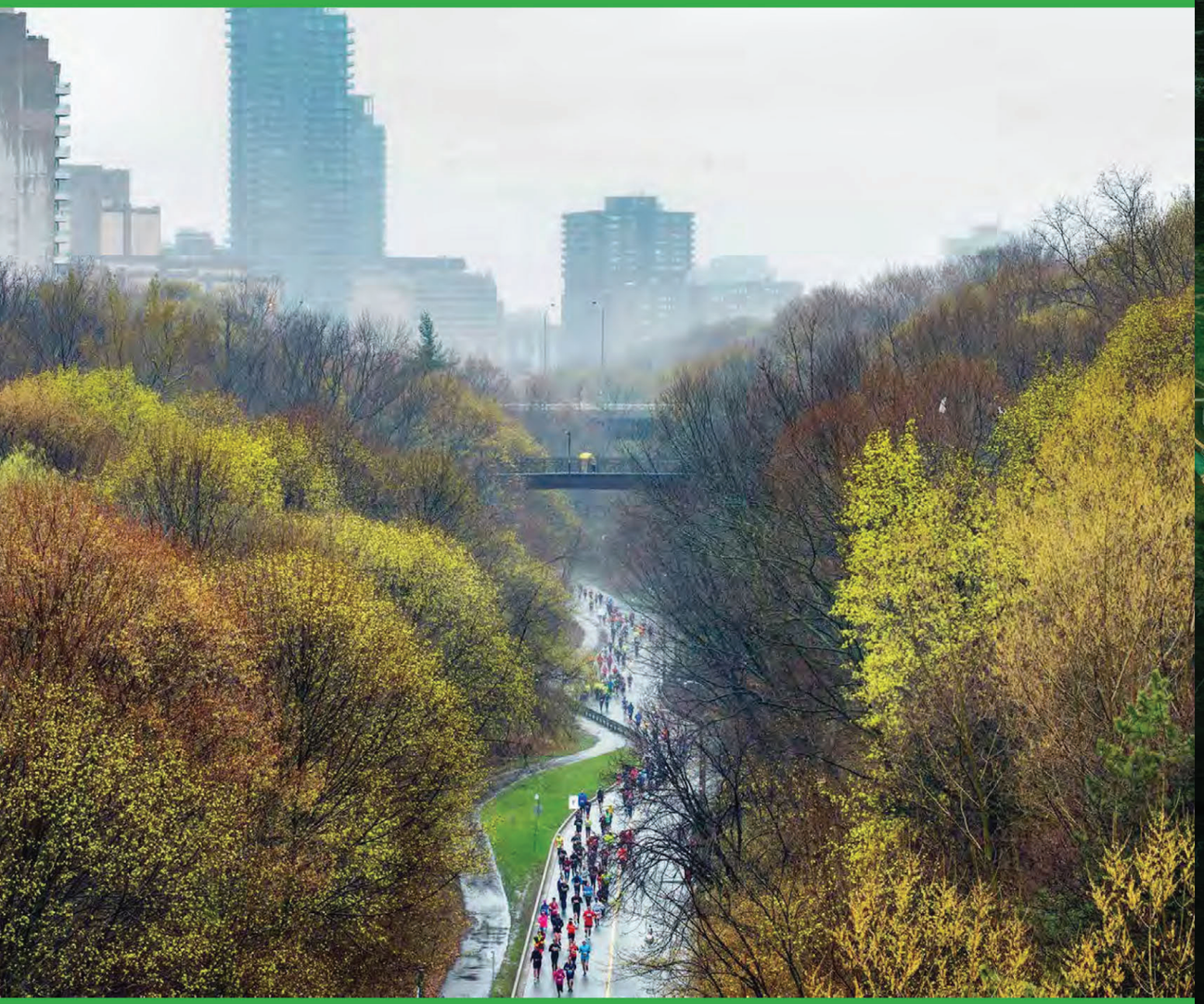
DESIGNING WITH TREES FOR STORMWATER MANAGEMENT

Thomas Brown, RLA, ASLA, CLARB
Arcadis U.S.

PRIORITIZING PRESERVATION
IMPROVING PERFORMANCE
DAYLIGHTING & STACKING BENEFITS
REFLECTING NATURE ... CREATIVELY
LEVERAGING TOOLS

PRIORITIZING PRESERVATION

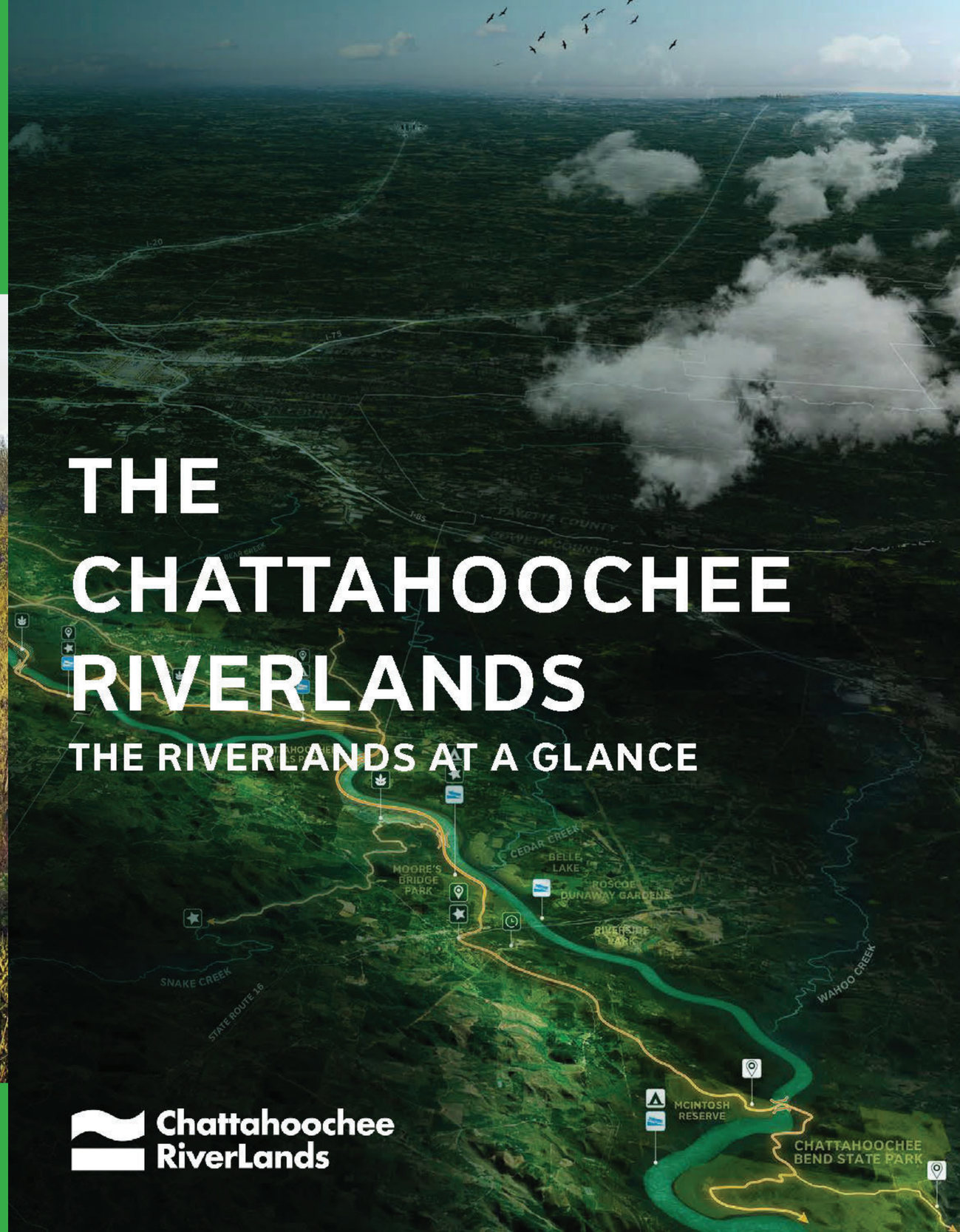
TORONTO RAVINE STRATEGY



TORONTO

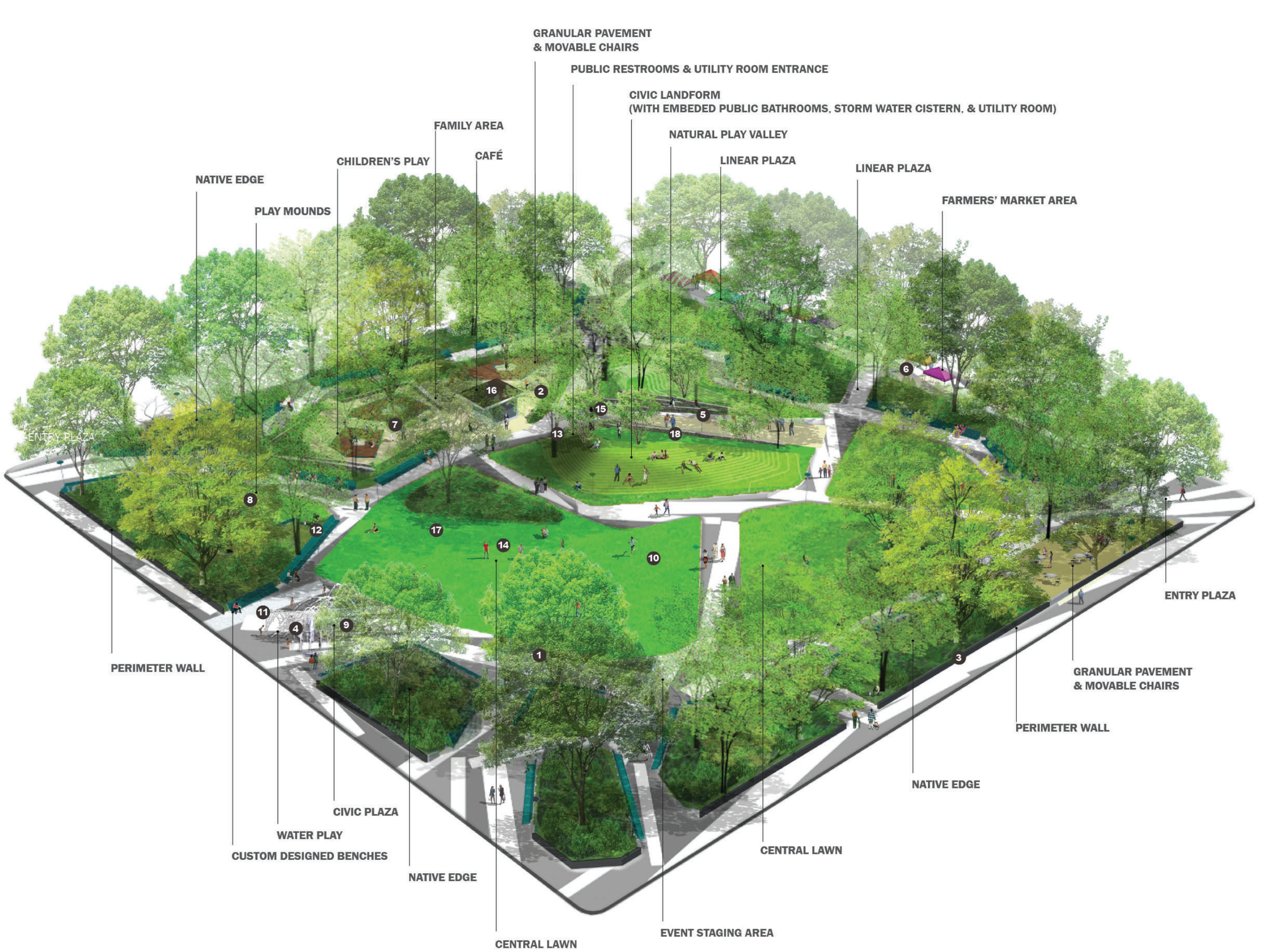
THE CHATTAHOOCHEE RIVERLANDS

THE RIVERLANDS AT A GLANCE

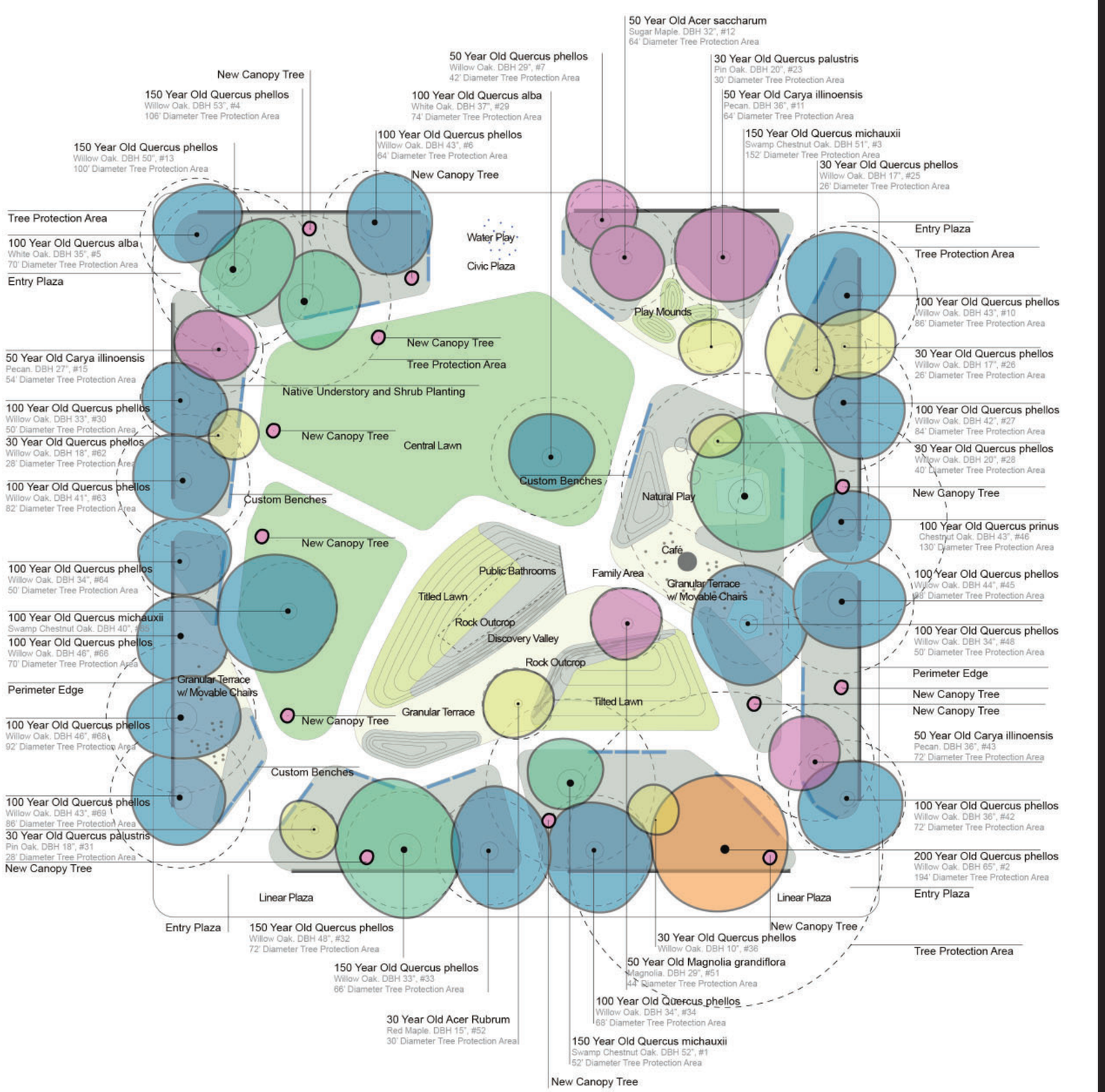



Richmond Hill
Markham
Whitby
Oshawa
Ajax
Pickering
SCARBOROUGH
NORTH YORK
Toronto
ROUGE NATIONAL URBAN PARK


AUGUSTA
ATLANTIC OCEAN
SAVANNAH
BUFORD
SUGAR HILL
SUWANEE
CUMMING
BUFORD DAM
JOHN'S CREEK
PEACHTREE CORNERS
BERKELEY LAKE
DULUTH
NORCROSS
ALPHARETTA
DUNWOODY
I-75
GA-400
I-285
ATLANTA
I-20
HARTSFIELD-JACKSON ATLANTA INTERNATIONAL AIRPORT
ROSWELL
SANDY SPRINGS
SMYRNA
MARIETTA
SOUTH FULTON
DOUGLASVILLE
I-20
CLAYTON COUNTY
FULTON COUNTY
COBB COUNTY
PAULDING COUNTY
I-85
FAYETTE COUNTY
COWETA COUNTY
BEAR CREEK
TO COCHRAN MILL PARK
TO SILK SHEETS
CHATTAHOOCHEE HILLS
TO SERENBE
DOG RIVER
CHATTAHOOCHEE HILLS PARK
NEWNAN
DOUGLAS COUNTY
CARROLL COUNTY
CEDAR CREEK
BELLE LAKE
ROSCOE DUNAWAY GARDENS
MOORE'S BRIDGE PARK
SNAKE RIVER TRAIL
TO BANNING MILLS
WHITESBURG
RIVERSIDE PARK
WAHOO CREEK
SNAKE CREEK
STATE ROUTE 16
MCINTOSH RESERVE
CHATTAHOOCHEE BEND STATE PARK
TO CHATTAHOOCHEE BEND TRAILHEAD
CARROLLTON

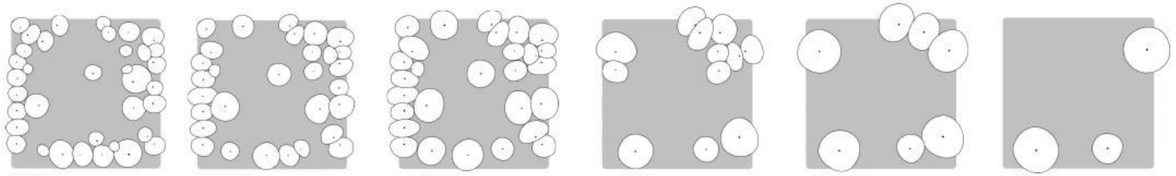

GRANULAR PAVEMENT
& MOVABLE CHAIRS
PUBLIC RESTROOMS & UTILITY ROOM ENTRANCE
CIVIC LANDFORM
(WITH EMBEDED PUBLIC BATHROOMS, STORM WATER CISTERN, & UTILITY ROOM)
FAMILY AREA
CAFÉ
NATURAL PLAY VALLEY
CHILDREN'S PLAY
LINEAR PLAZA
NATIVE EDGE
LINEAR PLAZA
PLAY MOUNDS
FARMERS' MARKET AREA
ENTRY PLAZA
PERIMETER WALL
GRANULAR PAVEMENT
& MOVABLE CHAIRS
ENTRY PLAZA
PERIMETER WALL
NATIVE EDGE
CIVIC PLAZA
WATER PLAY
CUSTOM DESIGNED BENCHES
NATIVE EDGE
CENTRAL LAWN
EVENT STAGING AREA
CENTRAL LAWN


#25) 30-Year-Old Quercus phellos
17” DBH, 26’ Diameter Tree Protection Area
#2) 200-Year-Old Quercus phellos
65” DBH, 194’ Diameter Tree Protection Area
#26) 30-Year-Old Quercus phellos
17” DBH, 26’ Diameter Tree Protection Area
#3) 150-Year-Old Quercus michauxii
51” DBH, 152’ Diameter Tree Protection Area
#32) 150-Year-Old Quercus phellos
48” DBH, 72’ Diameter Tree Protection Area
#45) 100-Year-Old Quercus phellos
44” DBH, 88’ Diameter Tree Protection Area
#48) 100-Year-Old Quercus phellos
34” DBH, 50’ Diameter Tree Protection Area
#36) 30-Year-Old Quercus phellos
10” DBH
#1) 150-Year-Old Quercus michauxii
52” DBH, 104’ Diameter Tree Protection Area
#52) 30-Year-Old Acer rubrum
15” DBH, 30’ Diameter Tree Protection Area
#46) 100-Year-Old Quercus prinus
43” DBH, 130’ Diameter Tree Protection Area
#27) 100 Year-Old-Quercus phellos
42” DBH, 84’ Diameter Tree Protection Area
#33) 100-Year-Old Quercus phellos
33” DBH, 66’ Diameter Tree Protection Area
#34) 100-Year-Old Quercus phellos
34” DBH, 68’ Diameter Tree Protection Area
#28) 30-Year-Old Quercus phellos
20” DBH, 40’ Diameter Tree Protection Area
#10) 100-Year-Old Quercus phellos
43” DBH, 86’ Diameter Tree Protection Area
DBH: Diameter at Breast Height



*DBH: Diameter at Breast Height

100 YEAR PROJECTION WITHOUT NEW CANOPY TREE PLANTING



2012
EXISTING CONDITIONS
36 existing canopy trees

2032
15% LOSS
30 existing canopy trees remain
One 200-year-old tree reaches maximum lifespan
Five 150-year-old trees reach maximum lifespan

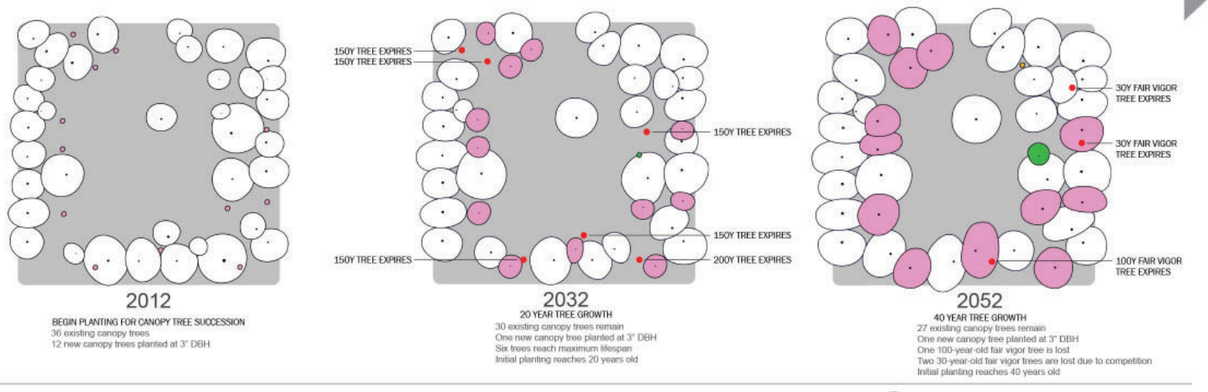
2052
25% LOSS
27 existing canopy trees remain
One 100-year-old fair vigor tree is lost
Two 30-year-old fair vigor trees are lost due to competition

2072
65% Loss
12 existing canopy trees remain
15 100-year-old trees reach maximum lifespan

2092
80% LOSS
Seven existing canopy trees remain
One 50-year-old tree is lost
Two 30-year-old fair vigor trees are lost

2112
90 % LOSS
Three existing canopy trees remain
Four 50-year-old trees reach maximum lifespan

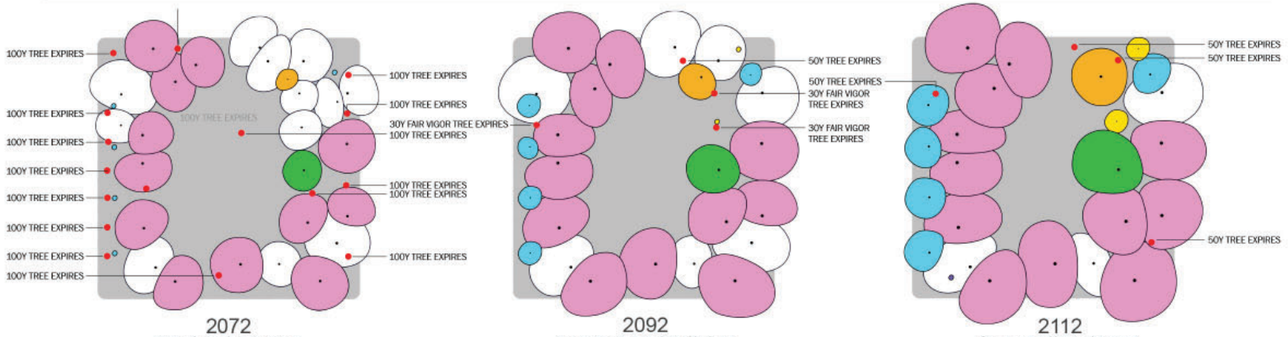
100 YEAR PROJECTION WITH NEW CANOPY TREE PLANTING STRATEGY



2012
BEGIN PLANTING FOR CANOPY TREE SUCCESSION
36 existing canopy trees
12 new canopy trees planted at 3" DBH

2032
20 YEAR TREE GROWTH
30 existing canopy trees remain
One new canopy tree planted at 3" DBH
Six trees reach maximum lifespan
Initial planting reaches 20 years old

2052
40 YEAR TREE GROWTH
27 existing canopy trees remain
One new canopy tree planted at 3" DBH
One 100-year-old fair vigor tree is lost
Two 30-year-old fair vigor trees are lost due to competition
Initial planting reaches 40 years old

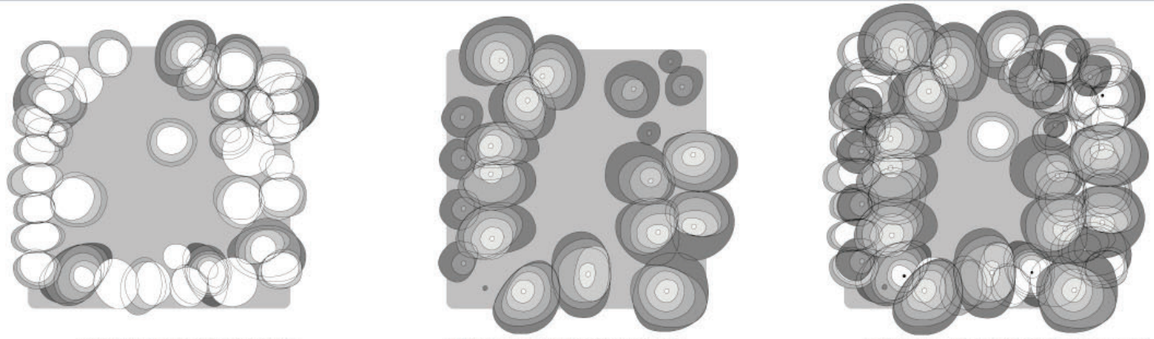


2072
EXISTING CANOPY COVER DIMINISHES
12 existing canopy trees remain
15 trees reach maximum lifespan
Five new canopy trees planted at 3" DBH
Initial planting reaches 60 years old

2092
NEW EDGE PLANTING REACHES 100% COVER
Seven existing canopy trees remain
Two new canopy tree planted at 3" DBH
One 50-year-old tree is lost
Two 30-year-old fair vigor trees are lost
Initial planting reaches 80 years old

2112
CANOPY TREE SUCCESSION COMPLETES
Three existing canopy trees remain
One new canopy tree planted at 3" DBH
Four trees reach maximum lifespan
Initial planting reaches 100 years old

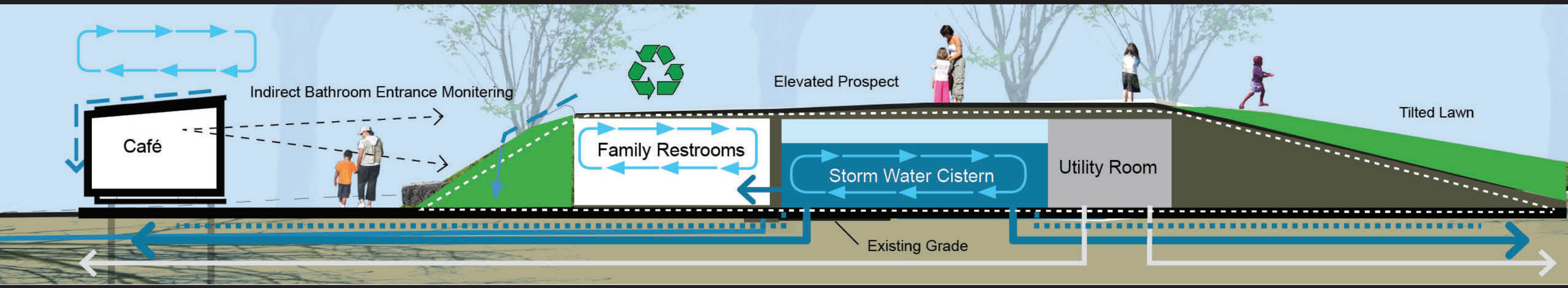
CANOPY GROWTH AND DECLINE COMPOSITE DIAGRAMS



EXISTING CANOPY GROWTH AND DECLINE COMPOSITE

PROPOSED CANOPY GROWTH AND DECLINE COMPOSITE

EXISTING AND PROPOSED CANOPY GROWTH AND DECLINE COMPOSITE


Indirect Bathroom Entrance Monitering
Café
Elevated Prospect
Tilted Lawn
Family Restrooms
Storm Water Cistern
Utility Room
Existing Grade

7. TREE PRESERVATION INCENTIVES

(a) Tree Preservation Credits

The preservation of specimen trees and other existing trees within the site and at the property perimeter is strongly encouraged. As an incentive to encourage the preservation of as many trees as practical on a development site, credit towards the minimum landscaping requirements may be applied to all existing trees in good health and condition which are retained as long as the intent and applicable standards of this Section are fully met. Credits shall be granted in accordance with the following standards:

(1) Qualifying Attributes

Preserved vegetation must be in good health and condition, and must be protected as described in Section 30-5.B.8, Tree Protection During Construction.

(2) Exempted Trees

The following trees, regardless of their size, shall be exempted from the requirements in this section.

a. Southern Yellow Pine;

b. Bradford Pear;

c. Mulberry; and

d. Silver Maple.

(3) Tree Death

If a preserved tree dies within twenty-four months of the completion of the landscape project, it must be replaced with the total number of trees which were credited to the existing tree, and the size of the new tree must comply with the size requirements for new trees as established in this section.

(b) Credit Toward Open Space

If specimen trees or groves of three or more trees over 4-inch caliper are preserved and protected during development of the site (beyond those credited toward landscaping requirements), credit may be applied toward the required open space acreage by calculating the area of the critical root zone circumference and multiplying that square footage by three, deriving a 300 percent credit. (See also Section 30-5.C.4, Bonuses and Incentives.)

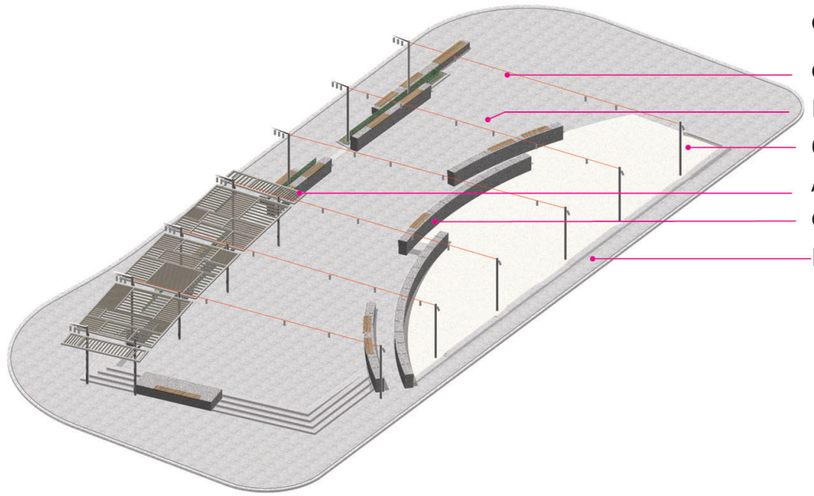
(c) Reduction in the Minimum Number of Required Parking Spaces

Up to a five percent reduction in the number of off-street parking spaces required on a development site shall be allowed if the reduction in the amount of required pavement will preserve the root zones of existing healthy specimen trees. The amount of reduction can be determined only after taking into consideration any unique site conditions and the impact of the reduction on parking needs for the use, and must be agreed upon by both the applicant and the City Manager. Alternative paving materials (see Section 30-5.A.8.i, Alternative Materials) may be required by the City Manager in cases where required parking areas encroach upon critical root zones.

IMPROVING PERFORMANCE

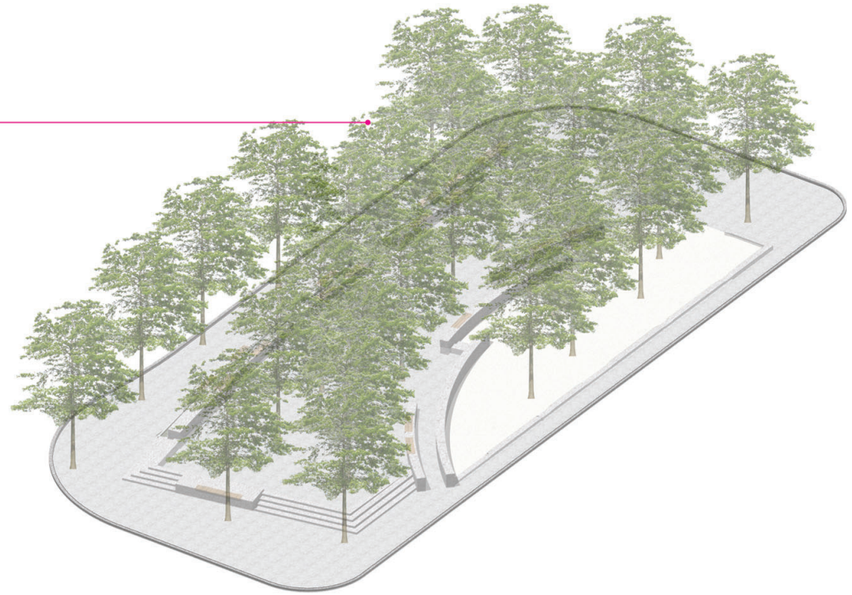

ONLY

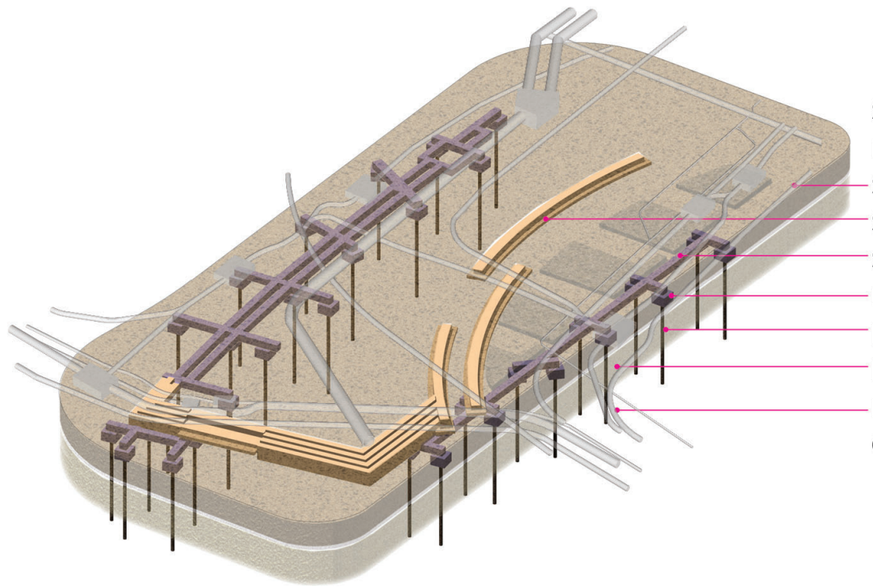
Structural Support



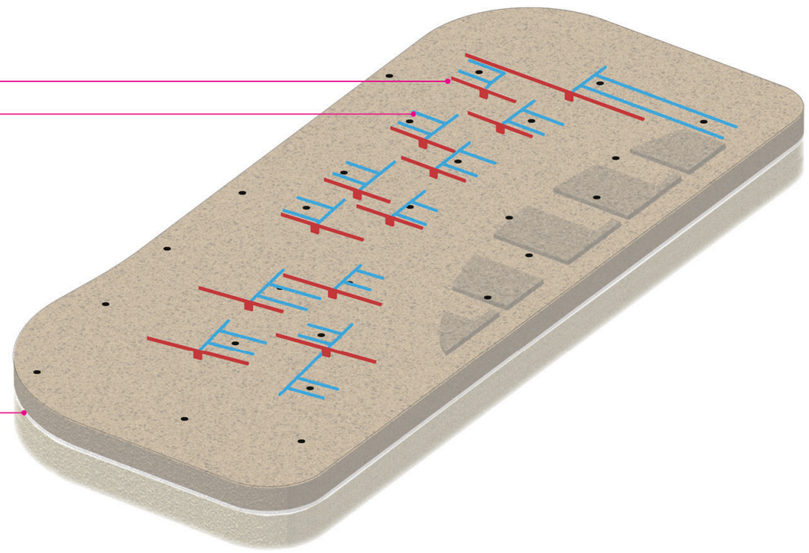
Canopy
Catenary System
Light Fixture
6 – Inch Pole
Arbor
Granite Wall
Dry Paving

Horticultural Support





Slot Drain
Perforated Pipe
Structural Soil
Shallow Spread Footing
Suspended Grade Beam
Pile Cap
Drilled Mini-Pile
Existing Urban Fill
Existing Utilities Network
Crushed Stone Reservoir




TATTOO


SOULCYCLE


Native Tree Species
Custom Tree Grates
with Uplighting
600 Cubic Feet Per Tree
Soil Volume
2000 Gallon
Non-Potable Irrigation Storage
4.85%
Accessible Route
4.85%
Accessible Route

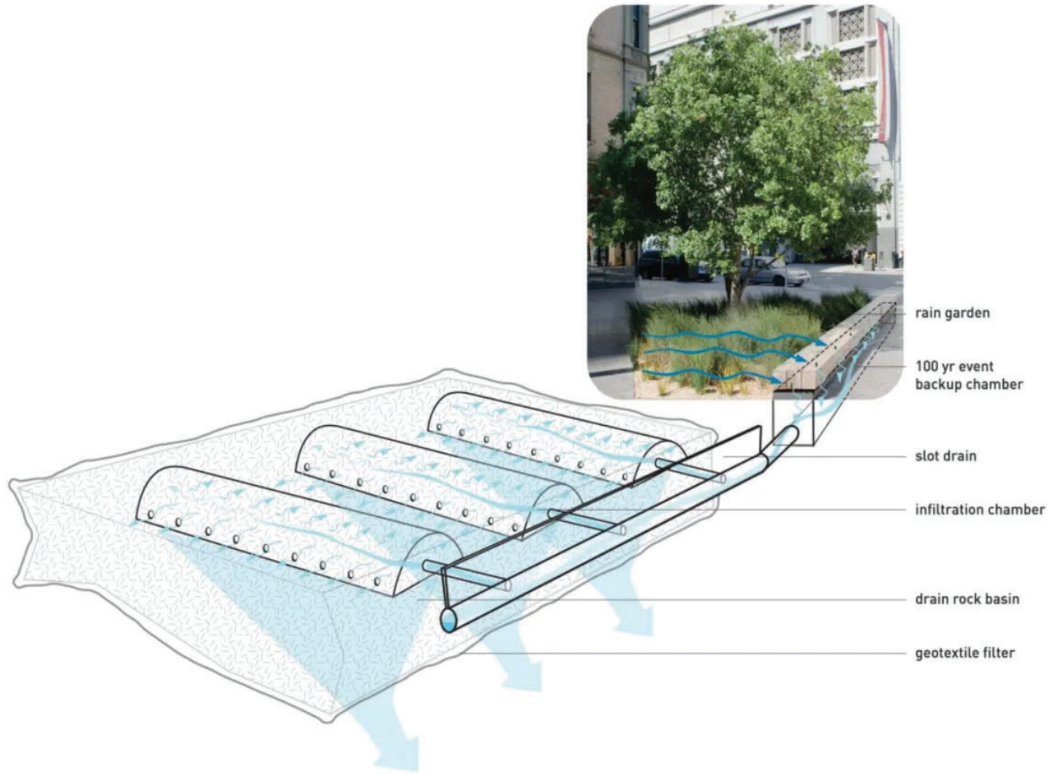
DAYLIGHTING & STACKING BENEFITS

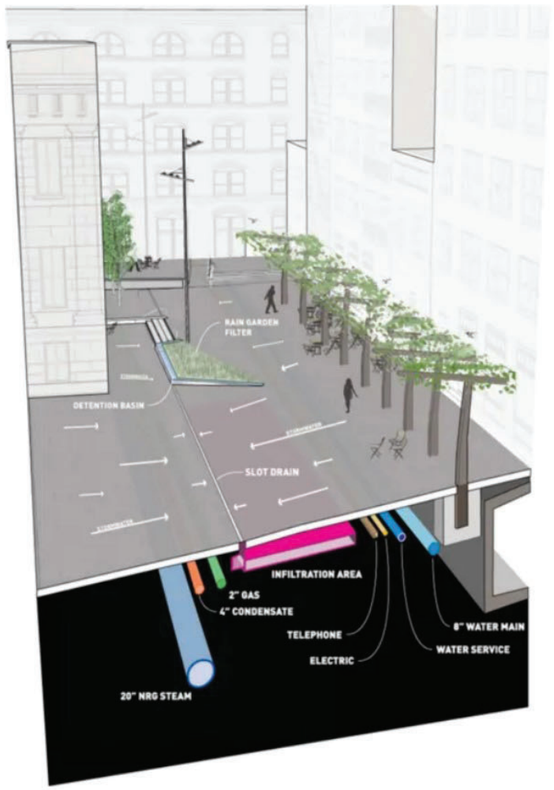

K-STYLE HUB
Come and Enjoy
the arts, beauty and
DUTY FREE

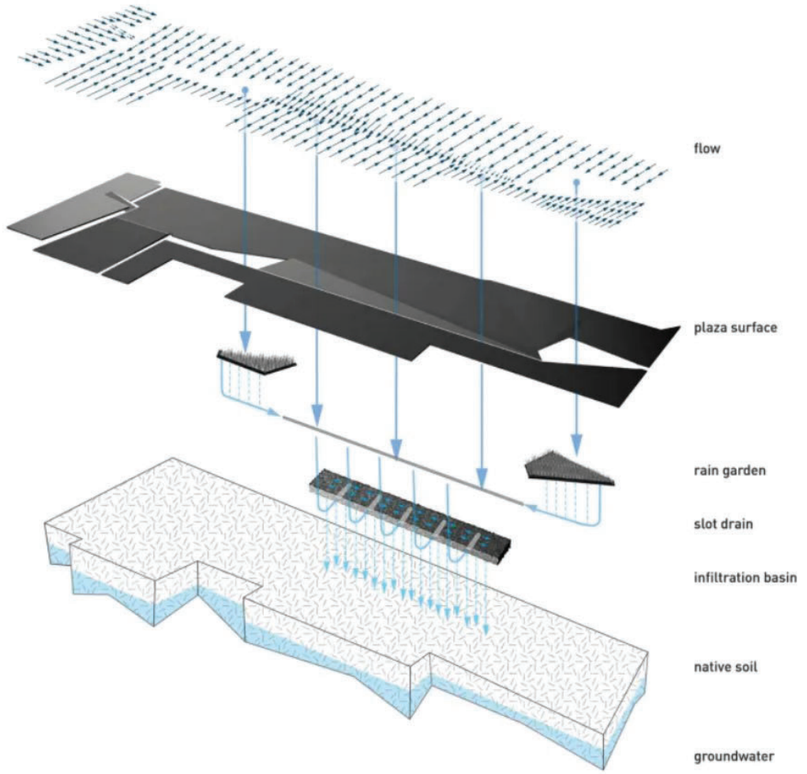

Mr Peeples


46,300 GAL

REFLECTING NATURE ... CREATIVELY


rain garden
100 yr event
backup chamber
slot drain
infiltration chamber
drain rock basin
geotextile filter


RAIN GARDEN
FILTER
DETENTION BASIN
SLOT DRAIN
INFILTRATION AREA
2" GAS
4" CONDENSATE
TELEPHONE
ELECTRIC
8" WATER MAIN
WATER SERVICE
20" NRG STEAM


flow
plaza surface
rain garden
slot drain
infiltration basin
native soil
groundwater

14
MINT
PLAZA

NIGHT

DAY

PV Cells generate electricity for the site and pump water to a tank at the top of the tree

Solar thermal collectors

Rain Water tank at top of Supertree

Warm moist air intake

Hot air purged to atmosphere

Supertrees used to moderate the climate at ground level to enhance human comfort - shade and draughts.

Rising air in the tree draws in external air- this creates a breeze at ground level

Turbine creates electricity from water flow shifting energy generated in the day to be usable at night

Electricity generated for the site

Empty water tank gets filled

Electricity generated for the site

Heat to dehumidifier plant

Air handling unit Dehumidifier

Hot process air from dehumidifier plant exhausted up supertree mid way up

Dehumidified air to conservatory and buildings

LEVERAGING TOOLS

i-Tree Design v7.0

1 AMB Dr NW, Atlanta, GA 30313, USA

Get started with these easy steps:

1. Draw Structures ?

2. Place Trees ?

Please break large projects into smaller projects of no more than 25 trees at a time.

Describe your tree:

- Tree species: Red maple
  Common
- Tree diameter: 4 Inches
  or circumference: 12.6
- Tree condition: Excellent
- Tree exposure to sunlight: Full sun

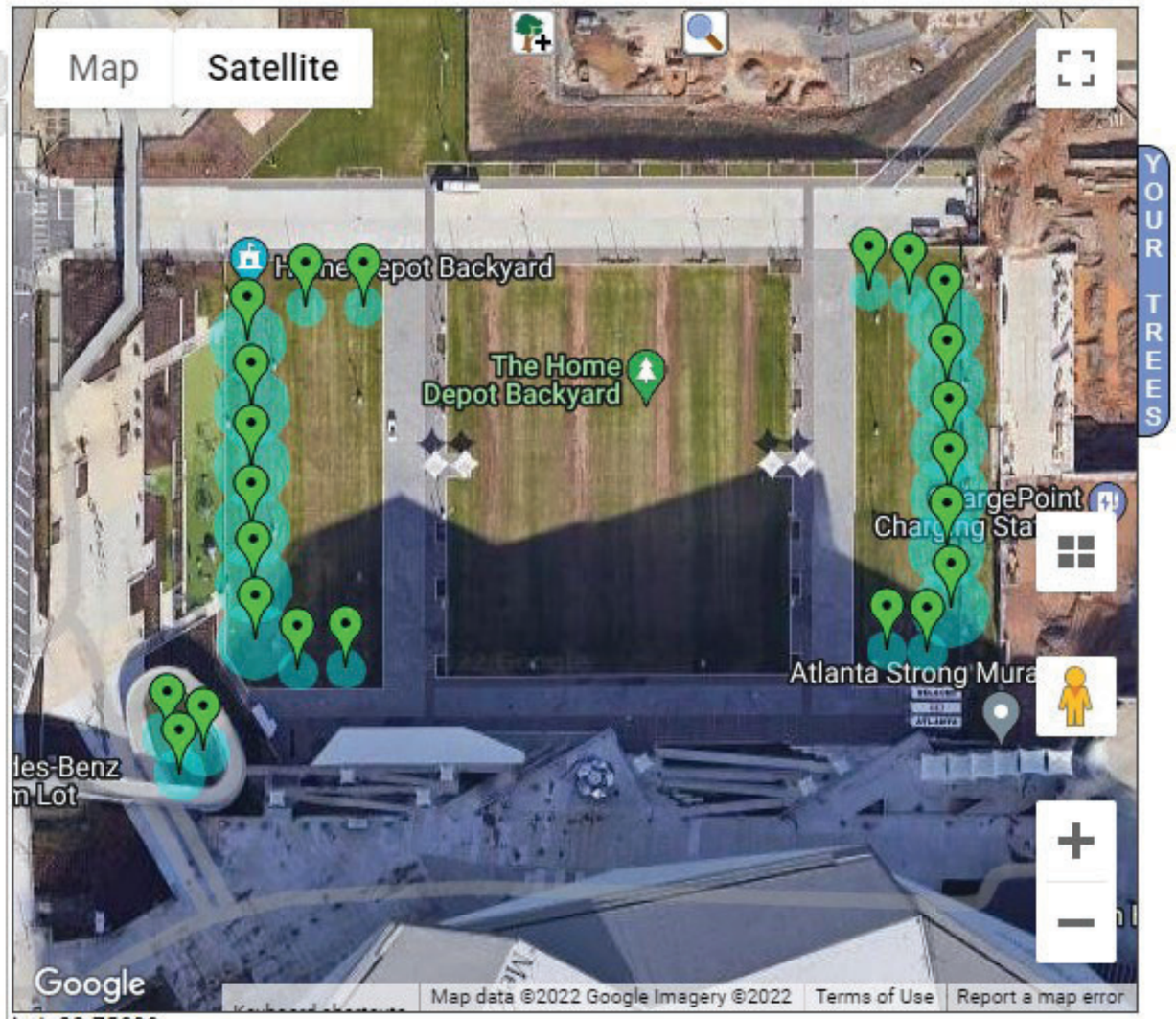
To place a tree:

- Drag this icon to the location on the map where you would like to place your tree.
- Repeat to place additional trees.
- Hover over any tree you have placed on the map to display its benefits.

Model the tree(s) future crown growth over time:

Model Crown Growth

3. Estimate Benefits ?



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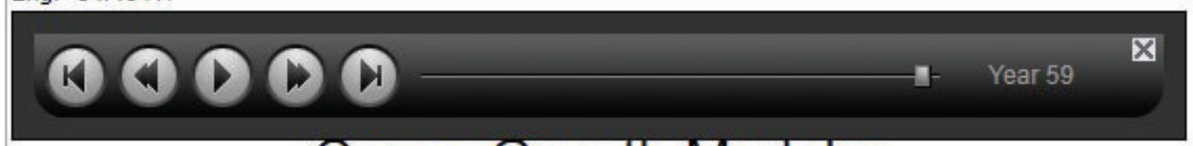
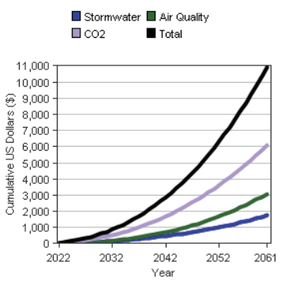
Lng: -84.40117



Crown Growth Modeler

Overall Benefits | Stormwater | Energy | Air Quality | Carbon Dioxide

Current Year (2022) | Future Year (2062) | Total (2022-2062) | Total to Date



Breakdown of tree benefits

Click on one of the tabs above for more detail

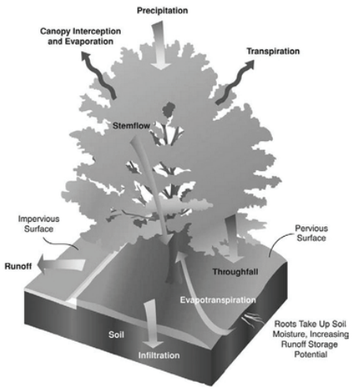
If they are cared for, these trees will provide a total of $10,924 worth of overall benefits over next 40 years.

While some functional benefits of trees are well documented, others are difficult to quantify (e.g., human social and communal health). Trees' specific geography, climate, and interactions with humans and infrastructure are highly variable and make precise calculations that much more difficult. Given these complexities, the results presented here should be considered initial approximations to better understand the environmental and economic value associated with trees and their placement.

Benefits of trees do not account for the costs associated with trees' long-term care and maintenance.

Overall Benefits | Stormwater | Energy | Air Quality | Carbon Dioxide

Current Year (2022) | Future Year (2062) | Total (2022-2062) | Total to Date



Over the next 40 years, these trees will intercept a total of 1,092,274 gallons of rainfall and help avoid 195,033 gallons of stormwater runoff.

Urban stormwater runoff (or "non-point source pollution") washes chemicals (oil, gasoline, salts, etc.) and litter from surfaces such as roadways and parking lots into streams, wetlands, rivers, and oceans. The more impervious the surface (e.g., concrete, asphalt, rooftops), the more quickly pollutants are washed into our community waterways. Drinking water, aquatic life, and the health of our entire ecosystem can be adversely affected by this process.

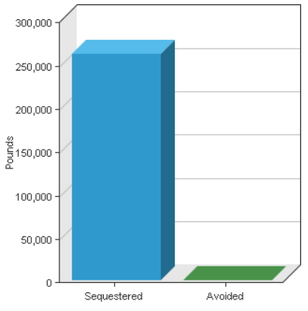
Trees act as mini-reservoirs, controlling runoff at the source. Trees reduce runoff by:

- Intercepting and holding rain on leaves, branches, and bark
- Increasing infiltration and storage of rainwater through the tree's root system
- Reducing soil erosion by slowing rainfall before it strikes the soil

Please see this document for more on stormwater modeling and estimated value differences between i-Tree applications: iTree Streets/Design/Eco Rainfall Interception Model Comparison.

Overall Benefits | Stormwater | Energy | Air Quality | Carbon Dioxide

Current Year (2022) | Future Year (2062) | Total (2022-2062) | Total to Date



Over the next 40 years, these trees will reduce atmospheric carbon dioxide (CO_2) by a total amount of 262,002 pounds.

How significant is this number? Most car owners of an "average" car (mid-sized sedan) drive 12,000 miles (19,312 kilometers) generating about 11,000 pounds (4,990 kilograms) of carbon dioxide (CO_2) every year. A flight from New York to Los Angeles adds 1,400 pounds (635 kilograms) of CO_2 per passenger. Trees can have an impact by reducing atmospheric carbon in two primary ways (see figure at left):

- They sequester ("lock up") CO_2 in their roots, trunks, stems, and leaves while they grow, and in wood products after they are harvested.
- Trees near buildings can reduce heating and air conditioning demands, thereby reducing emissions associated with power production. However, if a tree produces no energy benefits there will be no resulting avoided CO_2.

Combating climate change will take a worldwide, multifaceted approach, but by planting a tree in a strategic location, driving fewer miles/kilometers, or replacing business trips with conference calls, it's easy to see how we can each reduce our individual carbon "footprints".

EPA National Stormwater Calculator

NEW SAVE OPEN RESOURCES CONTACT

- Location
- Soil Type
- Soil Drainage
- Topography
- Precipitation/Evaporation
- Climate Change
- Land Cover
- LID Controls
- Project Cost
- Results

LID Controls

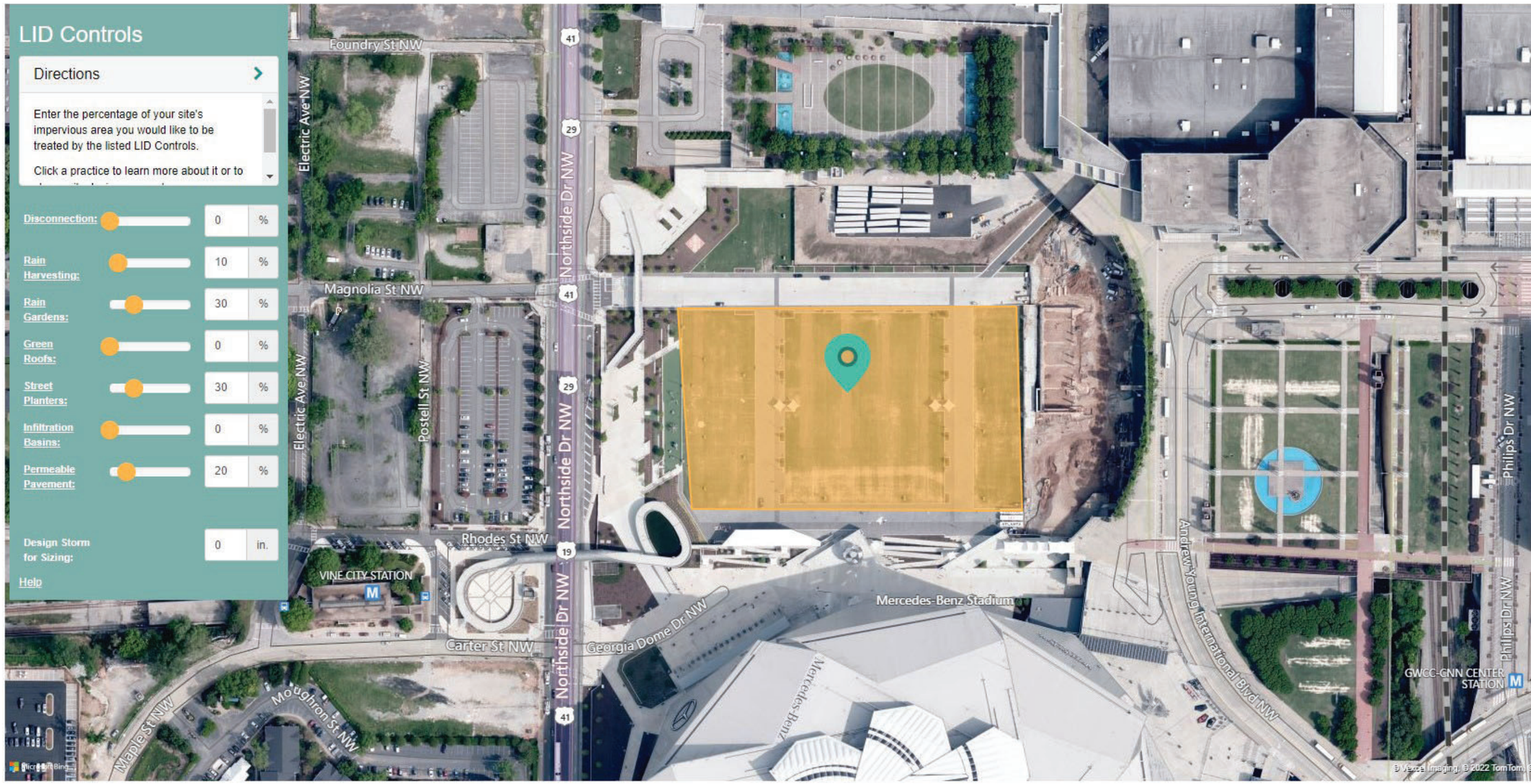
Directions

Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.

Click a practice to learn more about it or to

Disconnection:	0	%
Rain Harvesting:	10	%
Rain Gardens:	30	%
Green Roofs:	0	%
Street Planters:	30	%
Infiltration Basins:	0	%
Permeable Pavement:	20	%
Design Storm for Sizing:	0	in.

Help



Location
Soil Type
Soil Drainage
Topography
Precipitation/Evaporation
Climate Change
Land Cover
LID Controls
Project Cost
Results

Results

Directions

The Results page is where the site's hydrologic response to a long term period of historical hourly rainfall is computed and reported on. Statistics for both annual and daily rainfall/runoff are presented.

The user controls on this page are grouped together in three sections:

1. Options

The Options section allows you to specify how the rainfall record should be analyzed with respect to:

- The number of most recent years of rainfall record to use,
- The minimum amount of daily rainfall or runoff that will constitute a measurable event,
- Whether subsequent days of back to back daily events should be counted or not.

2. Actions

The Actions section contains commands that allow you to:

- Refresh results after site data have changed.
- Use the most current results as a baseline scenario that can be compared with results from subsequent runs.

3. Reports

The Reports section allows you to select how the rainfall/runoff results generated for the site should be displayed.

Options:

Years to Analyze:

20

Event Threshold:

0.1

☐ **Ignore Consecutive Days**

Actions:

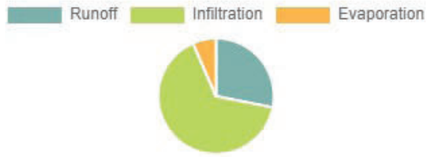
Refresh Results | Use as Baseline Scenario | Remove Baseline Scenario | Print Results to PDF File

Reports:

Summary Results

Current Scenario

Annual Rainfall: 52.71 in.



Baseline Scenario

Annual Rainfall: 52.71 in.

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	52.71	52.71
Average Annual Runoff (inches)	14.97	22.32
Days per Year with Rainfall	83.09	83.09
Days per Year with Runoff	24.23	39.47
Percent of Wet Days Retained	70.84	52.50
Smallest Rainfall w/ Runoff (inches)	0.21	0.18
Largest Rainfall w/o Runoff (inches)	1.23	0.55
Max Rainfall Retained (inches)	1.69	1.33

Carbon Conscience

Metrics

Carbon impacts update in realtime as you test landuse assumptions. Carbon units (tCO_2) are tonnes of CO_2.

Mean Embodied Carbon

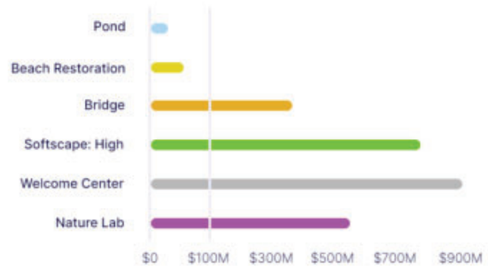
Insight: Reduce your embodied carbon by adding more landscape landuse softscapes.

Total Range: 97,719 tCO_2 - 145,022 tCO_2

Cost

Insight: Your project is less expensive and more aligned to your design goals because of the landuse's you choose.

Total Cost: $2860.87M



Landuse Manager

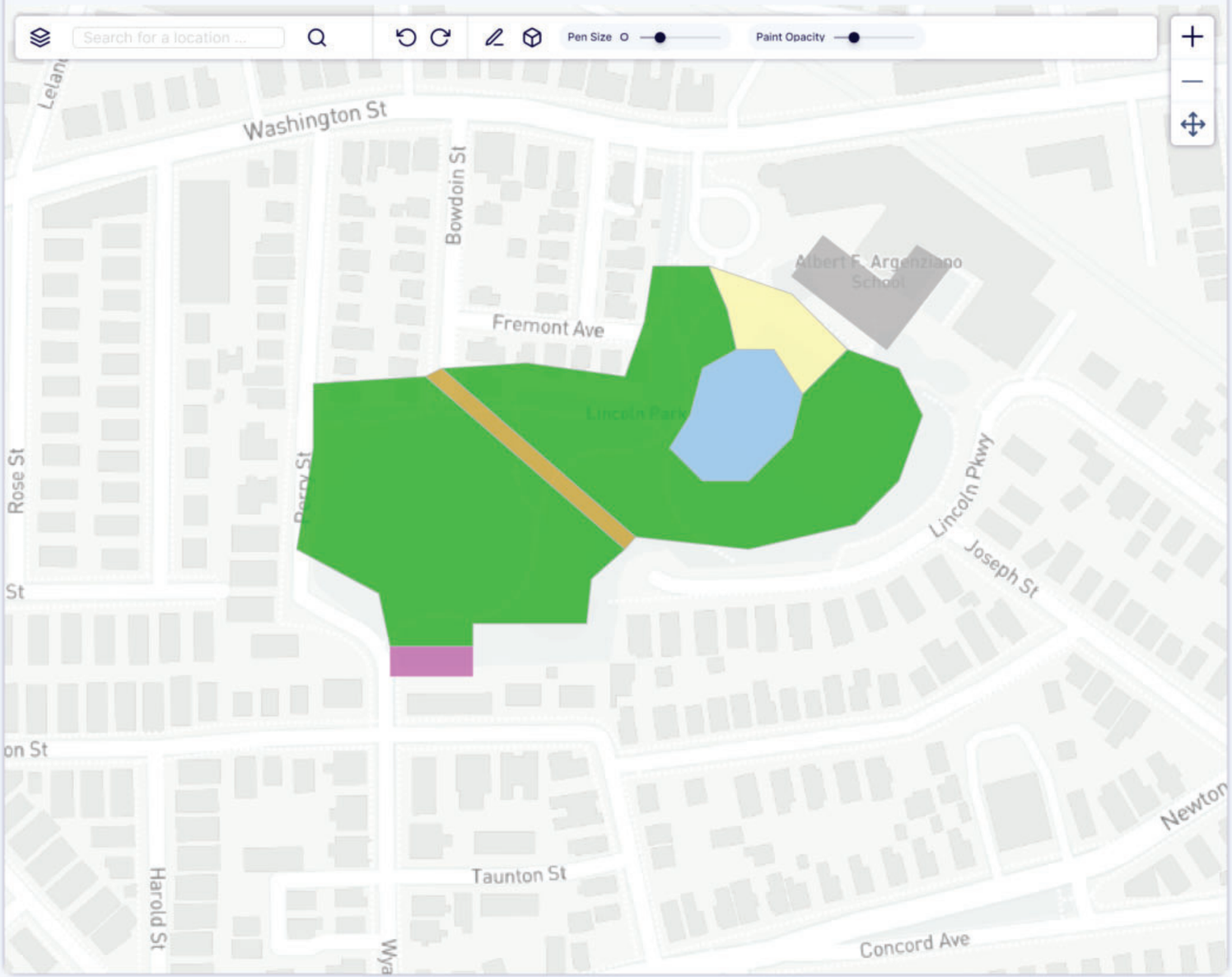
Create and edit landuse elements, then assign materials to see impacts

- Pond
- Beach Restoration
- Bridge
- Softscape: High
- Welcome Center
- Nature Lab

Create Landuse >

Map Paint

Once connected, your painted areas will be automatically applied to the matching landuses.



THANK YOU

SOURCES / IMAGE CREDITS

PRIORITIZING PRESERVATION
Toronto Ravine Strategy - City of Toronto
Chattahoochee RiverLands - Trust for Public Land & SCAPE Landscape Architecture
Moore Square - Christopher Counts Studio
Rosa Keller Library - Spackman Mossop Michaels
Tree Preservation Initiatives - City of Fayetteville, North Carolina

IMPROVING PERFORMANCE
Central Wharf Plaza - Reed Hilderbrand
Walnut Street - WMWA Landscape Architects
Patten Square - WMWA Landscape Architects
Chicago Riverwalk - SASAKI & GreenBlue

DAYLIGHTING & STACKING BENEFITS
Cheonggyecheon Stream Restoration - SeoAhn Total Landscape
Central Park - F.L. Olmsted & Central Park Conservancy
Sponge City - Turenscape
Bagby Street - Design Workshop
Shoemaker Green - Andropogon Associates

REFLECTING NATURE ... CREATIVELY
Getty Museum Central Green - Robert Irwin
Bodegas Tio Pepe - Aiden McRae Thomson
Biltmore Estate Terrace - L. Woodall
Mint Plaza - CMG Landscape Architects
Singapore Super Trees - Wilkinson Eyre / Grant Associates

LEVERAGING TOOLS
iTree - USDA Forest Service, Davey Tree Expert Company, The Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry
National Stormwater Calculator - US EPA
Carbon Conscience - SASAKI