Managing Flooding by Coupling Green Infrastructure with Gray Infrastructure on a Watershed Scale

Rutgers
New Jersey Agricultural Experiment Station

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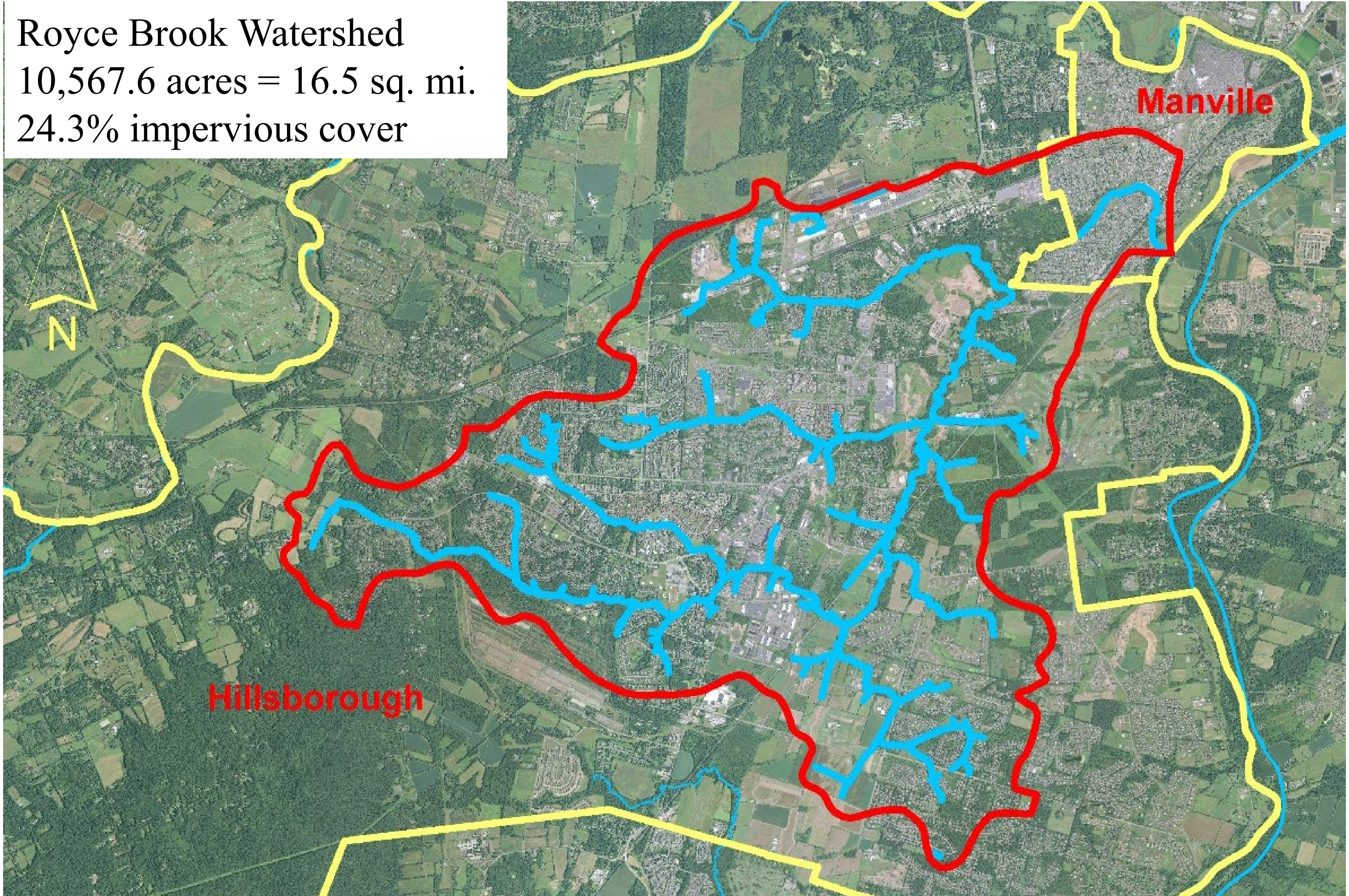
The death toll in New Jersey from Ida was 30 people; two of those victims were Hillsborough residents. The storm dumped **10 inches of rain in Hillsborough in a matter of hours**, and caused $95 billion in damages statewide to homes, businesses, and infrastructure.

Royce Brook Watershed
10,567.6 acres = 16.5 sq. mi.
24.3% impervious cover




Manville


Holy Ghost

Project Goal is to Reduce Flooding in Hillsborough and Manville (supported by NFWF Coastal Resiliency Fund)

- Design stormwater management systems that will manage the 100-year storm from existing development using the climate prediction rainfall total for 2100 of 12.15 inches
- Prioritize nature-based solutions; nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience
- Design retrofits to manage the increase in rainfall due to climate change for sites that already have stormwater management

Condition (100-yr Design Storm)	24-hour rainfall total (in)
2000 Rainfall Total	8.21
2020 Rainfall Total	8.95
2100 Rainfall Total	12.15

Types of Nature-Based Solutions (FEMA, 2021)

- **WATERSHED OR LANDSCAPE SCALE**: Interconnected systems of natural areas and open space. These are large-scale practices that require long-term planning and coordination.
- **NEIGHBORHOOD OR SITE SCALE**: Distributed stormwater management practices that manage rainwater where it falls. These practices can often be built into a site, corridor, or neighborhood without requiring additional space.
- **COASTAL AREAS**: Nature-based solutions that stabilize the shoreline, reducing erosion and buffering the coast from storm impacts. While many watershed and neighborhood-scale solutions work in coastal areas, these systems are designed to support coastal resilience.

WATERSHED SCALE

LAND CONSERVATION

Land conservation is one way of preserving interconnected systems of open space that sustain healthy communities.

Land conservation projects begin by prioritizing areas of land for acquisition. Land or conservation easements can be bought or acquired through donation.

GREENWAYS

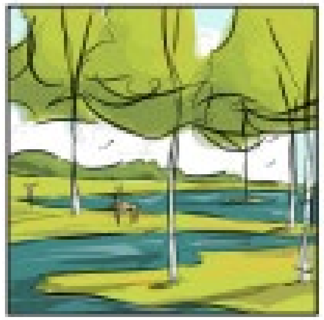
Greenways are corridors of protected open space managed for both conservation and recreation.

Greenways often follow rivers or other natural features. They link habitats and provide networks of open space for people to explore and enjoy.

FLOODPLAIN RESTORATION

Undisturbed floodplains help keep waterways healthy by storing floodwaters, reducing erosion, filtering water pollution, and providing habitat.

Floodplain restoration rebuilds some of these natural functions by reconnecting the floodplain to its waterway.



WETLAND RESTORATION AND PROTECTION

Restoring and protecting wetlands can improve water quality and reduce flooding. Healthy wetlands filter, absorb, and slow runoff.

Wetlands also sustain healthy ecosystems by recharging groundwater and providing habitat for fish and wildlife.

STORMWATER PARKS

Stormwater parks are recreational spaces that are designed to flood during extreme events and to withstand flooding.

By storing and treating floodwaters, stormwater parks can reduce flooding elsewhere and improve water quality.

NEIGHBORHOOD OR SITE SCALE

RAIN GARDENS

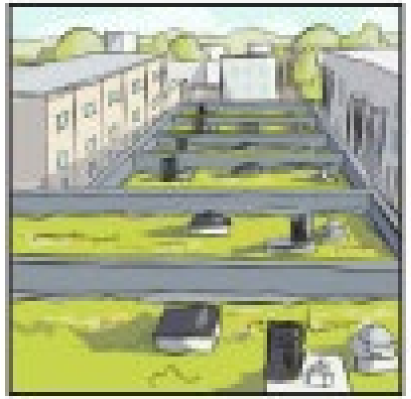
A rain garden is a shallow, vegetated basin that collects and absorbs runoff from rooftops, sidewalks, and streets.

Rain gardens can be added around homes and businesses to reduce and treat stormwater runoff.

VEGETATED SWALES

A vegetated swale is a channel holding plants or mulch that treats and absorbs stormwater as it flows down a slope.

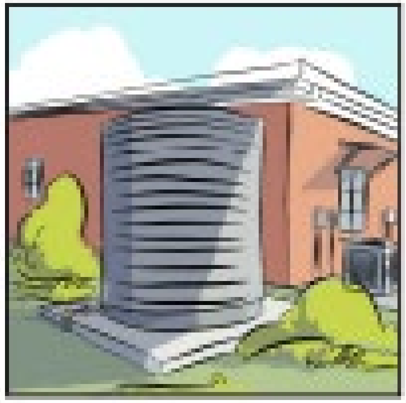
Vegetated swales can be placed along streets and in parking lots to soak up and treat their runoff, improving water quality.



GREEN ROOFS

A green roof is fitted with a planting medium and vegetation. A green roof reduces runoff by soaking up rainfall. It can also reduce energy costs for cooling the building.

Extensive green roofs, which have deeper soil, are more common on commercial buildings. Intensive green roofs, which have shallower soil, are more common on residential buildings.



RAINWATER HARVESTING

Rainwater harvesting systems collect and store rainfall for later use. They slow runoff and can reduce the demand for potable water.

Rainwater systems include rain barrels that store tens of gallons and rainwater cisterns that store hundreds or thousands of gallons.

PERMEABLE PAVEMENT

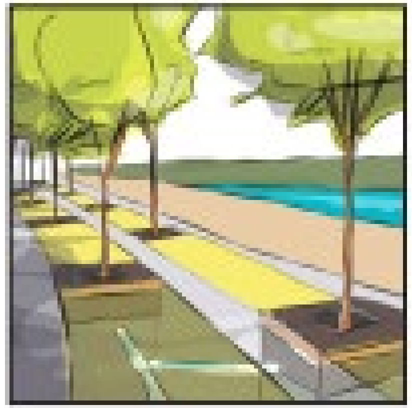
Permeable pavements allow more rainfall to soak into the ground. Common types include pervious concrete, porous asphalt, and interlocking pavers.

Permeable pavements are most commonly used for parking lots and roadway shoulders.

TREE CANOPY

Tree canopy can reduce stormwater runoff by catching rainfall on branches and leaves and increasing evapotranspiration. By keeping neighborhoods cooler in the summer, tree canopy can also reduce the "urban heat island effect."

Because of trees' many benefits, many cities have set urban tree canopy goals.



TREE TRENCHES

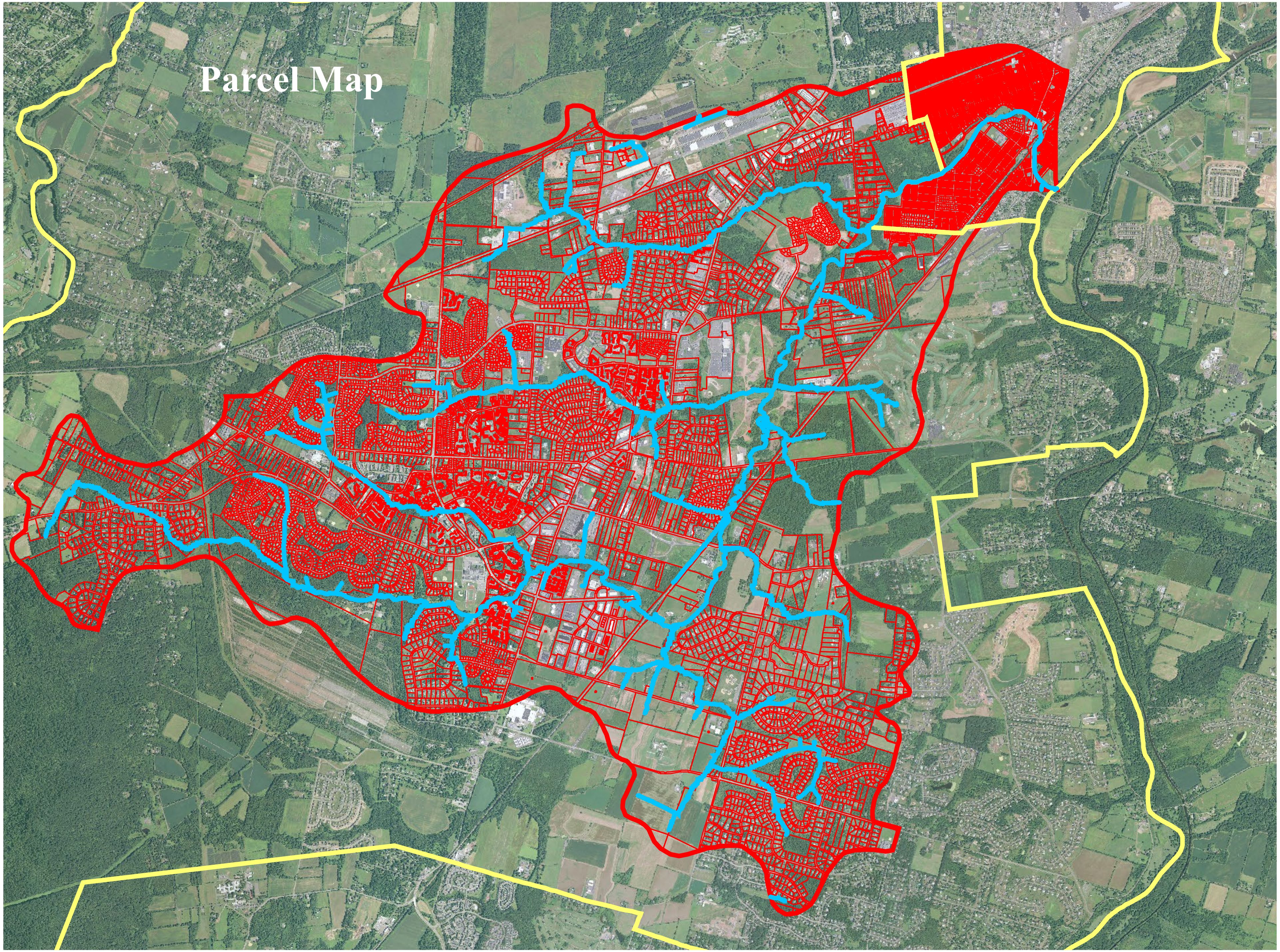
A stormwater tree trench is a row of trees planted in an underground infiltration structure made to store and filter stormwater.

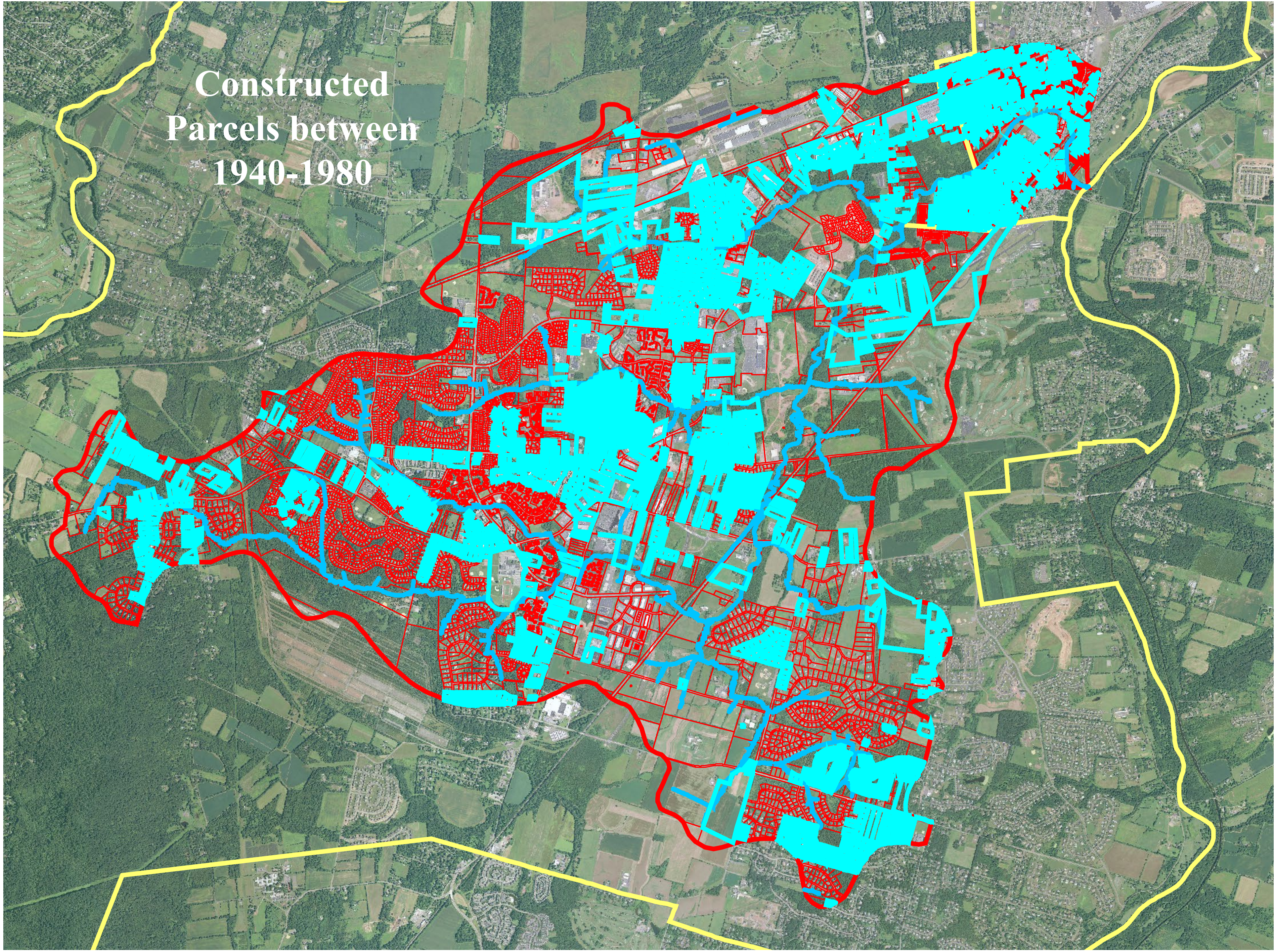
Tree trenches can be added to streets and parking lots with limited space to manage stormwater.

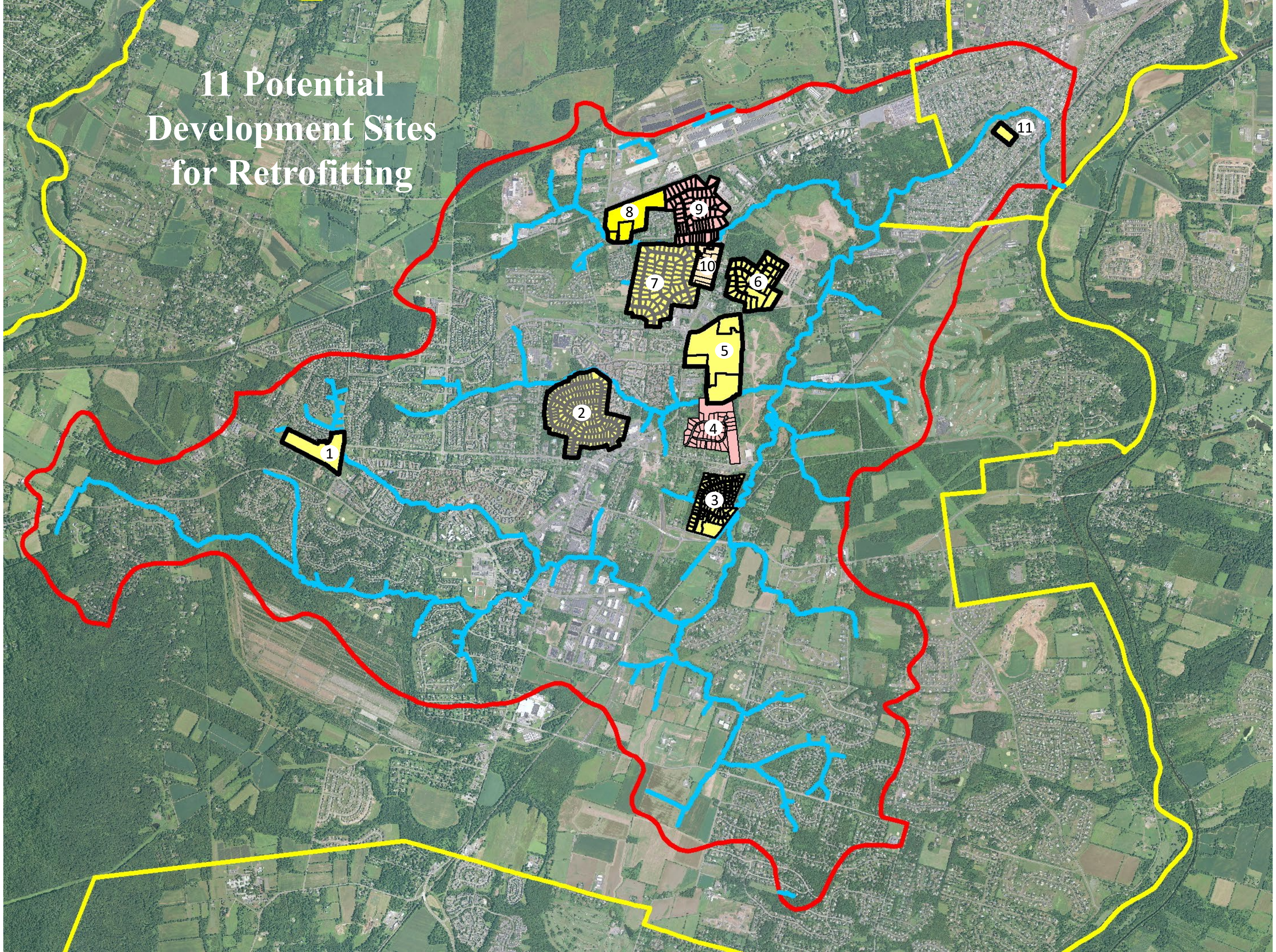
GREEN STREETS

Green streets use a suite of green infrastructure practices to manage stormwate runoff and improve water quality.

Adding green infrastructure features to a street corridor can also contribute to a safer and more attractive environment for walking and biking.


Parcel Map


Constructed
Parcels between
1940-1980



11 Potential Development Sites for Retrofitting
1
2
3
4
5
6
7
8
9
10
11

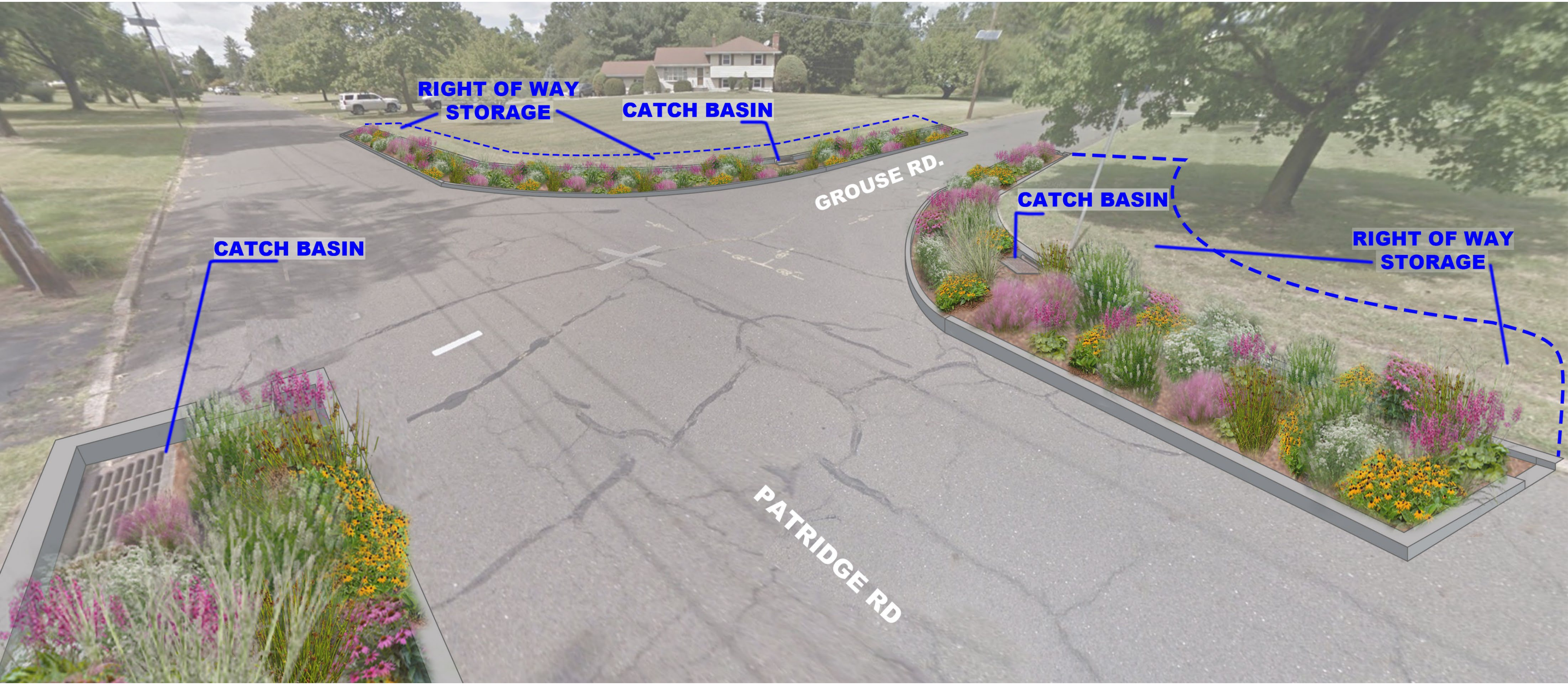
11 Potential Development Sites for Retrofitting

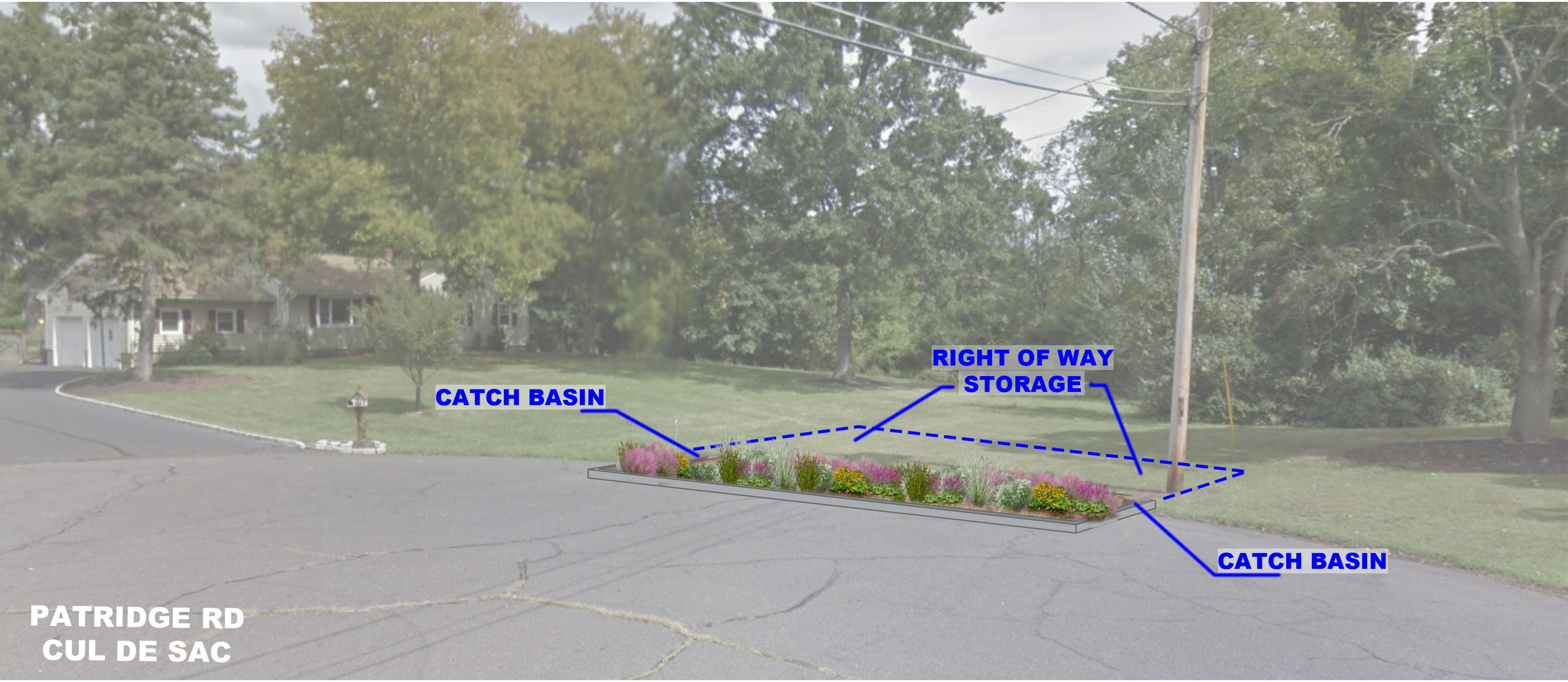
- 673.4 acres = 1.05 sq. mi.
- Six residential developments
- Three commercial sites (one with some stormwater management)
- One municipal site
- One public school
- Possible solutions
  - Constructed wetlands
  - Bioretention
  - Permeable pavement
  - Roadside rain gardens
  - Homeowner rain gardens

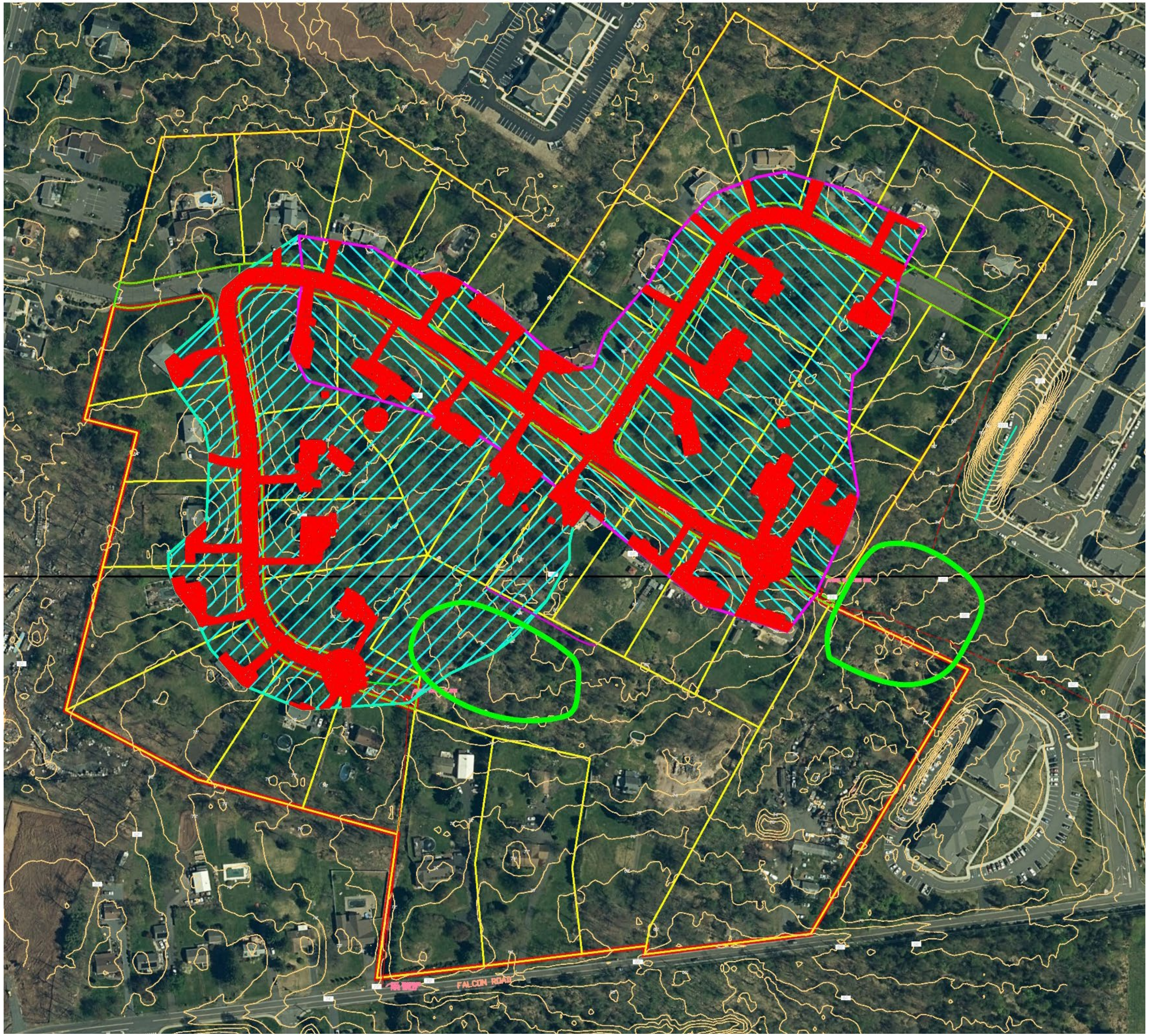
Site 6 – Partridge Rd Development

Total Area = 2,574,518 sq. ft. = 59.1 acres

Impervious Surface = 4,557,478 sq. ft. = 10.5 acres


RIGHT OF WAY
STORAGE
CATCH BASIN
GROUSE RD.
CATCH BASIN
RIGHT OF WAY
STORAGE
CATCH BASIN
PATRIDGE RD


RIGHT OF WAY
STORAGE
CATCH BASIN
CATCH BASIN
PATRIDGE RD
CUL DE SAC



Two bioretention systems can capture 40.3% of the drainage area including 51.4% of the impervious cover.

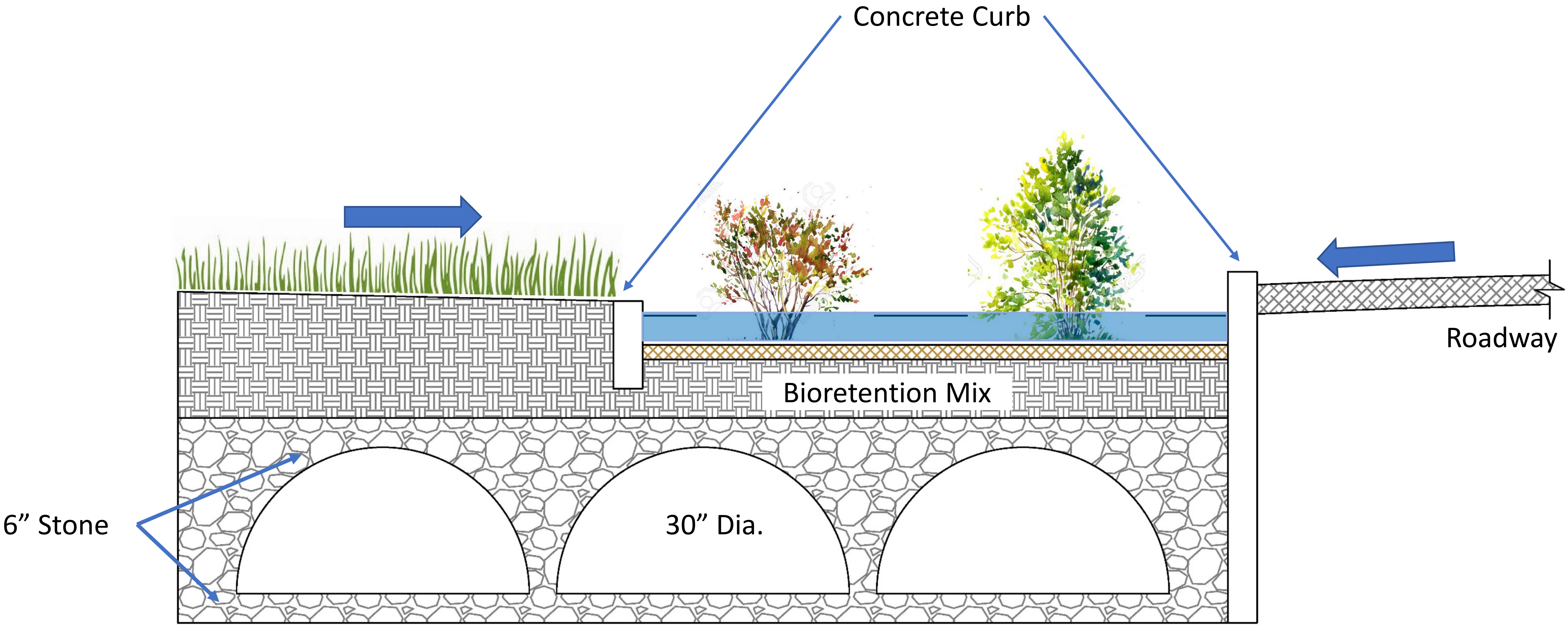
23 Bioswales = 47,375 cu. ft. storage

Bioswales capture and treat runoff for first 2″ of rainfall

Basin 1 = 233,464 cu. ft. storage

Basin 2 = 266,220 cu. ft. storage

Total Storage = 547,059 cu. ft.


Concrete Curb
Roadway
Bioretention Mix
6” Stone
30” Dia.

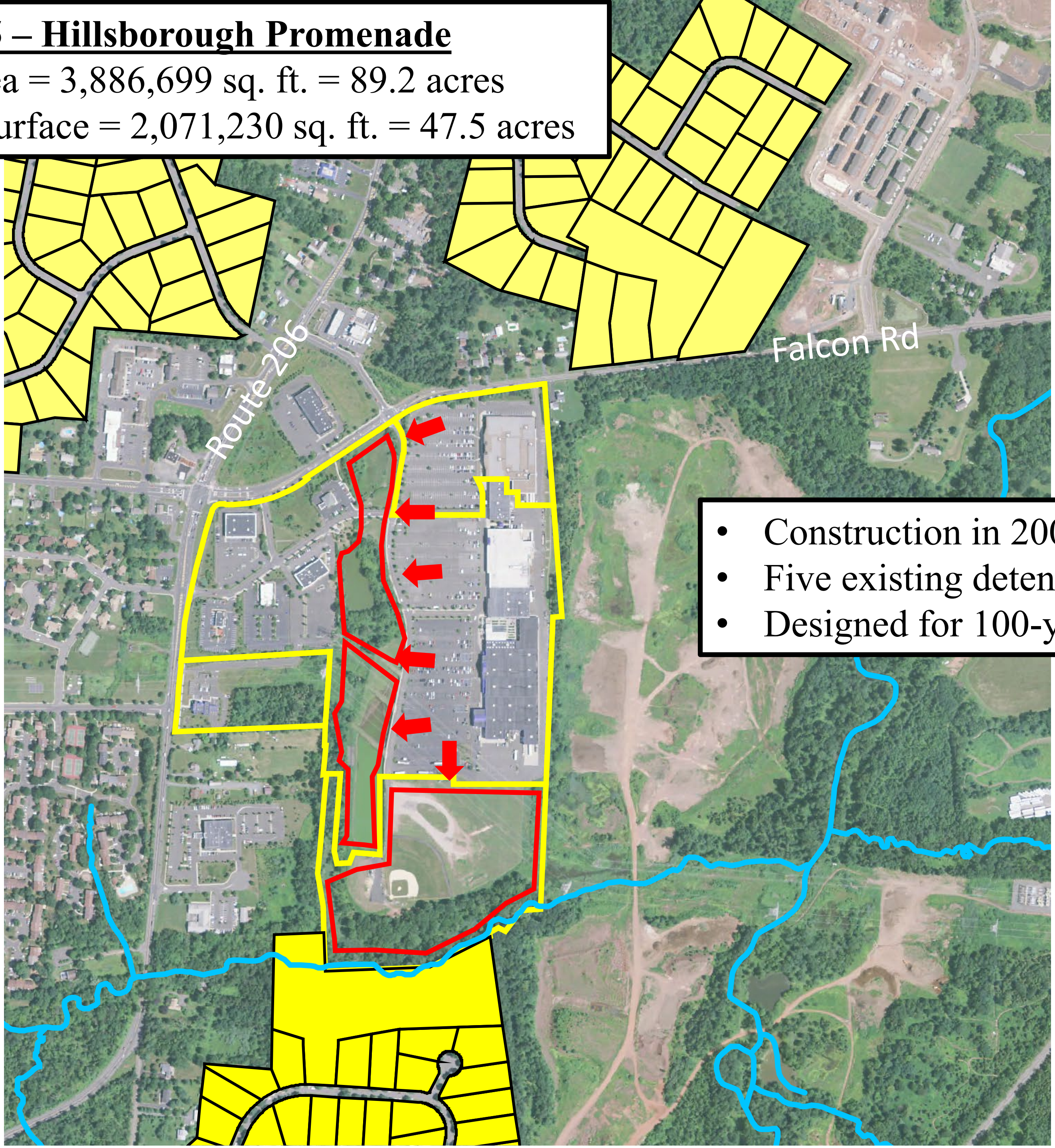
Preliminary Design Results

100-year Storm	Rainfall (in)	Volume (cu. Ft.)	Volume Managed (%)
2000	8.21	510,868	107.1%
2020	8.95	572,362	95.6%
2100	12.15	839,248	65.2%

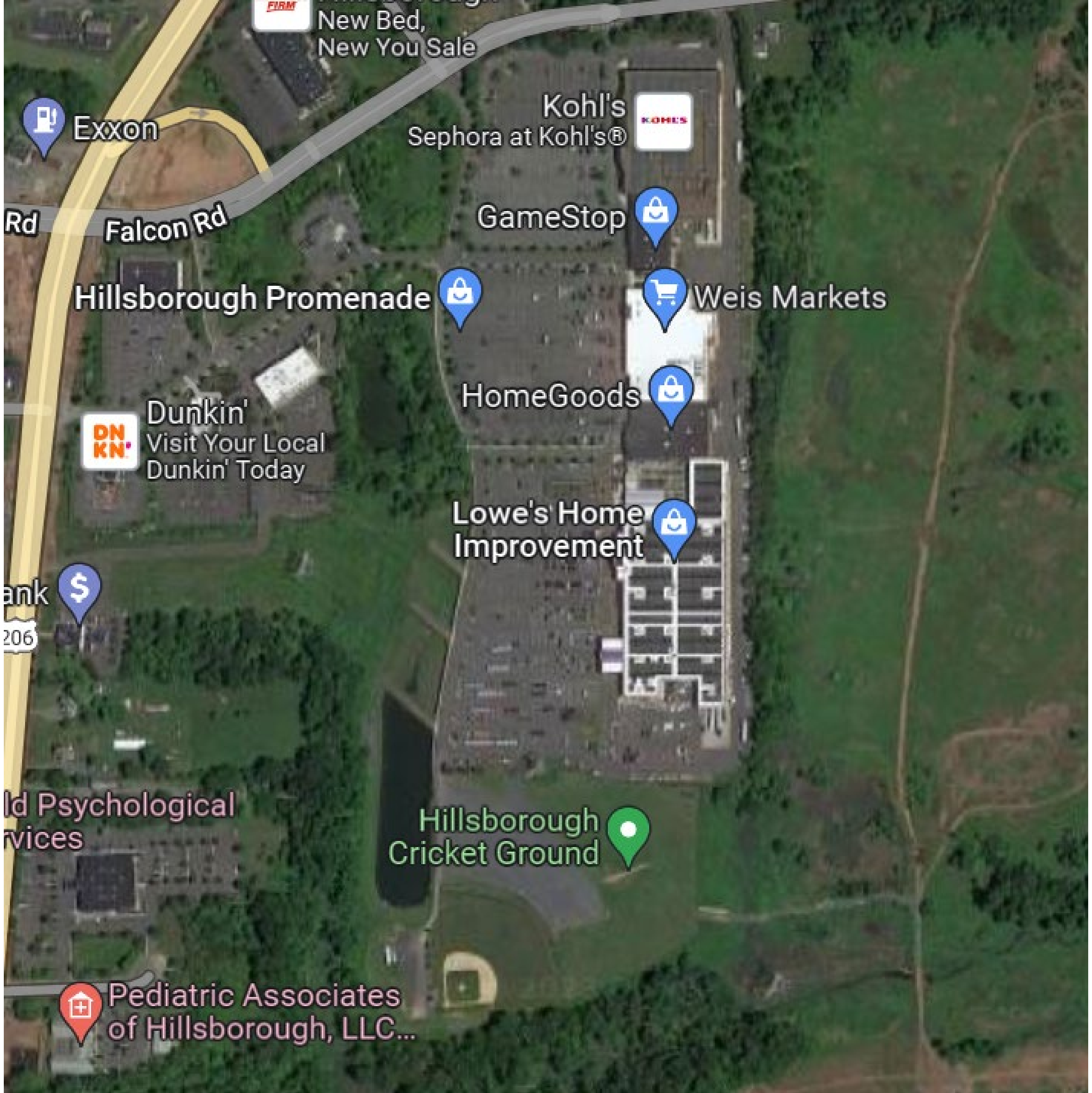
Site 5 – Hillsborough Promenade

Total Area = 3,886,699 sq. ft. = 89.2 acres

Impervious Surface = 2,071,230 sq. ft. = 47.5 acres



- Construction in 2005
- Five existing detention basins manage 59.5 acres
- Designed for 100-year storm = 8.21″


New Bed,
New You Sale
Kohl's
Sephora at Kohl's®
Exxon
Falcon Rd
Rd
GameStop
Hillsborough Promenade
Weis Markets
HomeGoods
Dunkin'
Visit Your Local
Dunkin' Today
Lowe's Home
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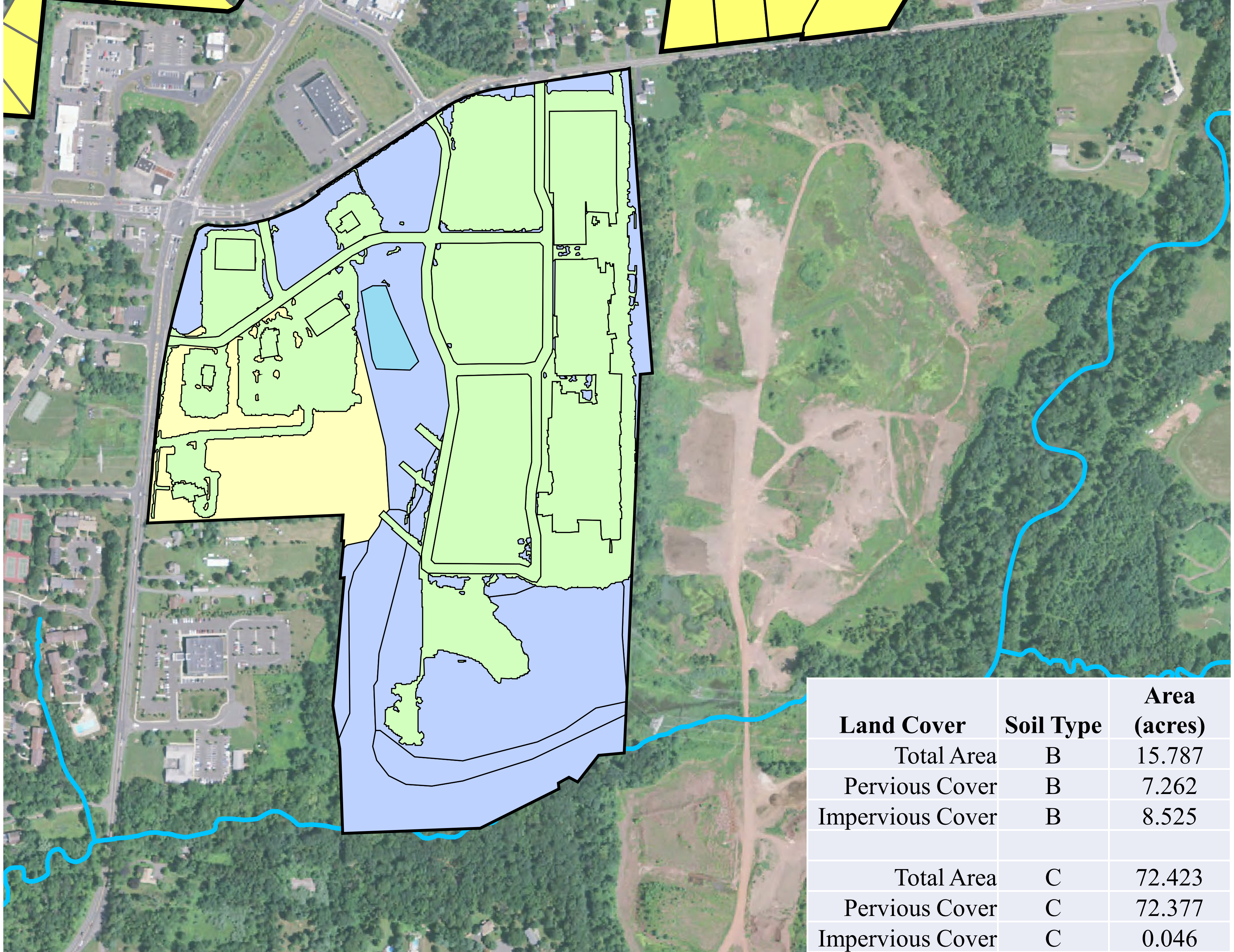
Hillsborough
Cricket Ground
Pediatric Associates
of Hillsborough, LLC...



Land Cover	Soil Type	Area (acres)
Total Area	B	15.787
Pervious Cover	B	7.262
Impervious Cover	B	8.525
Total Area	C	72.423
Pervious Cover	C	72.377
Impervious Cover	C	0.046

HILLSBOROUGH PLAZA

GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
256 US-206, HILLSBOROUGH CITY]
SOMERSET COUNTY, NEW JERSEY

PROJECT DESCRIPTION:

GREEN INFRASTRUCTURE DEMONSTRATION PROJECT WILL BE INSTALLED IN 256 US-206 PLAZA.

1. ISLANDS OF PARKING LOT WILL BE DE-PAVED AND RE-INSTALLED TO BE RAIN GARDENS, TO CAPTURE, INFILTRATE THE STORMWATER RUNOFF FROM THE ROAD.
2. RAIN GARDENS WILL BE INSTALLED ON THE GRASS AREA AROUND THE PLAZA, TO CAPTURE, INFILTRATE THE STORMWATER RUNOFF FROM THE ROAD.
3. PARKING LOT AT THE SOUTH SIDE OF PLANET FITNESS WILL BE REPLACED WITH PERVIOUS CONCRETE TO CAPTURE THE STORMWATER RUNOFF FROM THE ROAD AND THE ROOF.
4. UNDERGROUND STORAGE TANK WILL BE INSTALLED UNDER THE PARKING LOT TO INCREASE THE CAPACITY OF GREEN INFRASTRUCTURES.

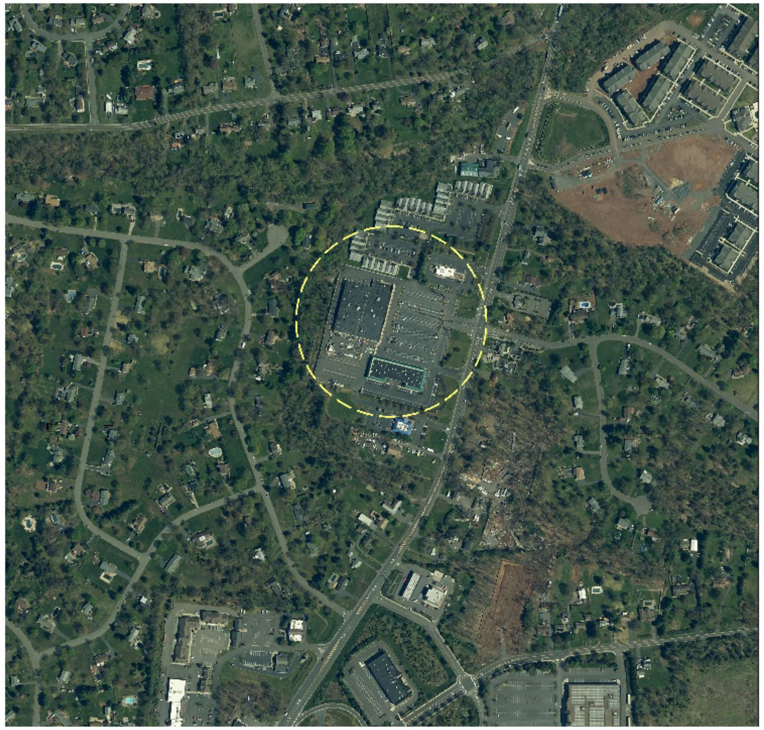
THE PROJECT WILL SERVE AS A DEMONSTRATION FOR CITIZEN TO LEARN ABOUT SUSTAINABLE STORMWATER MANAGEMENT AND LOCAL POLLINATOR ECOLOGY.

LIST OF DRAWINGS:

SHEET NAME	TITLE
COVER	COVER SHEET
P-1	EXISTING CONDITIONS AND DEMOLITION PLAN
P-2	PROPOSED SITE PLAN
DT-1	DETAILS
DT-2	DETAILS 2
DT-3	DETAILS 3
DT-4	DETAILS 4

LOCATION MAP (N.T.S):

N



LEGEND:

- EXISTING DRAINAGE AREA
- EDGE OF PAVEMENT
- EXISTING CENTERLINE
- EXISTING TREELINE
- EXISTING TREE/SHRUB
- EXISTING BUILDING
- EXISTING LIGHT POLE
- AREA TO BE DEPAVED
- PROPOSED GREEN INFRASTRUCTURE
- PROPOSED POROUS ASPHALT
- PROPOSED TOP OF BERM

GENERAL NOTES:

1. SURVEY CONDUCTED BY RUTGERS COOPERATIVE EXTENSION WATER RESOURCES PROGRAM. ALL ELEVATIONS ARE RELATIVE TO THE 100.00' BENCHMARK POINT. (OR ELEVATION DATA OBTAINED FROM [INSERT DATA SOURCE HERE, TYP NOAA DIGITAL COASTAL LIDAR]. ELEVATION ARE HEIGHT ABOVE MEAN SEA LEVEL SET BY NAVD 1988).
2. EXISTING SOILS ARE PENN SILT LOAM WHICH ARE CLASSIFIED AS HYDROLOGIC SOIL GROUP C WHICH HAVE LOW INFILTRATION RATES BASED ON THE NRCS WEB SOIL SURVEY (websoilsurvey.sc.egov.usda.gov).
3. ANY OVERHEAD AND UNDERGROUND UTILITIES SHOWN ARE FROM FIELD OBSERVATIONS AND ARE NOT A COMPLETE REPRESENTATION. A UTILITY MARKOUT NEEDS TO BE CONDUCTED PRIOR TO MOBILIZATION BY THOSE RESPONSIBLE FOR EXCAVATION. NJ ONE CALL: 811 OR 800-272-1000

PLAN REVISIONS		
REV. DATE	REV. SUMMARY	REV. SHEETS

CHRISTOPHER C. OBROPTA, Ph.D., P.E.
PROFESSIONAL ENGINEER - NJ LICENSE # 37532

DATE XX/XX/XX

DRAWN | CHECKED | APPROVED CCO | DATE

PLAN REVISIONS: No. | DATE | DESCRIPTION

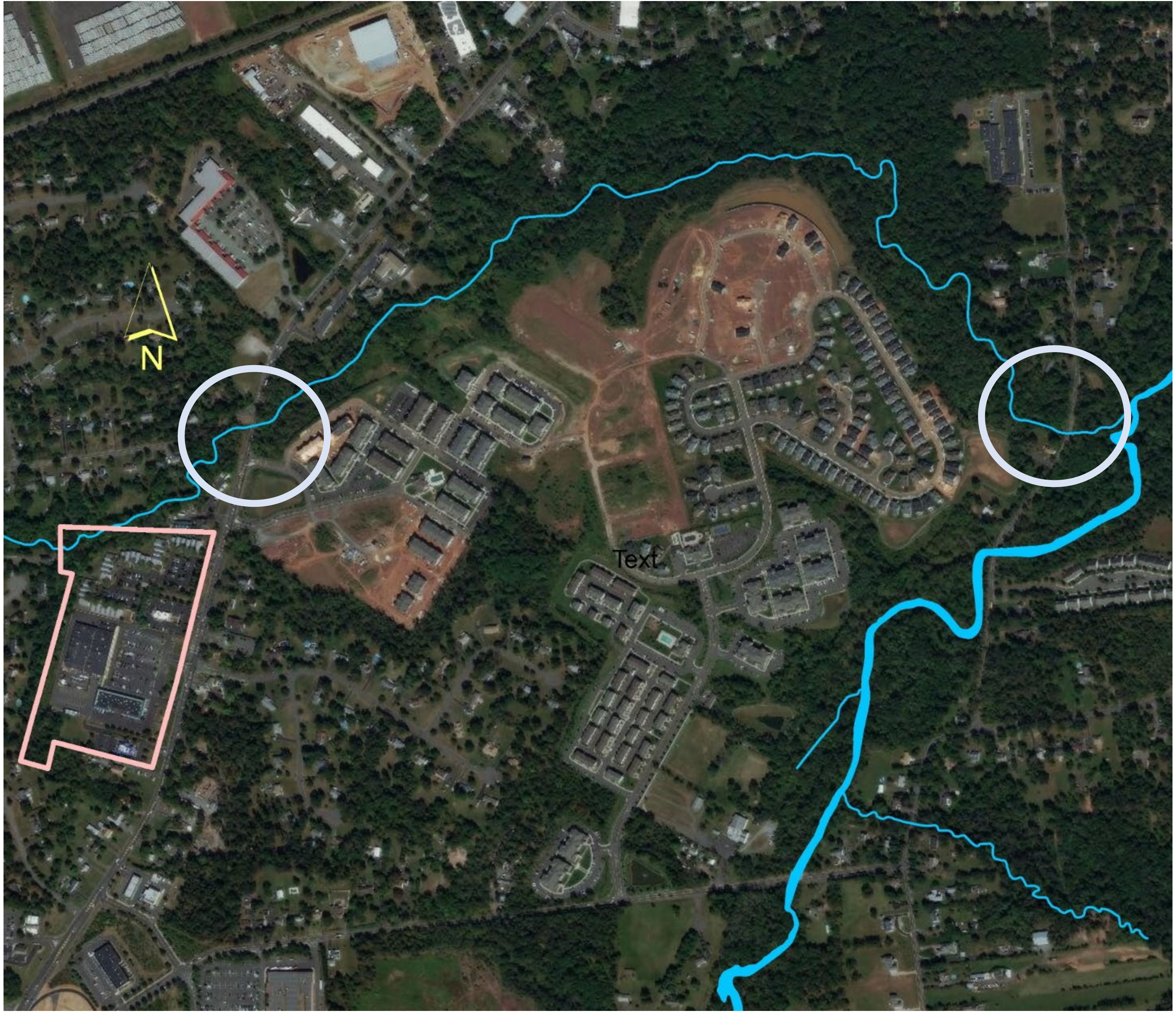
DRAFT

HILLSBOROUGH PLAZA
GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
256 US-126, HILLSBOROUGH CITY]
SOMERSET COUNTY, NJ

COVER SHEET

RUTGERS
New Jersey Agricultural Experiment Station

SHEET NAME
COVER



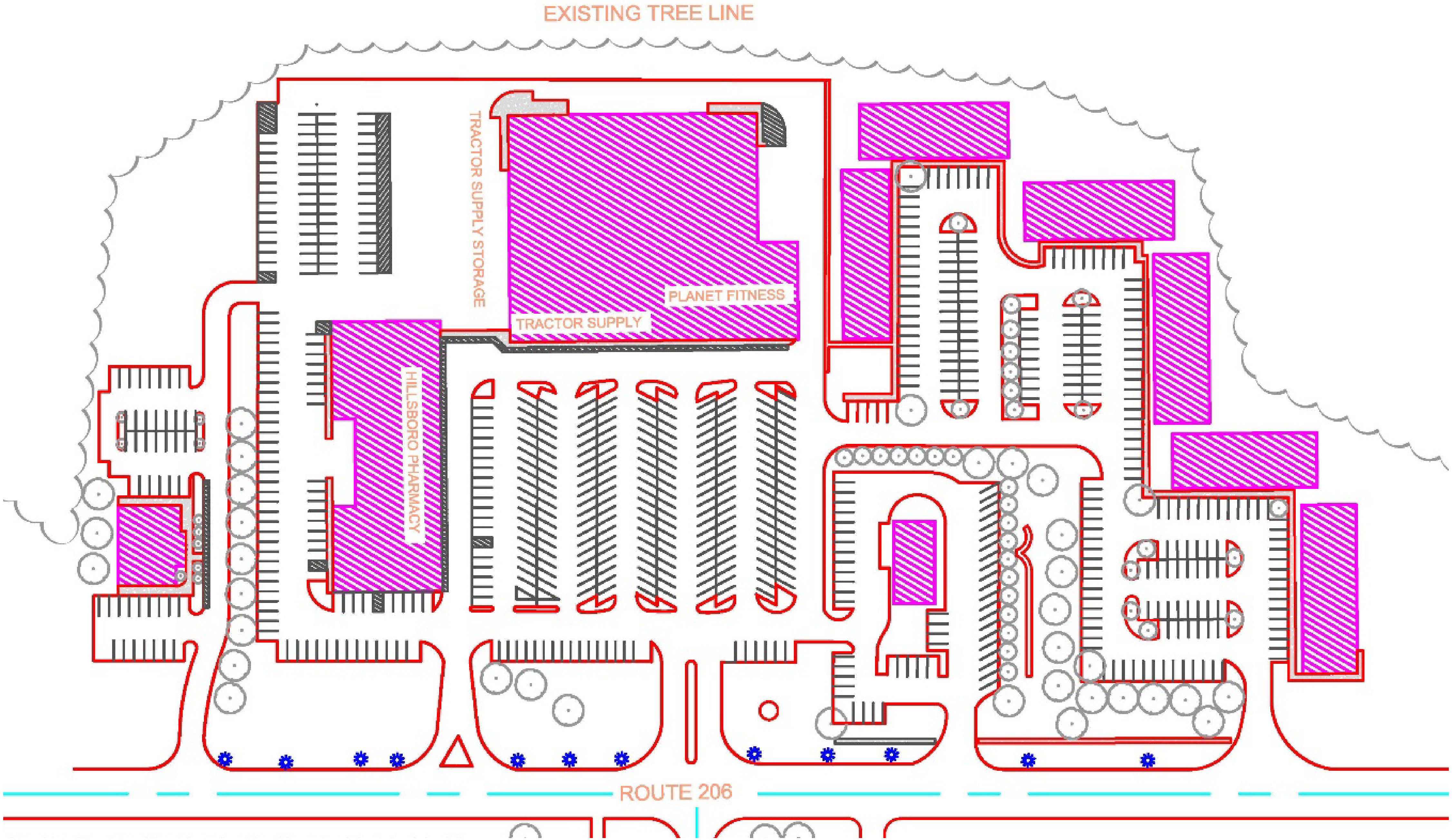
N
Text

Hillsborough Plaza
256 Route 206
Hillsborough, New Jersey


DOLLAR TREE
Google


DOLLAR TREE
Google

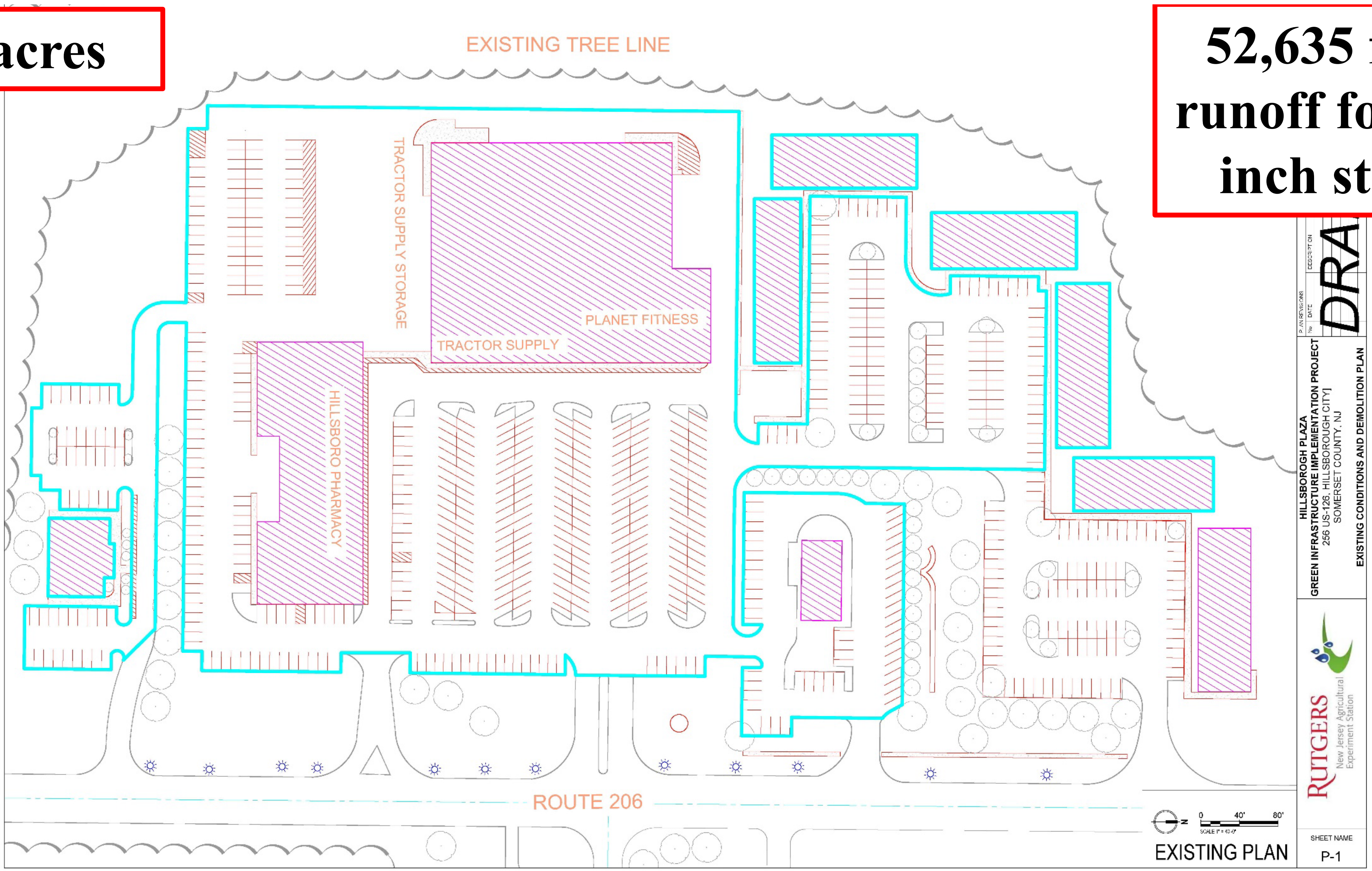

FIRE LANE


EXISTING TREE LINE
TRACTOR SUPPLY STORAGE
PLANET FITNESS
TRACTOR SUPPLY
HILLSBORO PHARMACY
ROUTE 206

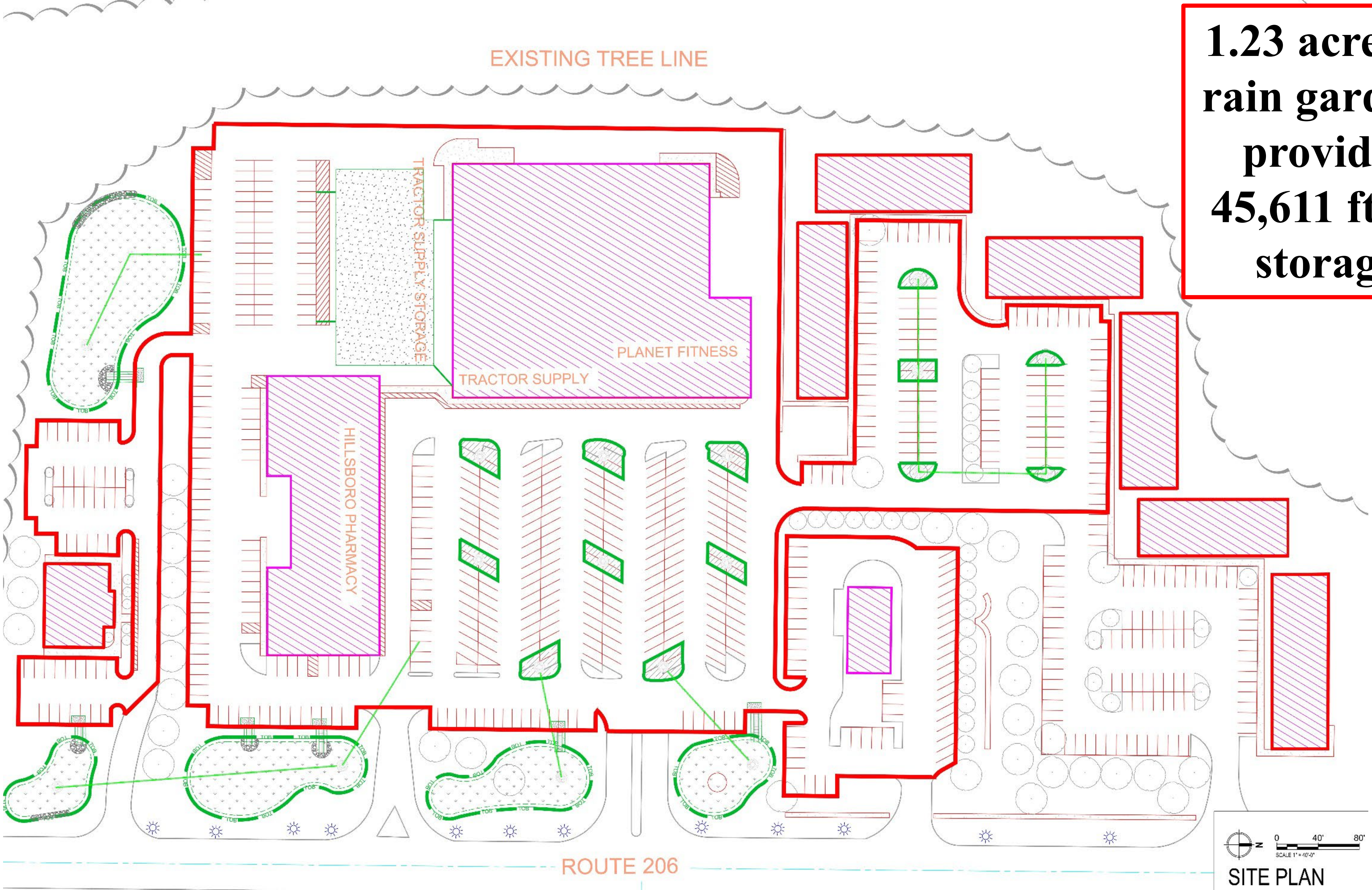
Water Quality Storm Analysis (1.25 inches)

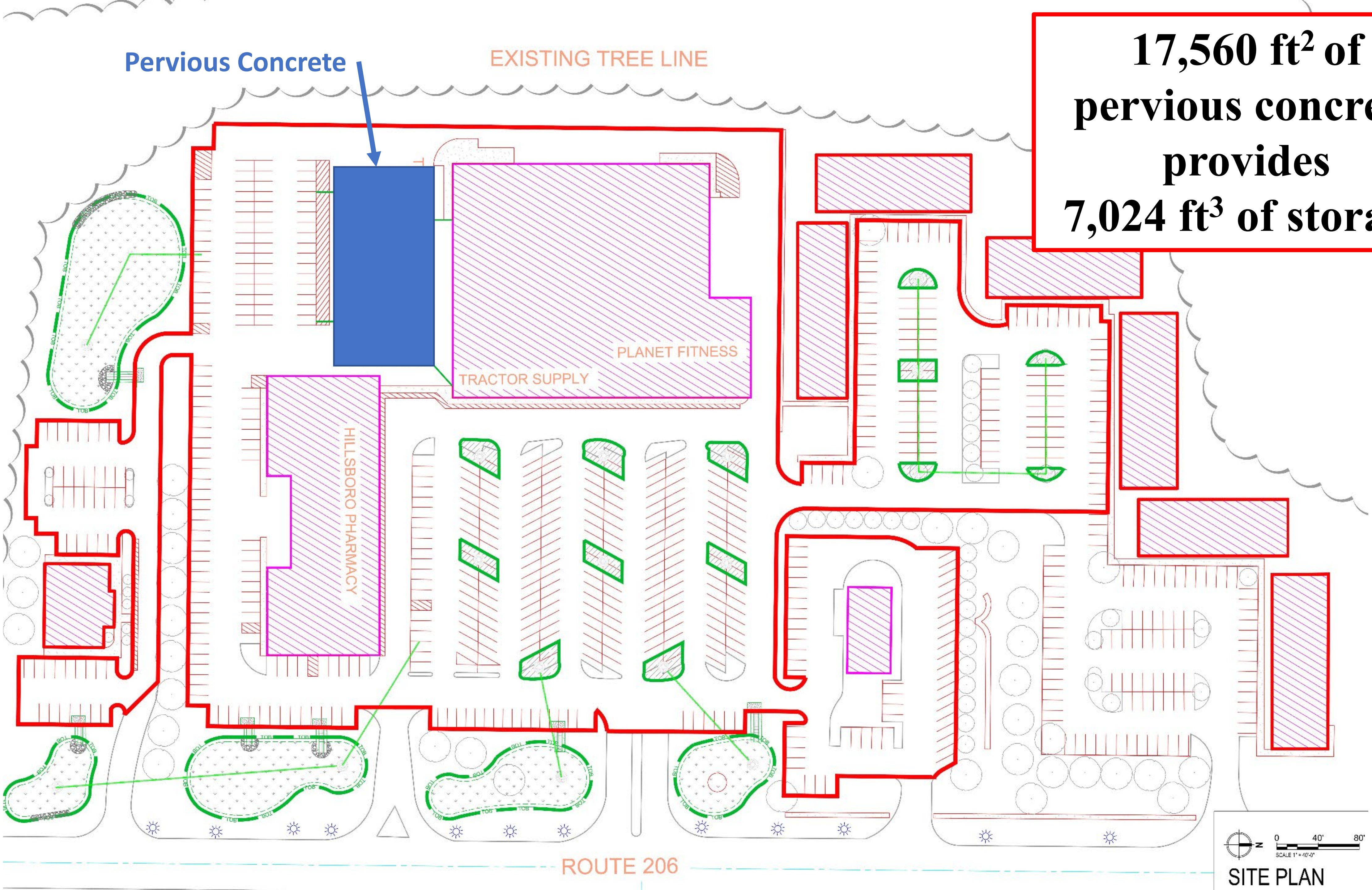
11.6 acres

52,635 ft^3 of runoff for 1.25 inch storm



1.23 acres of rain gardens provides 45,611 ft^3 of storage



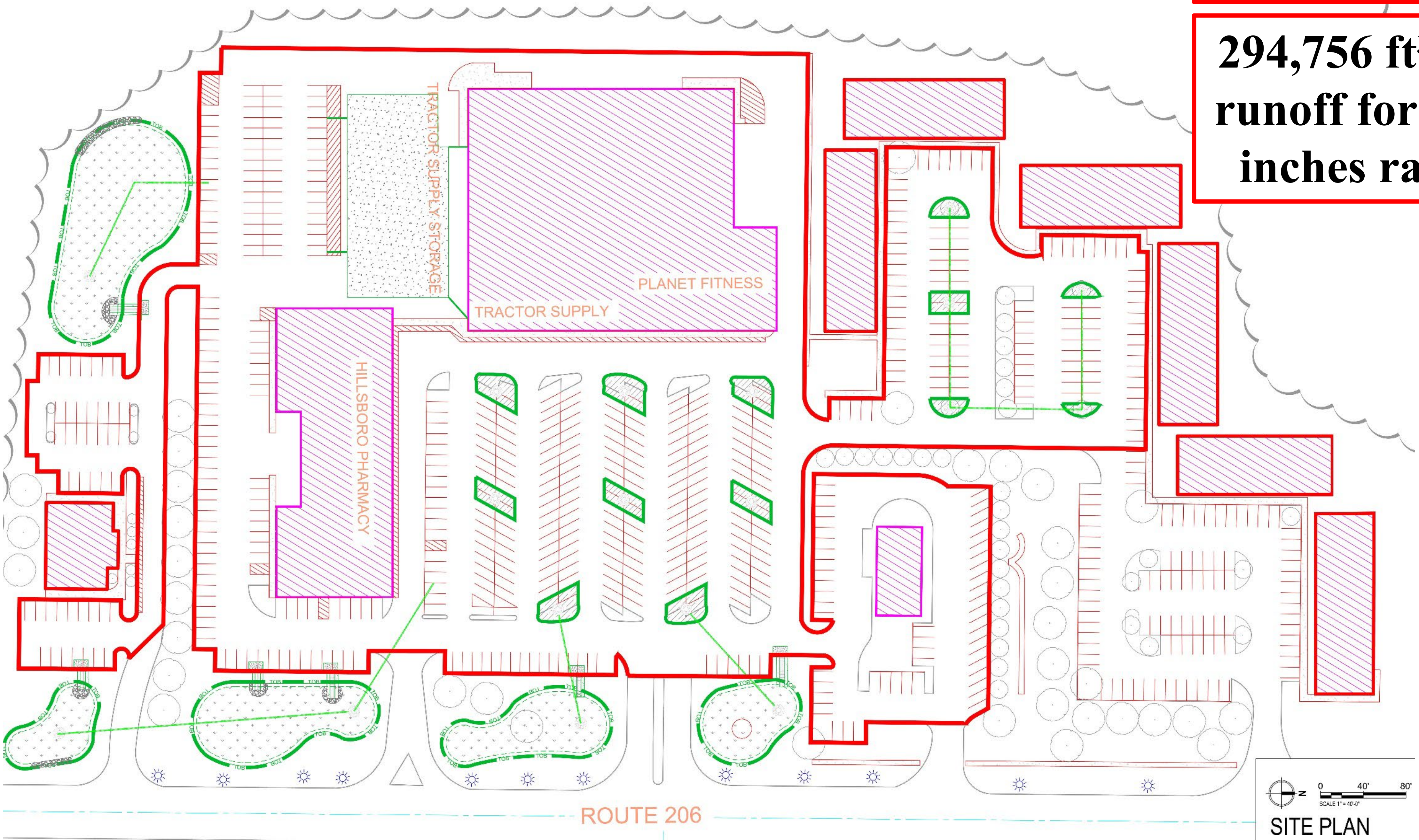


17,560 ft^2 of pervious concrete provides 7,024 ft^3 of storage

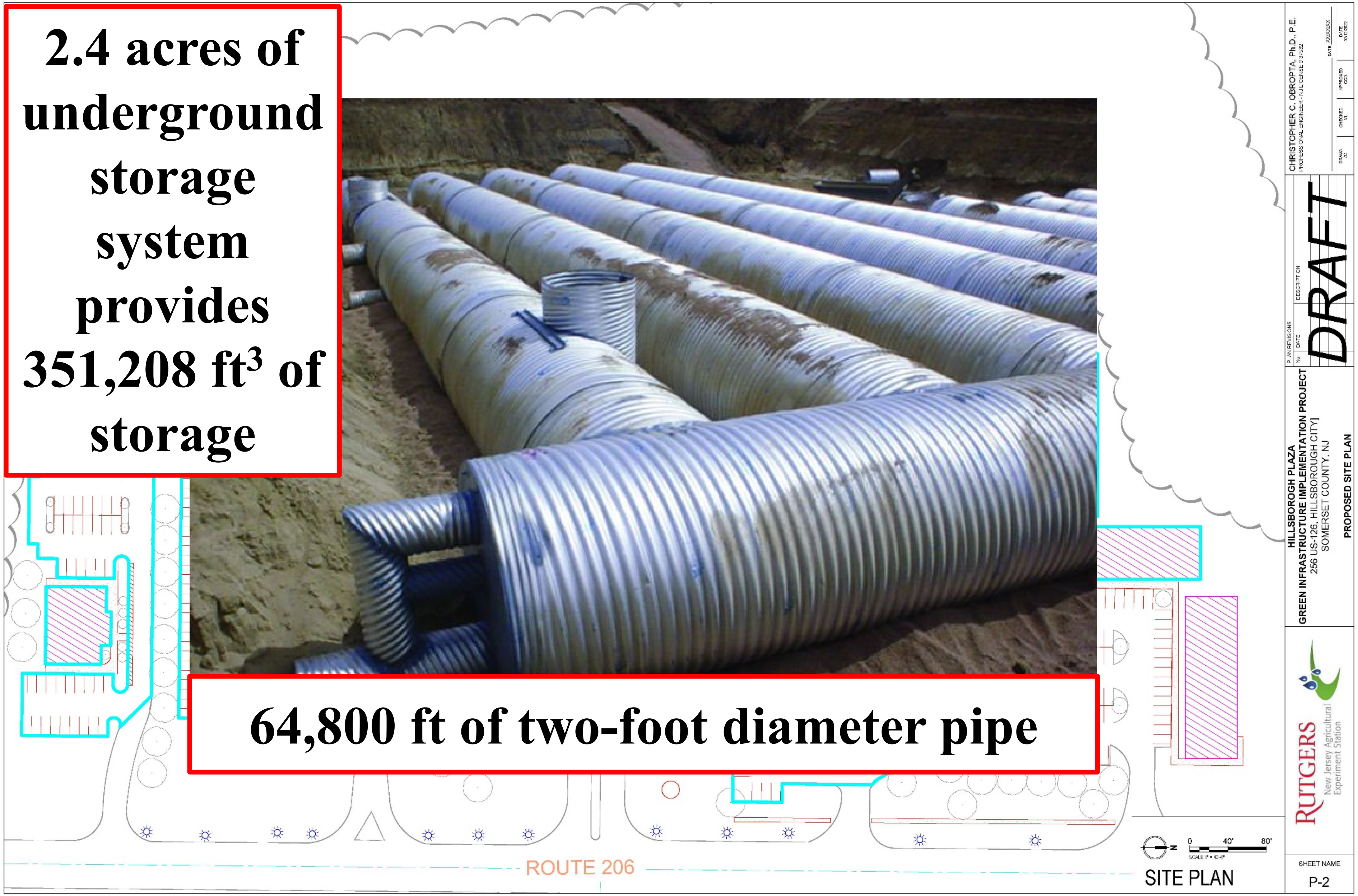
100-Year Storm Analysis 8.25 inches

11.6 acres

294,756 ft^3 of runoff for 7.0 inches rain

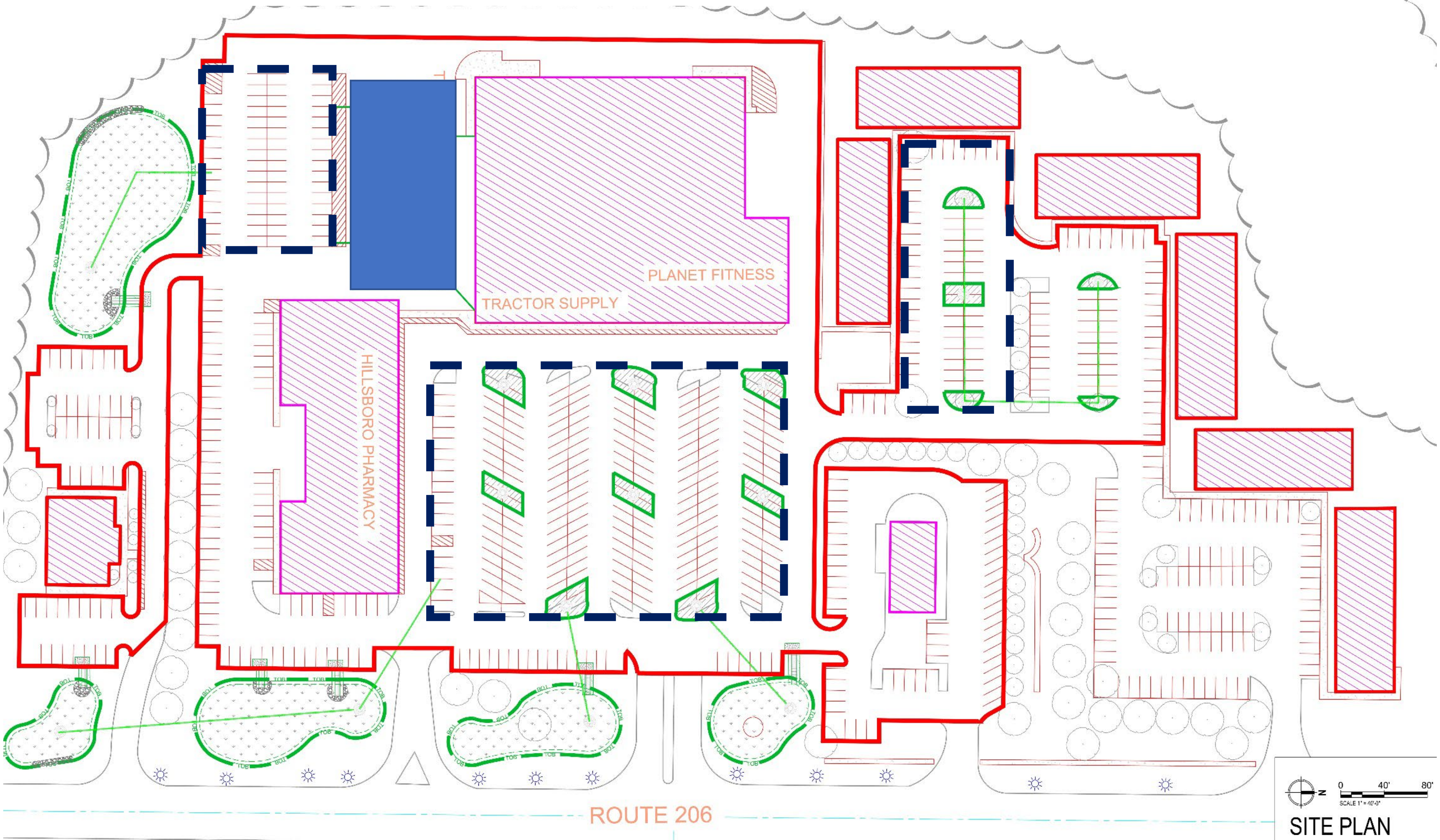


2.4 acres of underground storage system provides 351,208 ft^3 of storage



64,800 ft of two-foot diameter pipe

Green and Gray Infrastructure Practices



Questions?

1. How long do we hold the larger storms before we can safely release the stormwater?
2. Can we link the release with downstream elevations?
3. What is the cost?

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