



RUTGERS UNIVERSITY

Water Resources Program

New Jersey Agricultural Experiment Station



Nature Based Solutions to Manage Extreme Weather Events in the Royce Brook Watershed, Somerset County, New Jersey

Rutgers Cooperative Extension Water Resources Program

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February 21, 2026



Rutgers Cooperative Extension

Rutgers Cooperative Extension (RCE) helps the diverse population of New Jersey adapt to a rapidly changing society and improves their lives through an educational process that uses science-based knowledge.





Water Resources Program



Our mission is to identify and address water resources issues by engaging and empowering communities to employ practical science-based solutions to help create a more equitable and sustainable New Jersey.

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
- Prioritize nature-based solutions
- Design retrofits to manage the increase in rainfall due to climate change for sites that already have stormwater management



**Let's Talk
About Rain**

What's a 100-year storm?



How often do we get the 100-year storm?

Annual probability (%) = 100/recurrence interval (years)

100-year storm = $100/100$ = 1%

10-year storm = $100/10$ = 10%

2-year storm = $100/2$ = 50%



But let's adjust it for today's data and future rainfall

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



Let's Talk About Nature-Based Solutions

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.

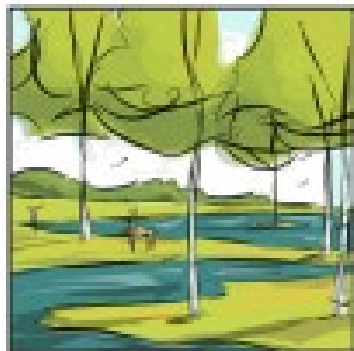
WATERSHED SCALE



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.



WETLAND RESTORATION AND PROTECTION

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

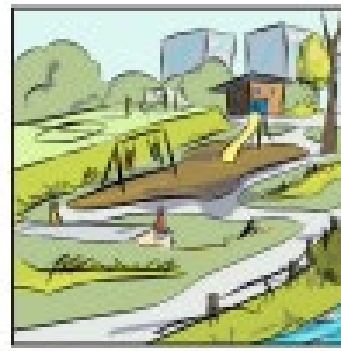
Wetlands also sustain healthy ecosystems by recharging groundwater and providing habitat for fish and wildlife.



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.



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.

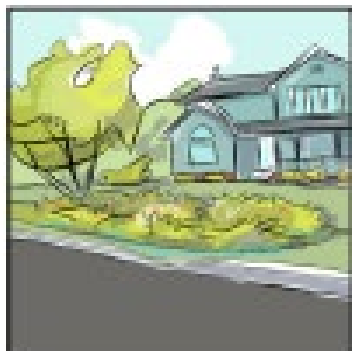


FLOODPLAIN RESTORATION

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.

NEIGHBORHOOD OR SITE SCALE



RAIN GARDENS

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

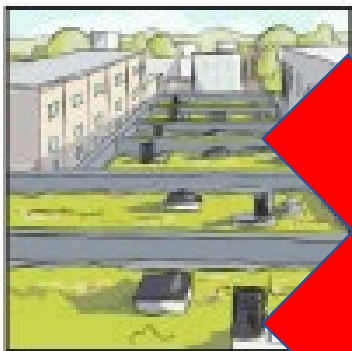
Rain gardens can be added around homes and businesses to reduce and treat stormwater runoff.



VEGETATED SWALES

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

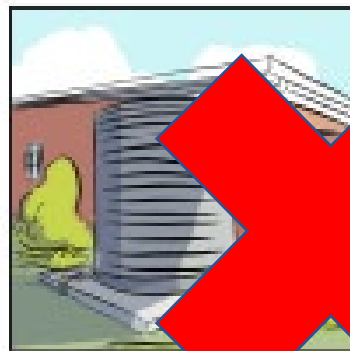
Vegetated swales can be placed along streets and in parking lots to soak up and treat their runoff, improving water quality.



GREEN ROOFS

A green roof is fitted with a planting medium and vegetation. A green roof can reduce energy costs for buildings by soaking up rainfall.

Green roofs can also reduce energy costs for buildings by soaking up rainfall. Green roofs can reduce energy costs for buildings by soaking up rainfall. Green roofs can reduce energy costs for buildings by soaking up rainfall.



RAINWATER HARVESTING

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

Rainwater harvesting systems include rain barrels, rainwater cisterns 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 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.



TREE CANOPY

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

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



GREEN STREETS

Green streets use a suite of green infrastructure practices to manage stormwater 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.

How do we improve water quality and reduce flooding in the Royce Brook Watershed?

- Redesign existing stormwater basins to remove pollutants and enhance stormwater retention
- Install stormwater management for developed areas that currently are not managed

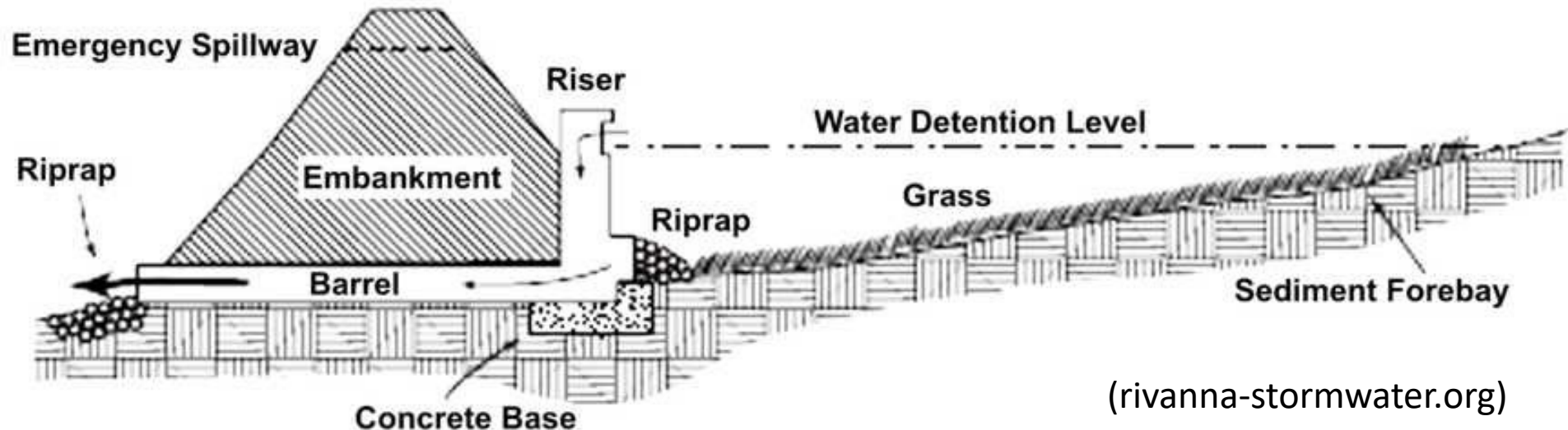
Issues with Existing Stormwater Management

- Basins are not designed to improve water quality or recharge groundwater
- Basins fill and drain quickly during rainfall events
- Low retention time results in excessive runoff volumes being released while stream is high
- All basin designs are similar



How can we reduce 100-YR storm flooding?

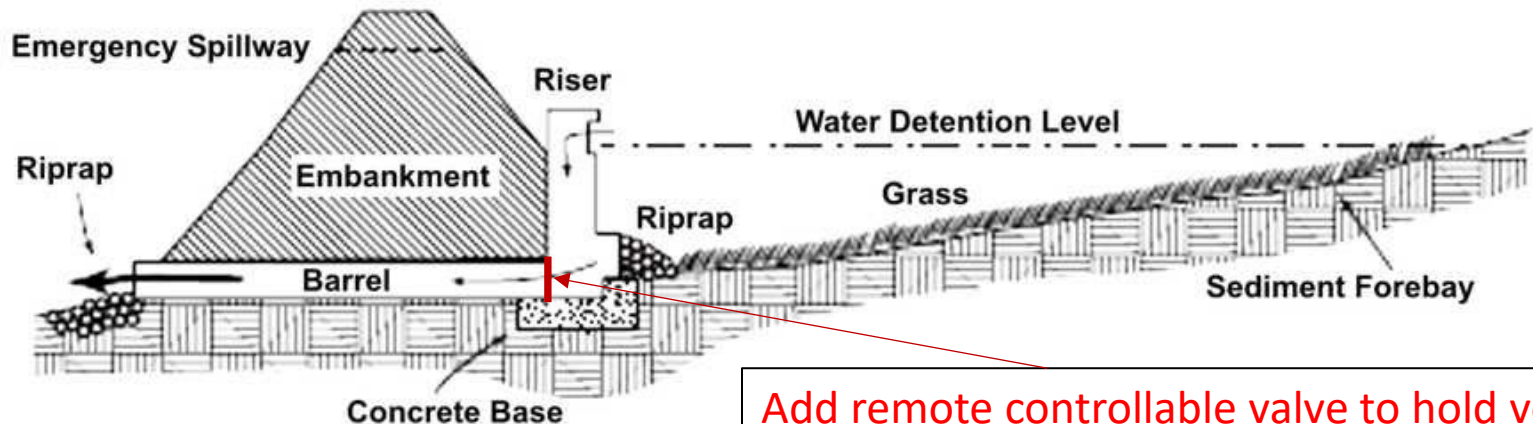
- Capture stormwater and detain it to reduce the peak flow of the flooding
 - Typical detention basin approach
 - Effective if no back-up downstream
 - Can combine with distributed systems to hold more volume



(rivanna-stormwater.org)

How can we reduce 100-YR storm flooding?

- Hold a retain stormwater as long as possible
 - More effective when floodwater backed-up downstream
 - Digital control system to hold volume and release water once flood recedes
 - Would not work well as passive system due to smaller storm event management not draining quick enough
 - Difficult to combine with distributed storage systems



Add remote controllable valve to hold volume

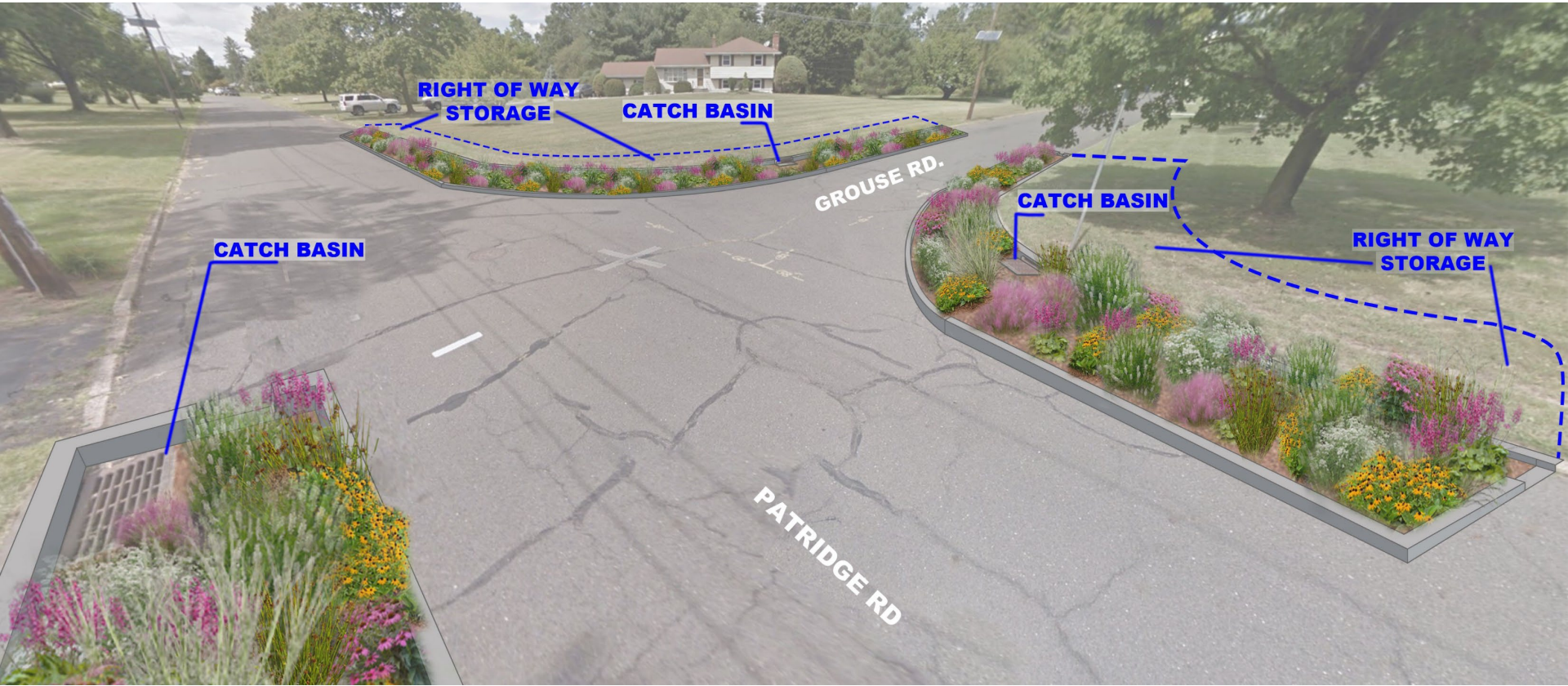
Where do we target our efforts?

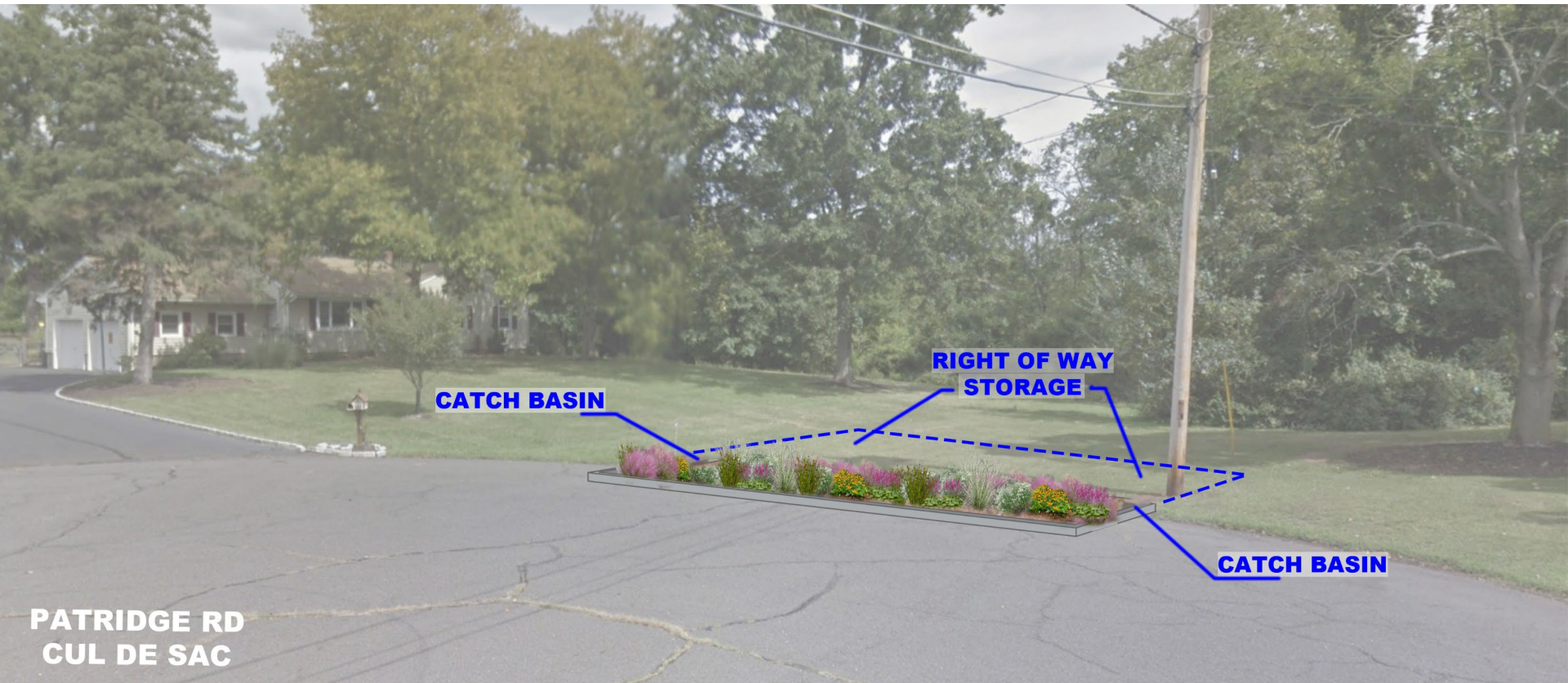
- Target developments with:
 - little to no existing stormwater management
 - available land to capture and hold large volumes of stormwater
 - willing participants for buyouts to create land for stormwater management
- Identify key flooding hotspots and identify areas contributing upstream of those areas
- Use right-of-way areas to capture stormwater
- In-line stream storage (complicated design and difficult to obtain NJDEP permits)

How can we hold the volume?

- Smaller distributed systems
 - Individual household rain gardens
 - Pervious pavement
 - Right-of-way stormwater planters







**PATRIDGE RD
CUL DE SAC**

CATCH BASIN

**RIGHT OF WAY
STORAGE**

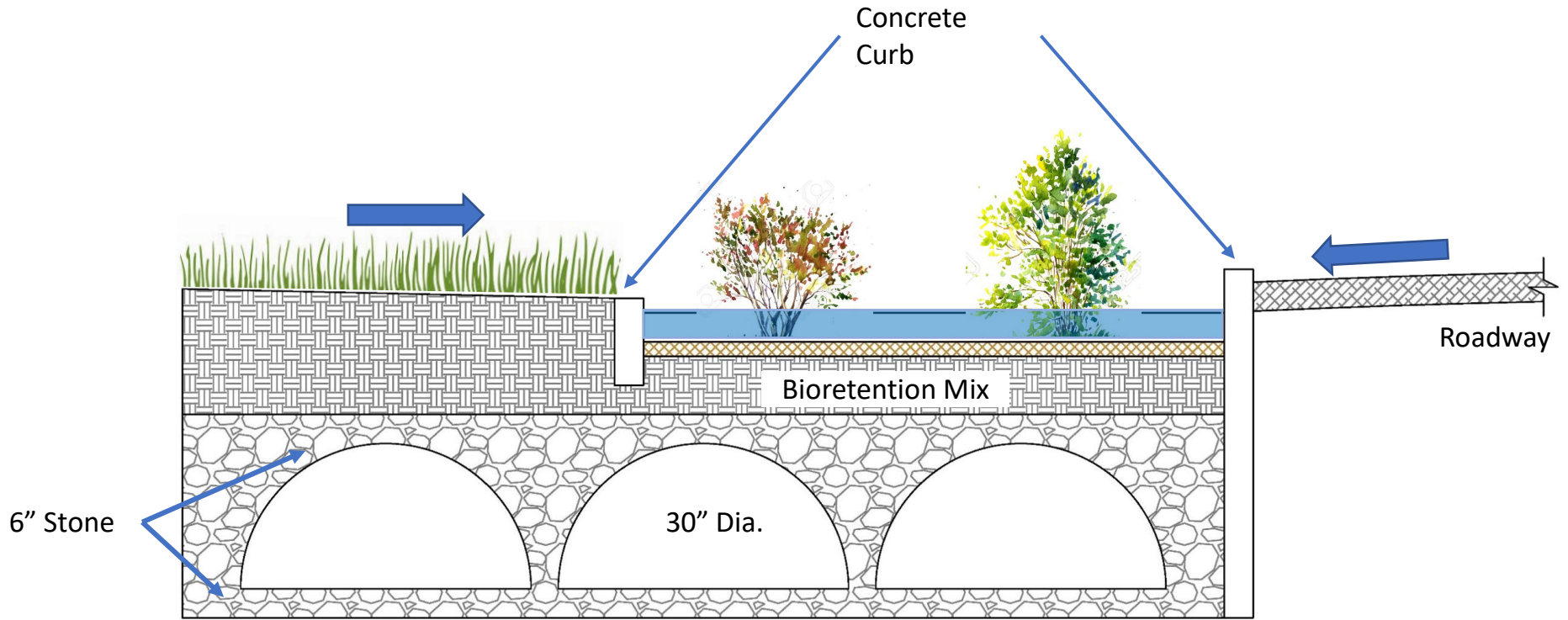
CATCH BASIN

How can we hold the volume?

- Large Detention/ Bioretention Basins
 - Can provide largest volume storage to land area

- Underground Storage Systems
 - Can create systems under lots by combining storage with
 - Allows mixed use of stormwater management area and recreational uses (i.e., parks)



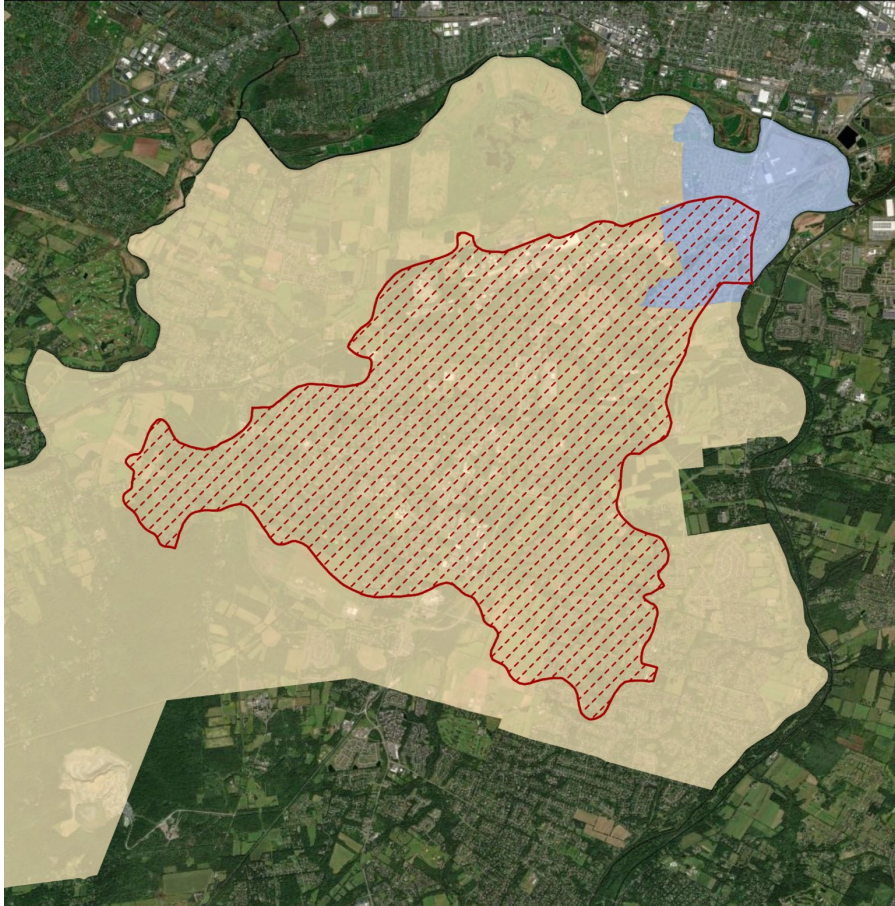


What are design options for retrofitting sites?

- Right of way only and public land
- Create distributed projects on private lands

- Residential
 - Small buyouts of residential area to create available land for stormwater capture
 - Large buyouts to maximize stormwater capture

- Commercial
 - Underground storage in parking lots
 - Remove sections of unutilized areas to create larger storage systems

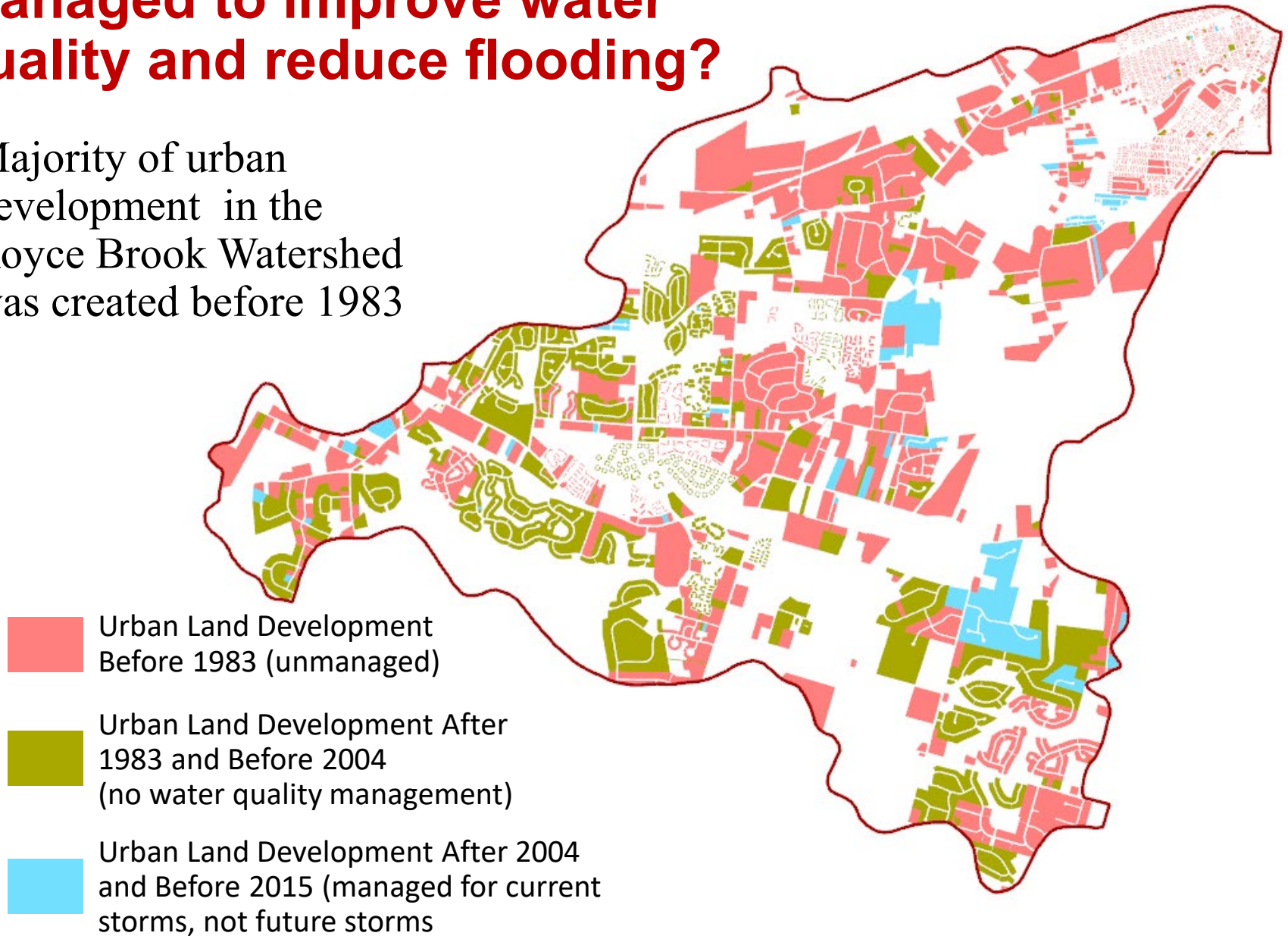


Royce Brook Watershed
10,567.6 acres = 16.5 sq. mi.
24.3% impervious cover



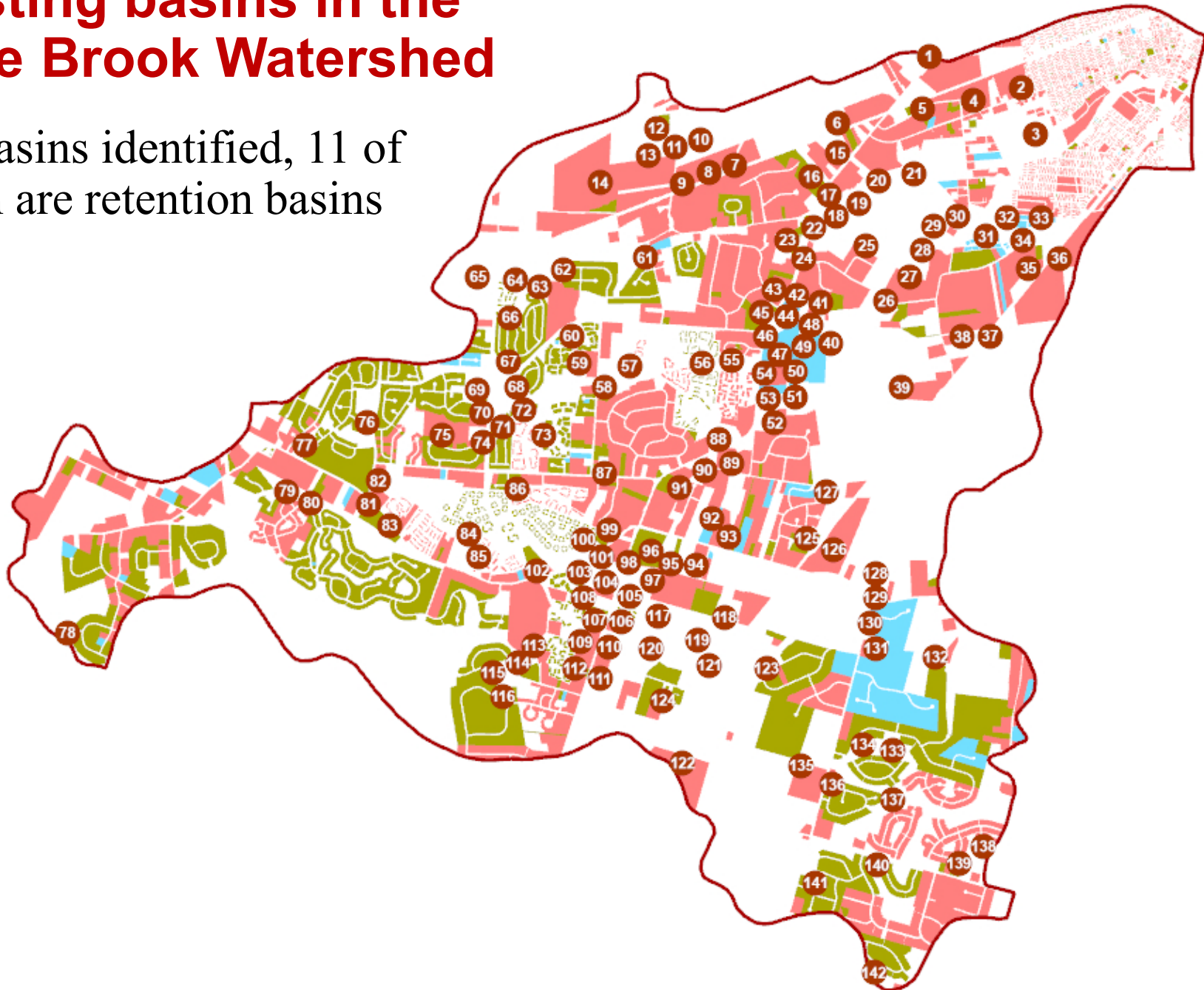
What land must be better managed to improve water quality and reduce flooding?

- Majority of urban development in the Royce Brook Watershed was created before 1983



Existing basins in the Royce Brook Watershed

- 142 basins identified, 11 of which are retention basins



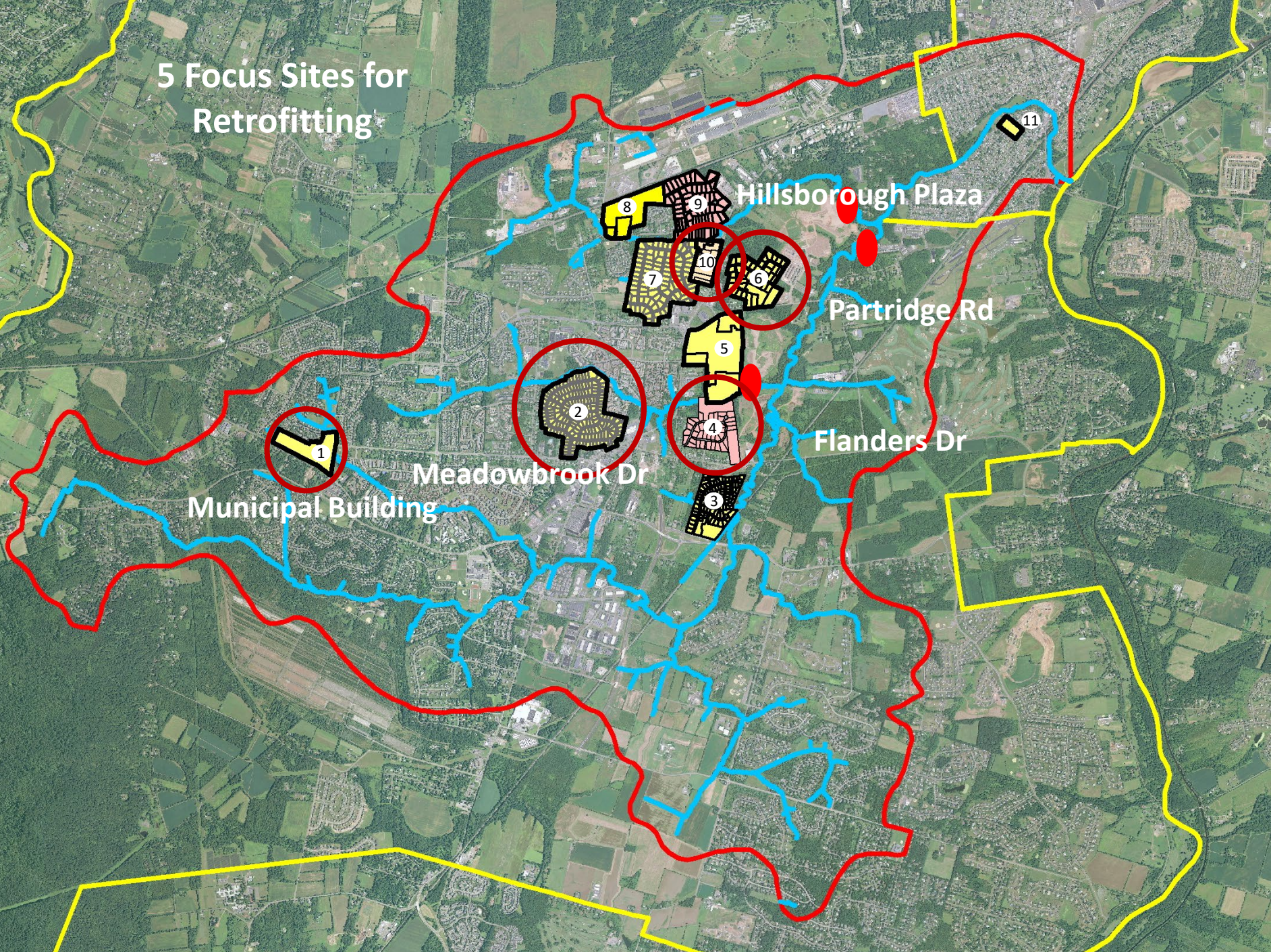
Existing Management

Total Watershed Area	16.5 square miles
Total Developed Area	10.2 square miles
Total Developed Area Managed by Existing Detention Basins	3.1 square miles
Unmanaged Developed Area	7.1 square miles
Undeveloped Forest Area	2.5 square miles
Undeveloped Wetland Area	2.2 square miles
Undeveloped Agriculture Area	1.2 square miles
Undeveloped Barren Land	0.3 square miles
Water	0.1 square miles

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

5 Focus Sites for Retrofitting



Hillsborough Plaza

Partridge Rd

Flanders Dr

Meadowbrook Dr

Municipal Building

5 Focus Sites for Retrofitting

- Hillsborough Municipal Building
- Flanders Drive
- Partridge Farm Road
- Meadowbrook Drive
- Hillsborough Plaza (Tractor Supply)

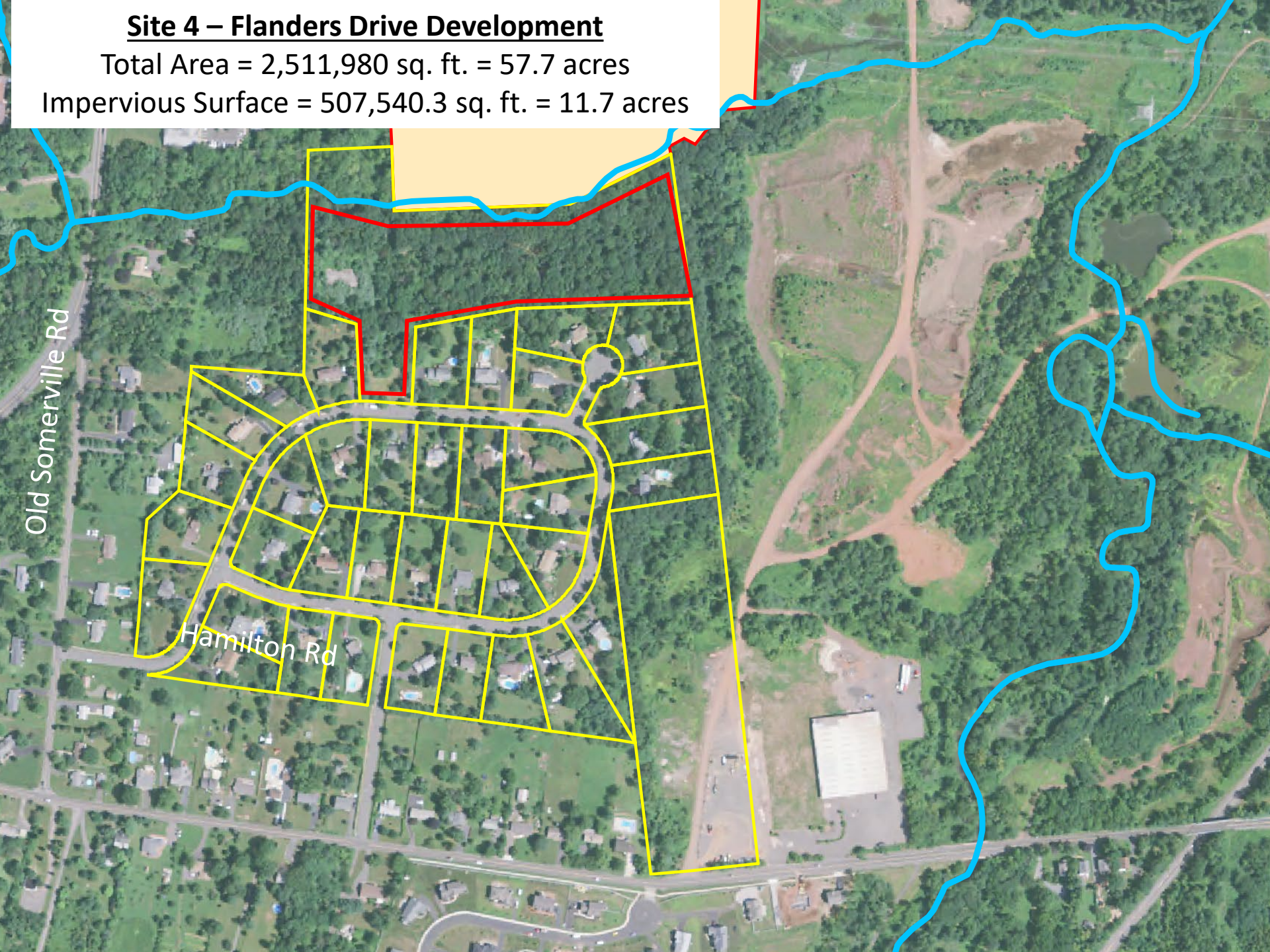
3 Key Cases

- Design is limited to municipal lands
- Design to retrofit
 - At least 80% reduction of predevelopment peak
- Design unrestrained to reach 100% capture and hold

Site 4 – Flanders Drive Development

Total Area = 2,511,980 sq. ft. = 57.7 acres

Impervious Surface = 507,540.3 sq. ft. = 11.7 acres



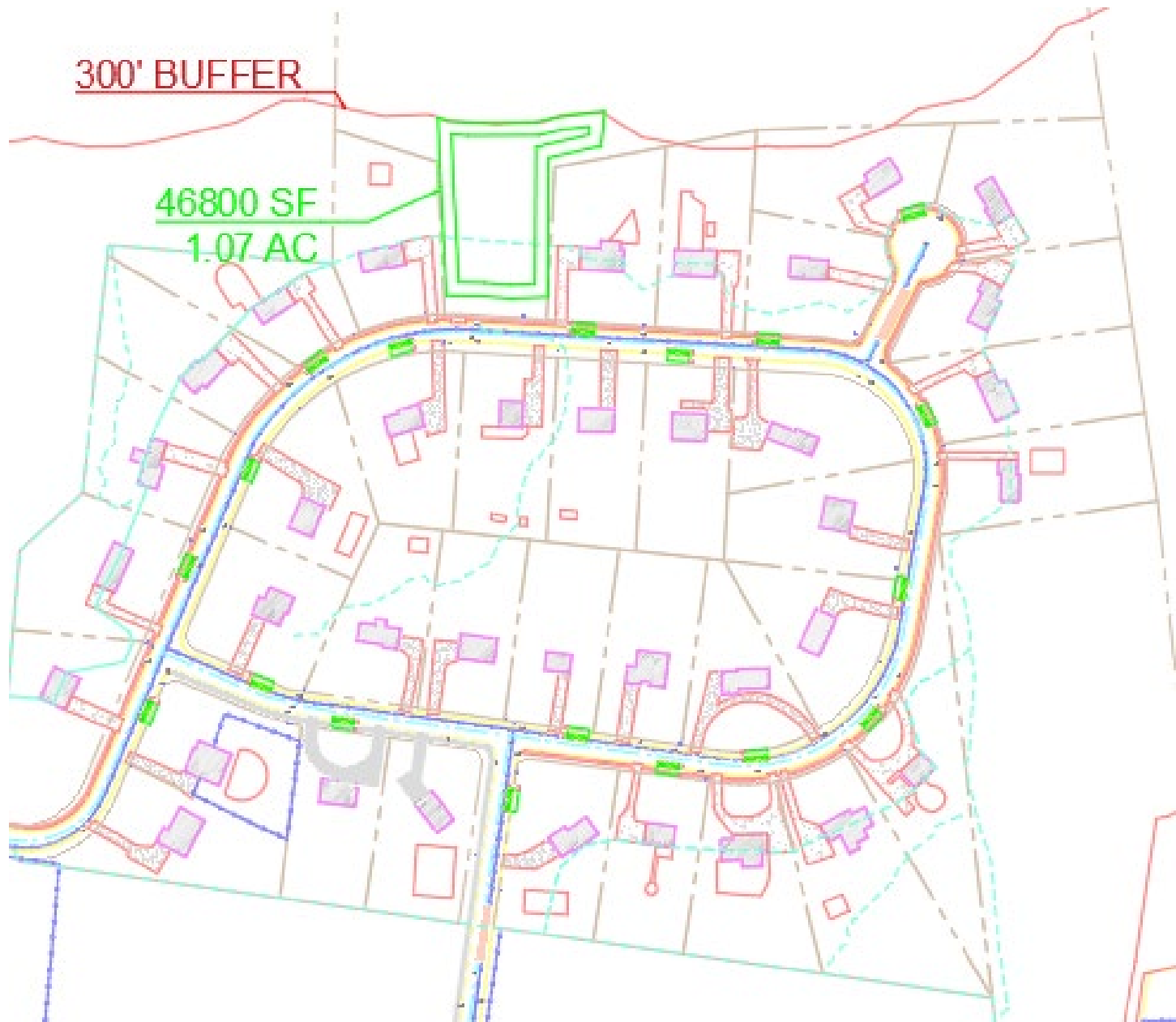
Municipal Land Only

- Reduces peak by 25% meeting stormwater regulations
- Space for 1 basin and roadside distributed systems

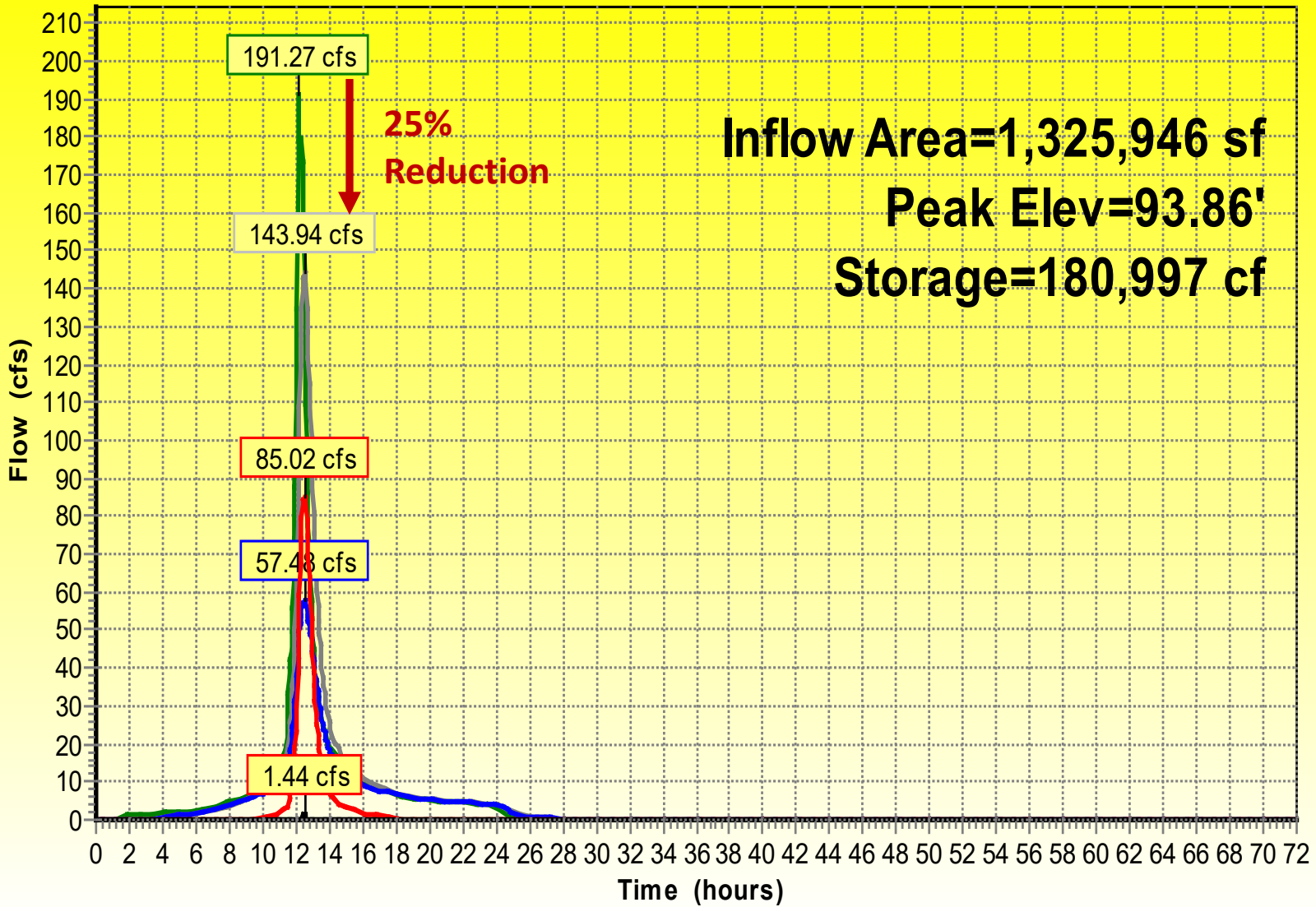


300' BUFFER

46800 SF
1.07 AC



Hydrograph



- Inflow
- Outflow
- Primary
- Secondary
- Tertiary

	Storage Volume (cf)	% Contribution
One acre Bioretention Basin	187,528	88%
Roadside Rain Gardens	25,464	12%
Total Storage Volume	212,992 cubic feet = 1,597,440 gallons	
Peak Reduction	25%	% of inflow
Detention Time 75%	14.4	hrs

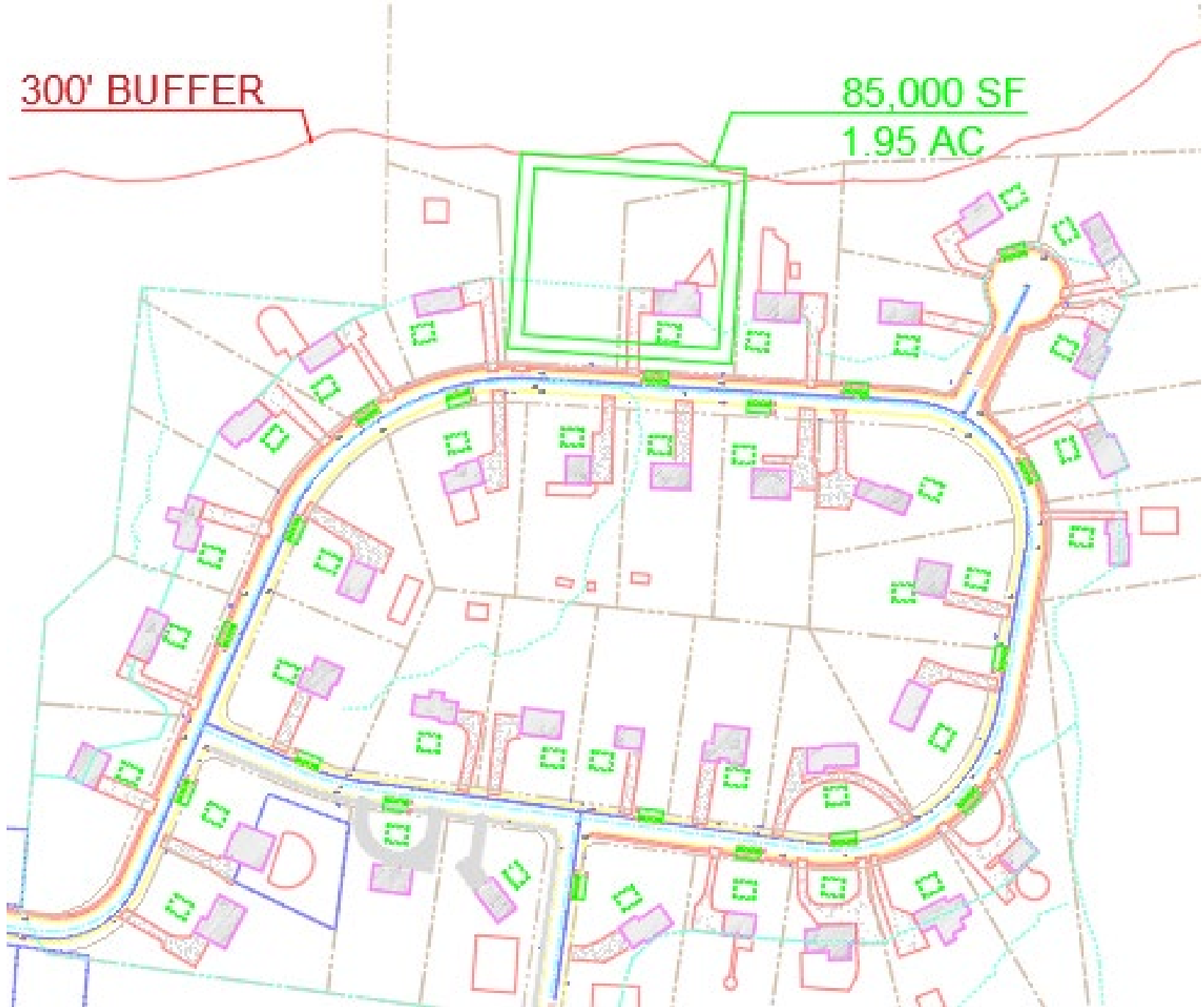
Second Option

- Double the size of bioretention basin (two acres)
- Add homeowner rain gardens to take roof runoff



300' BUFFER

85,000 SF
1.95 AC

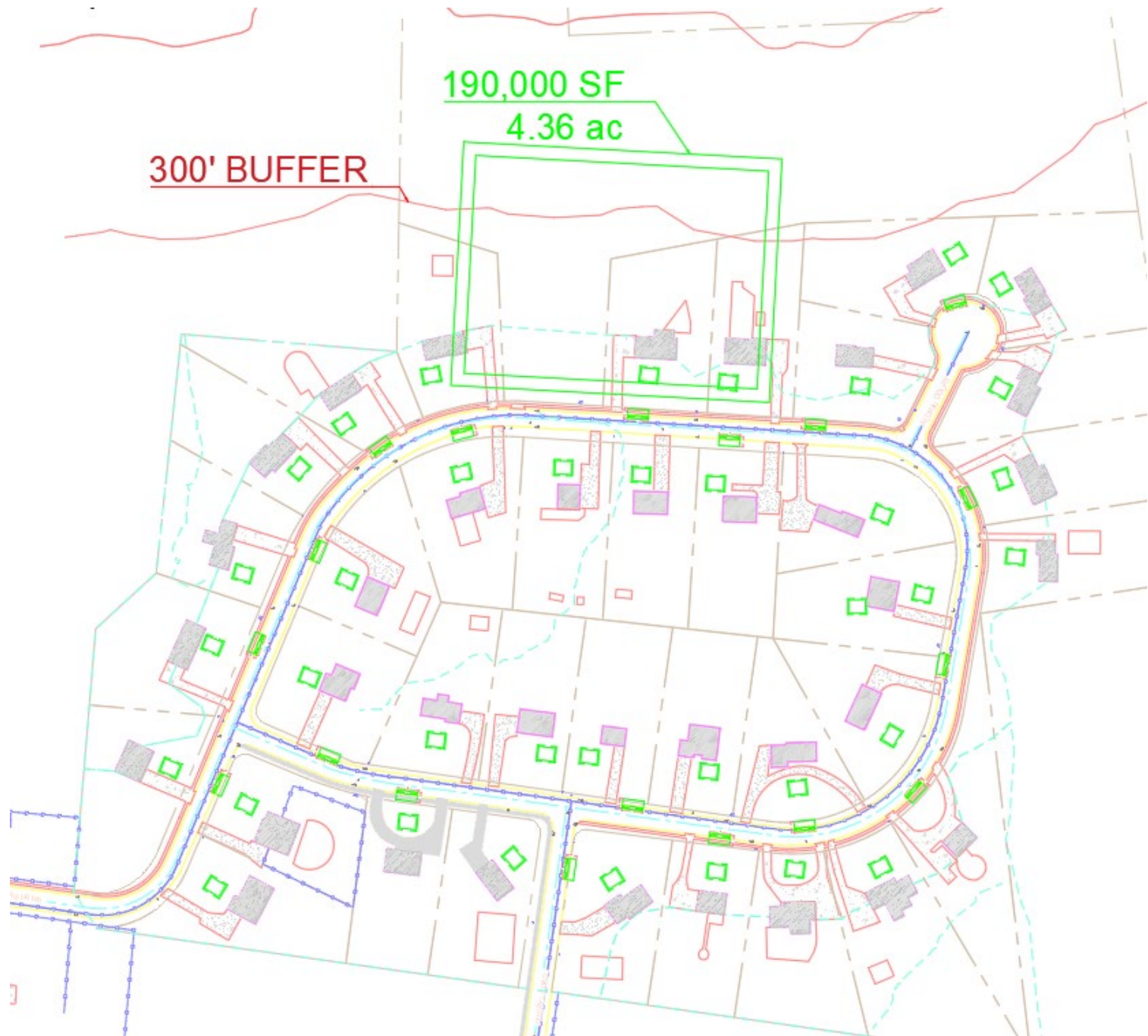


	Storage Volume (cf)	% Contribution
Bioretention Basin	370,550	78%
Porous Pavement	58,570	12%
Rain Garden - Roof	20,276	4%
Rain Garden - Road	25,464	5%
Total Storage Volume	474,860 cubic feet = 3,552,199 gallons	
Peak Discharge	52.7	cfs
Peak Reduction	72%	% of Inflow
Detention Time 75%	17	hrs
Basin Area	1.95	ac

Third Option

- All volume held in basin
- Valve will need to be released later and drained in reasonable time

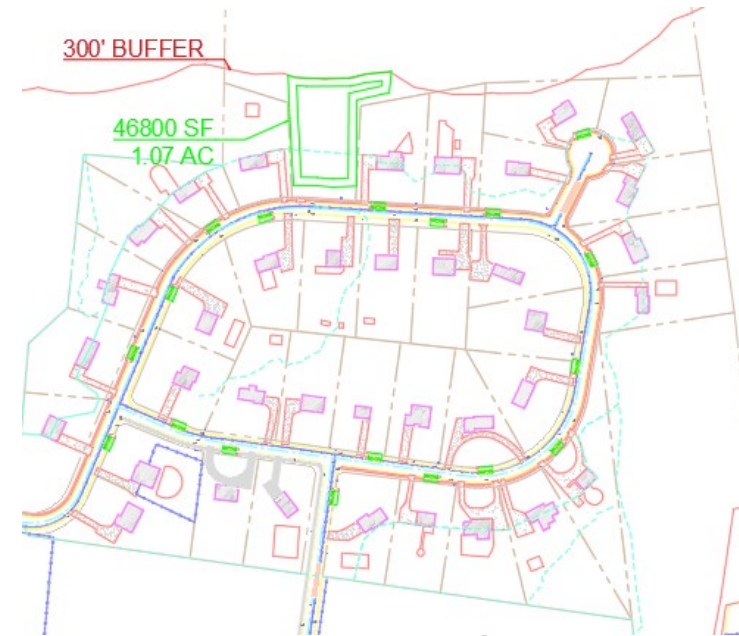




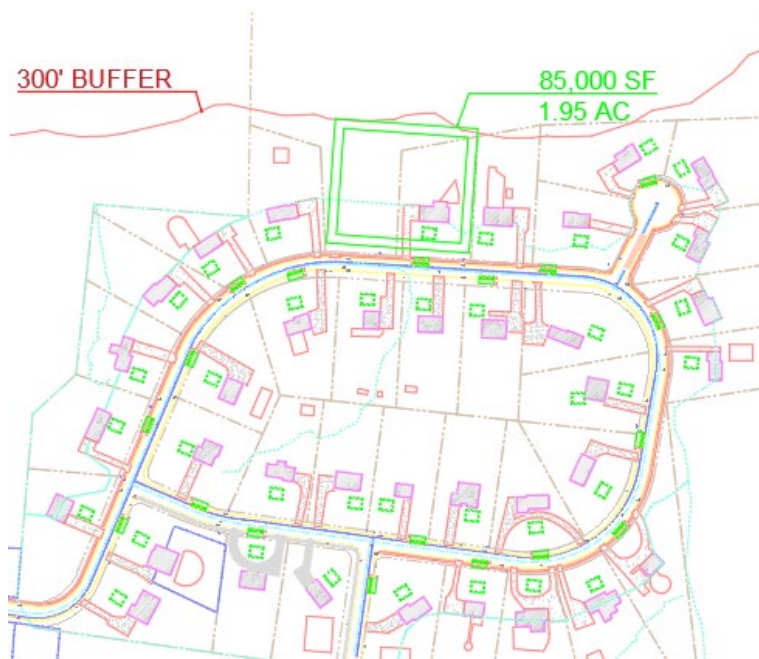
	Storage Volume (cf)	% Contribution
Bioretention Basin	866,000	89%
Porous Pavement	58,570	6%
Rain Garden – Roof	20,276	2%
Rain Garden - Road	25,464	3%
Total Storage Volume	970,310 cubic feet = 7,258,423 gallons	
Peak Discharge	0	cfs
Peak Reduction	100%	% of Inflow (191.3cfs)
Basin Storage Peak	853,911	cf
*Detention Time 50%	NA	hrs
Detention Time 75%	NA	hrs
Detention Time 100%	NA	hrs
Basin Area	190,000	sf
Basin Area	4.36	ac

Case Comparison

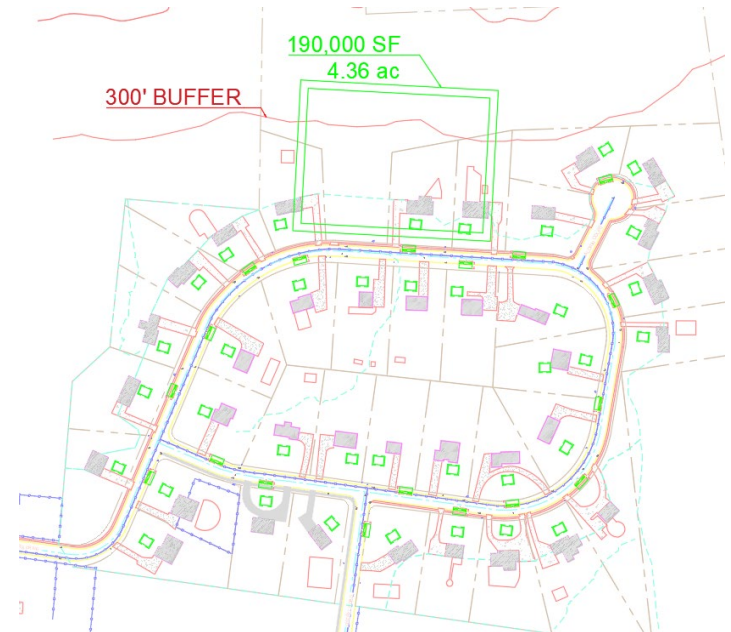
Parameter	Municipal	Current Reg	All Storage
Basin Size (acre)	1.07	1.95	4.36
Peak Red.	25%	72%	100%
Storage (CF)	212,992	474,860	970,310
Det. Time 75% (hr)	14.4	17	n/a



Municipal Only



Current Regulation



All Storage

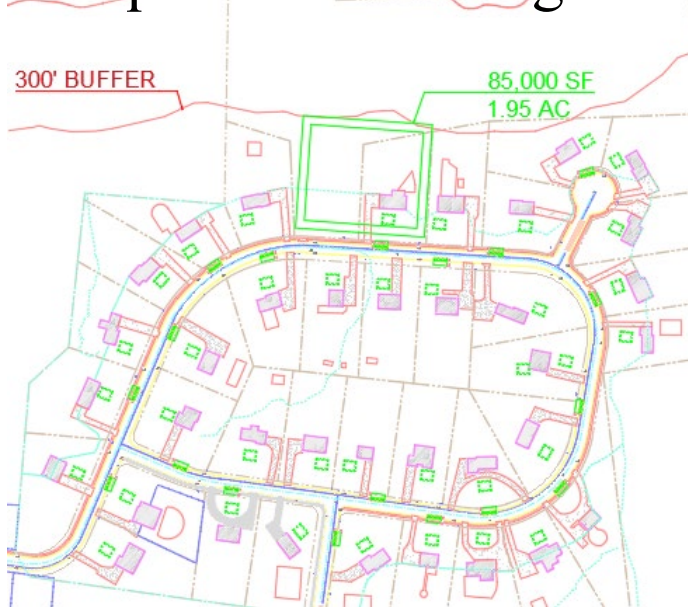
Cost Estimate Comparison

Parameter	Municipal	Current Reg	All Storage
Const. cost of systems w/ distributed	\$534,002	\$1,932,535	\$2,229,011
Cost of property buyouts	\$0 (0 properties)	\$538,500.00 (1 property)	\$1,634,700 (3 properties)
Total w/ distributed systems	\$534,002	\$2,471,035	\$3,863,711

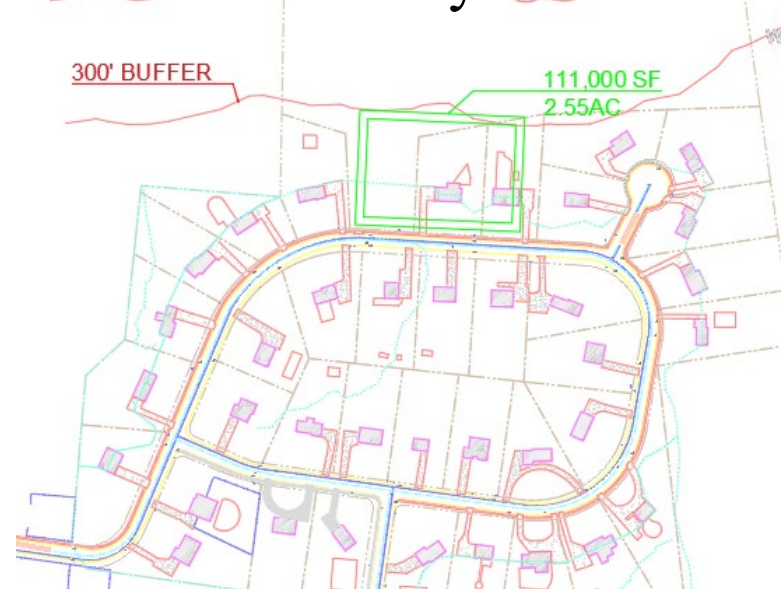
Parameter	Municipal (same basin)	Current Reg (larger basin)	All Storage (larger basin)
Const. cost w/ larger basin only (est.)	\$190,202	\$424,050	\$866,487
Cost of property buyouts (basin only)	\$0 (0 properties)	\$1,117,900 (2 properties)	\$2,140,400 (4 properties)
Total larger basin only	\$190,202	\$1,541,950	\$3,006,887

How much do distributed systems help?

- Types of systems
 - Roadway stormwater planters (160 SF x 18 planters)
 - All non-road pavement pervious w/ storage underneath (6")
 - Rain garden at each house (750 SF x 37 gardens)
- Significantly reduces size of basin & water quality benefits
 - requires more design and logistics issues and may cost more

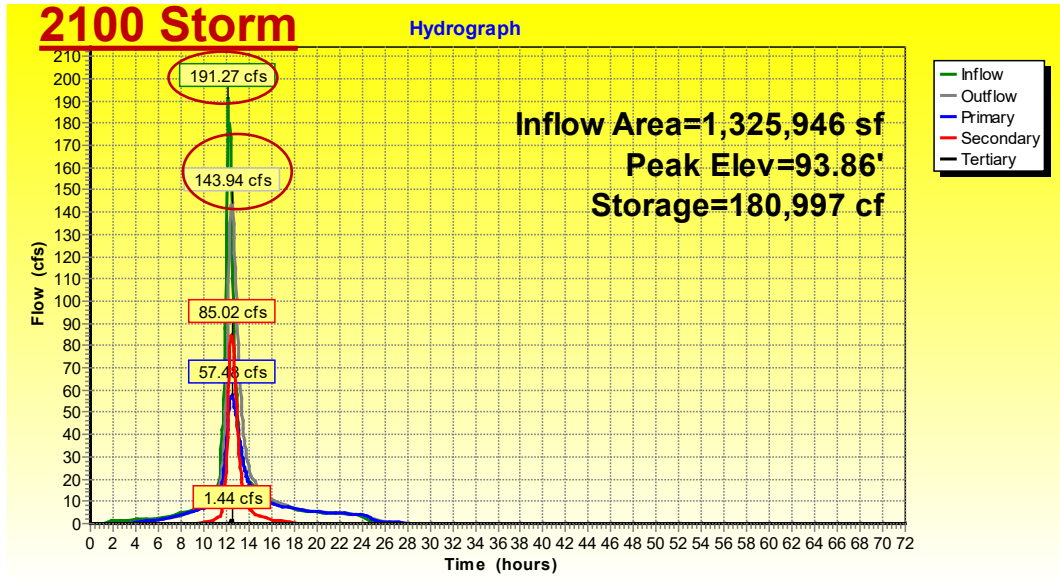


w/ distributed

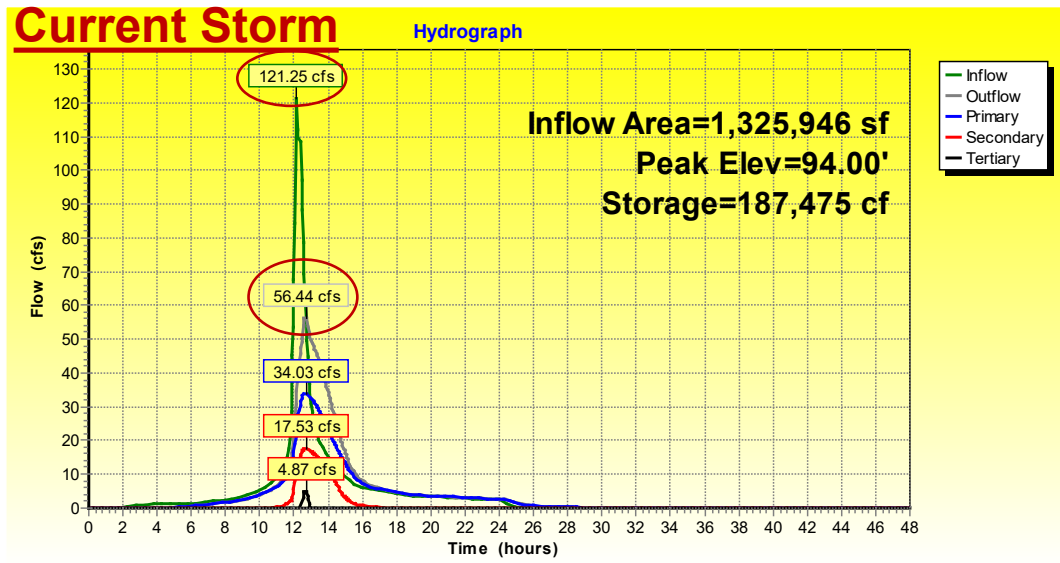


Basin only

Current 100-YR vs 2100 100-YR Storm?



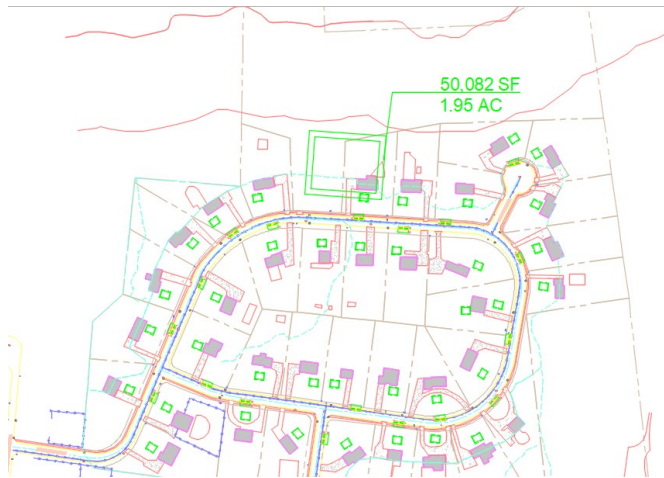
- Much higher inflow and outflow peaks in 2100 storm



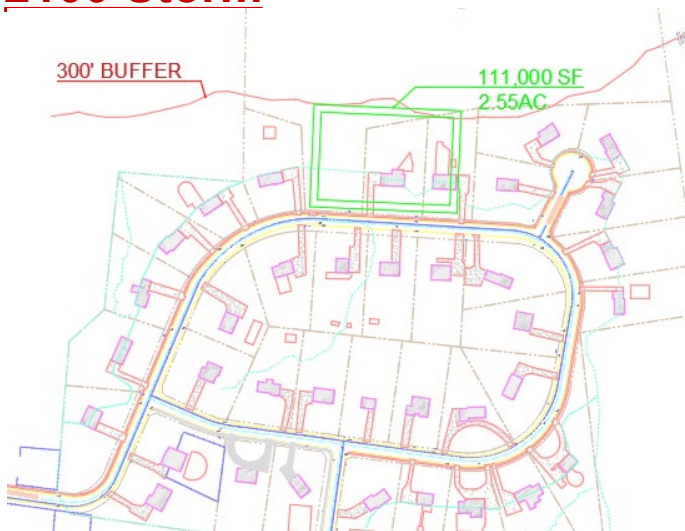
Municipal Only

How much do basins need to increase to manage 2100 storm vs. current?

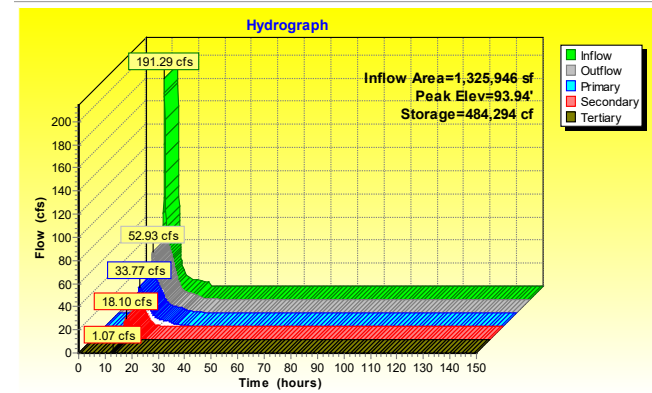
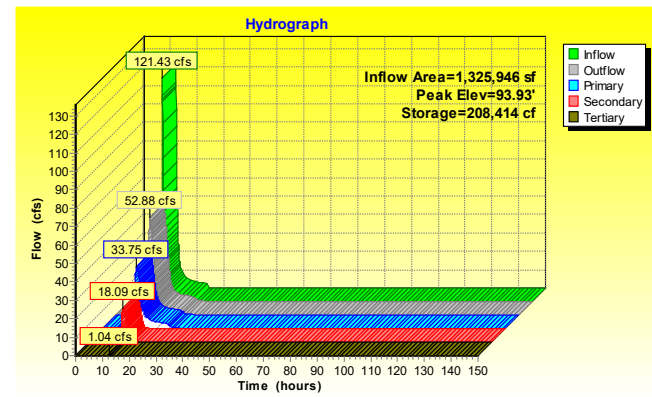
Current Storm



2100 Storm

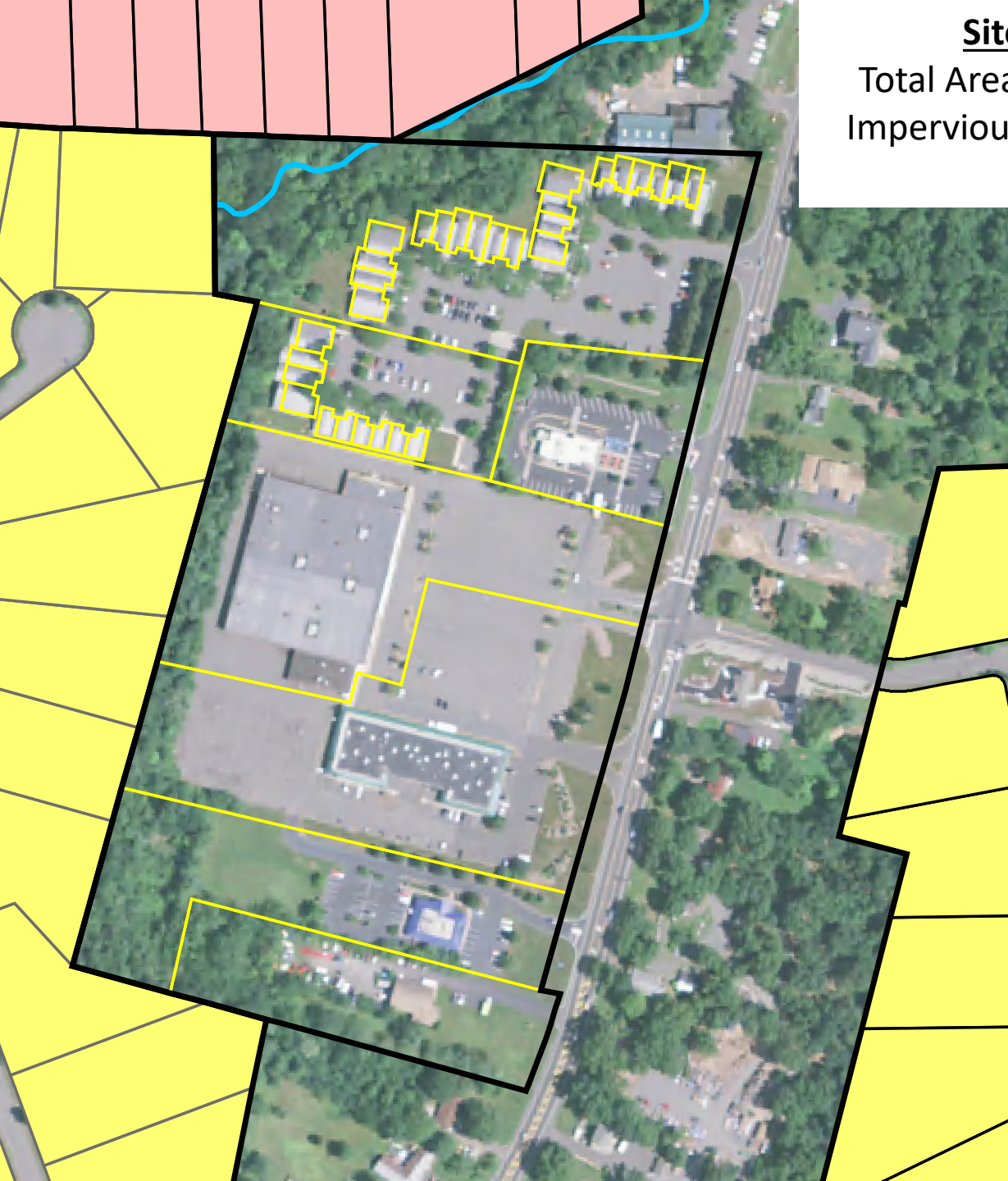


- Basins may need to be about 120% larger to produce similar hydrologic outputs (basin only case)
 - Highly variable based on site conditions and basin dimensions



Site 10 – Hillsborough Plaza

Total Area = 1,036,600 sq. ft. = 23.8 acres
Impervious Surface = 626,500 sq. ft. = 14.4
acres



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.

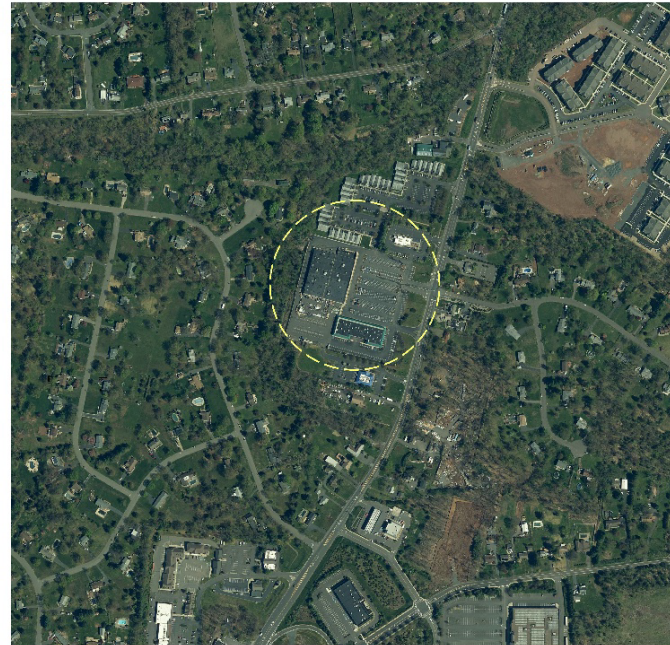
LIST OF DRAWINGS:

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

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

LOCATION MAP (N.T.S):

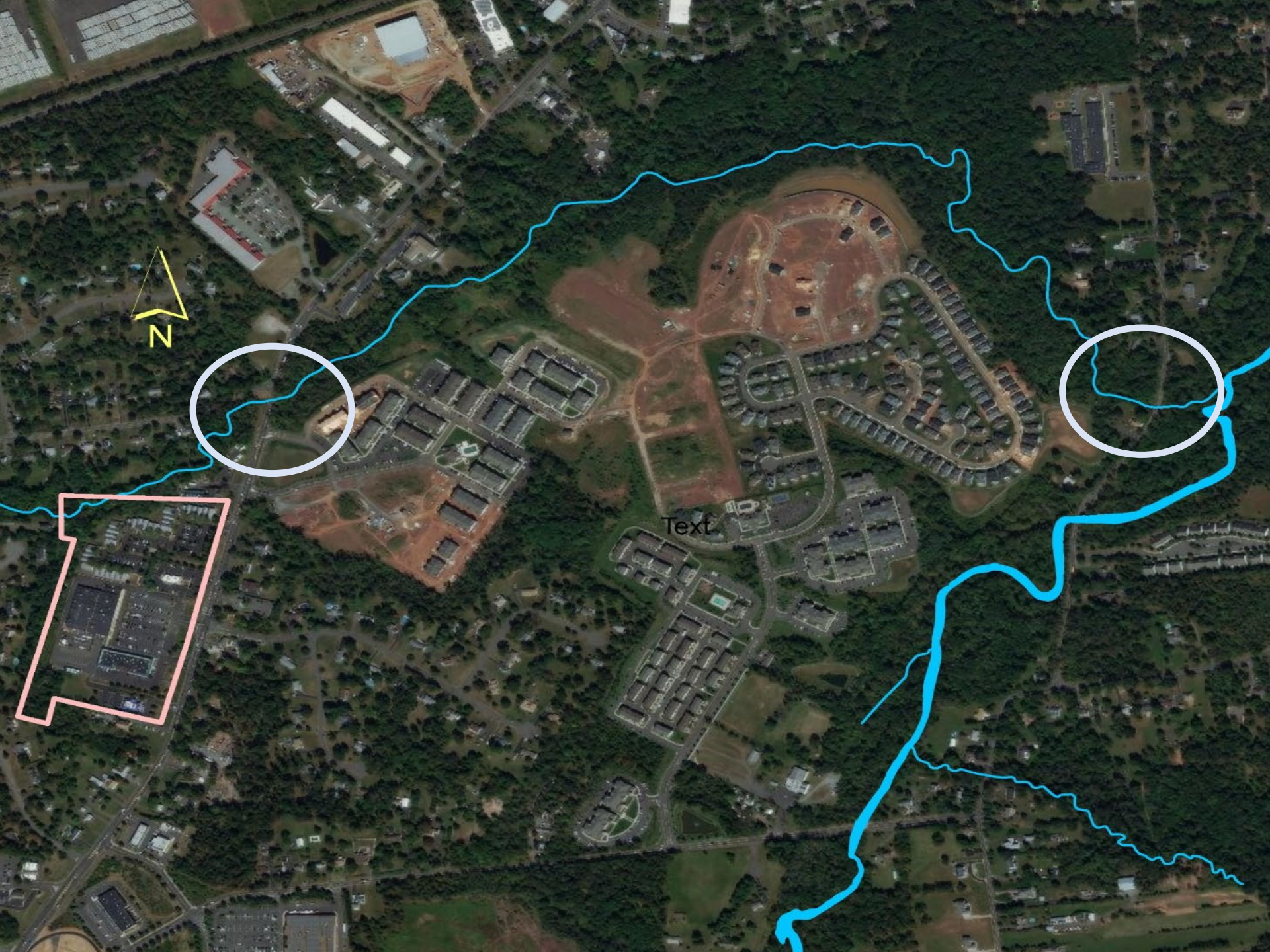


LEGEND:

	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

PLAN REVISIONS		
REV. DATE	REV. SUMMARY	REV. SHEETS



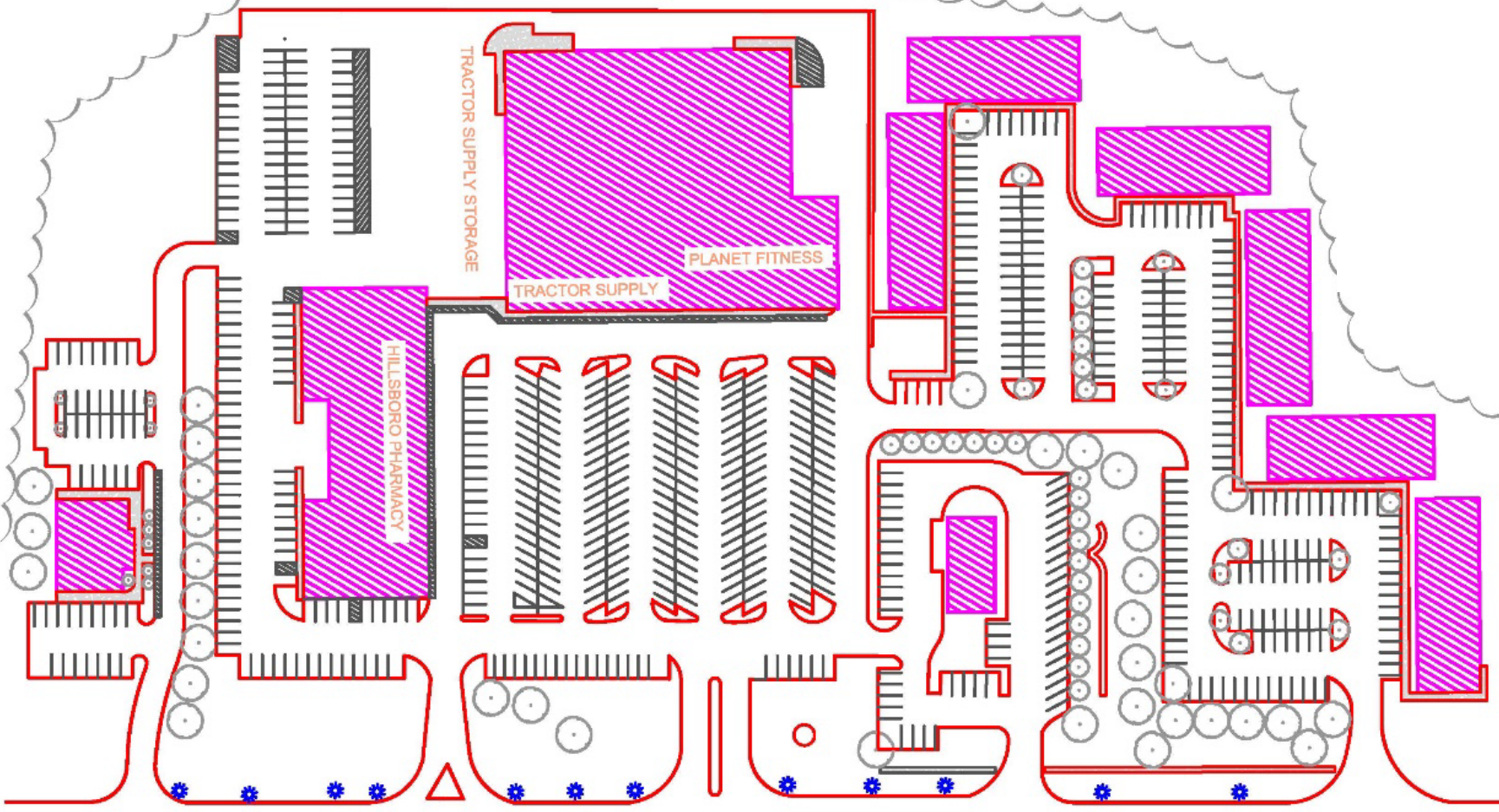


Text



Hillsborough Plaza
256 Route 206
Hillsborough, New Jersey

EXISTING TREE LINE

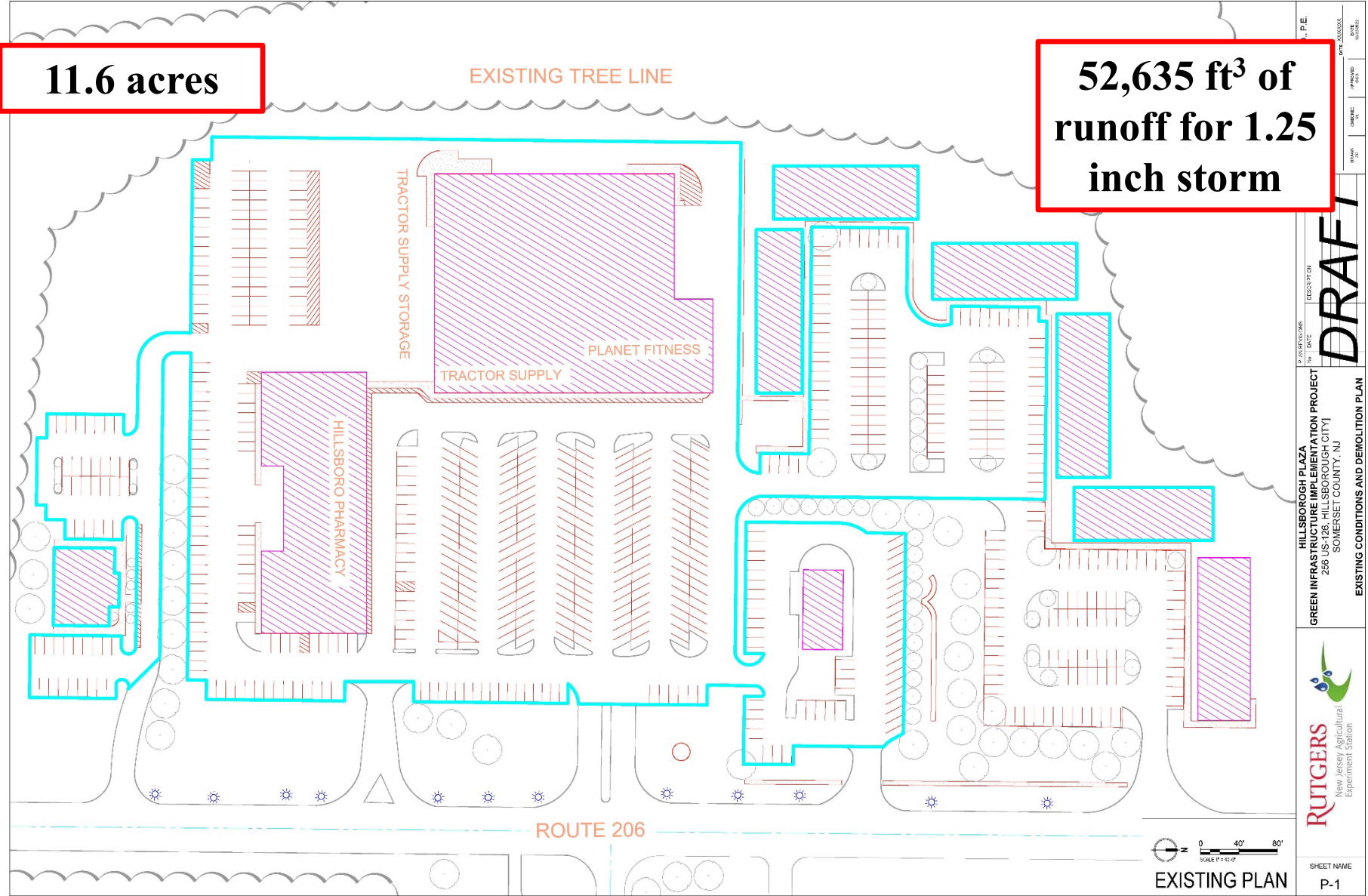


ROUTE 206

Water Quality Storm Analysis (1.25 inches)

11.6 acres

**52,635 ft³ of
runoff for 1.25
inch storm**



DATE: 10/20/2023
DRAWN BY: [Name]
CHECKED BY: [Name]
PROJECT NO.: [Number]
SHEET NO.: [Number]

REGISTERED PROFESSIONAL ENGINEER
STATE OF NEW JERSEY
NO. [Number] DATE [Date]

DRAFT

HILLSBORO PLAZA
GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
266 US-126, HILLSBOROUGH CITY
SOMERSET COUNTY, NJ

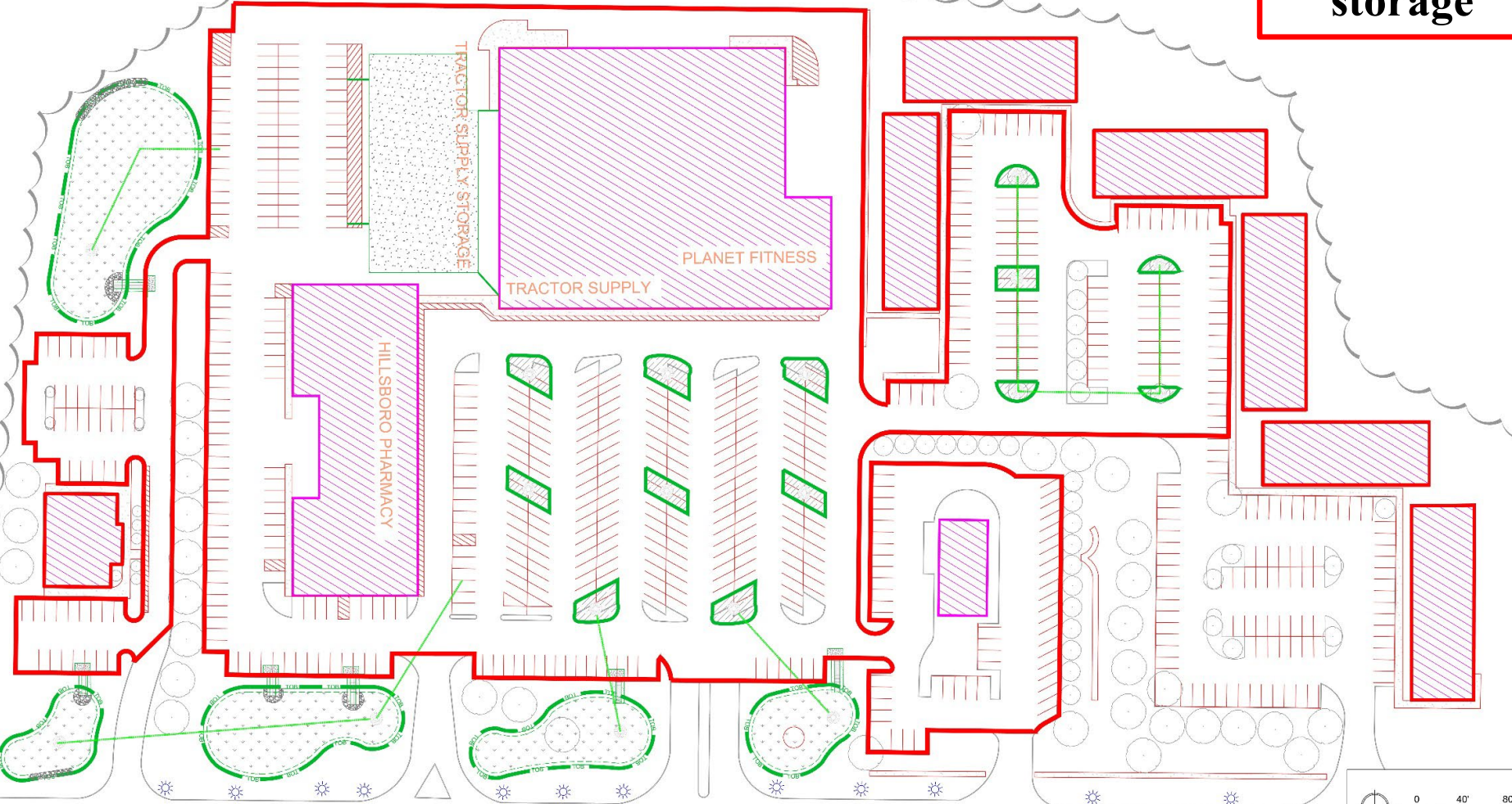
EXISTING CONDITIONS AND DEMOLITION PLAN

RUTGERS
New Jersey Agricultural
Experiment Station

SHEET NAME
P-1

**1.23 acres of
rain gardens
provides
45,611 ft³ of
storage**

EXISTING TREE LINE



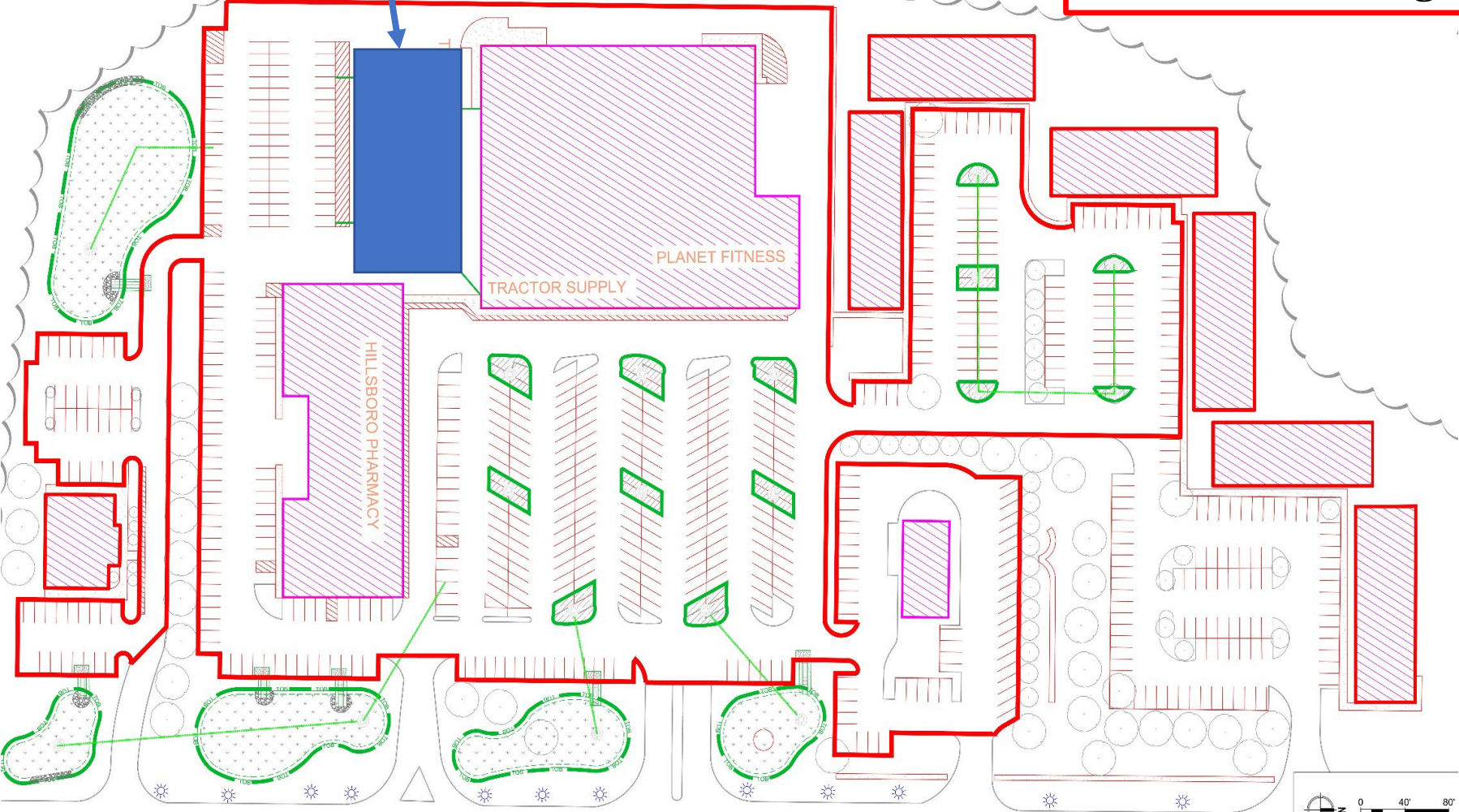
ROUTE 206

0 40' 80'
SCALE 1" = 40'
SITE PLAN

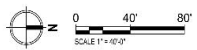
**17,560 ft² of
pervious concrete
provides
7,024 ft³ of storage**

Pervious Concrete

EXISTING TREE LINE



ROUTE 206

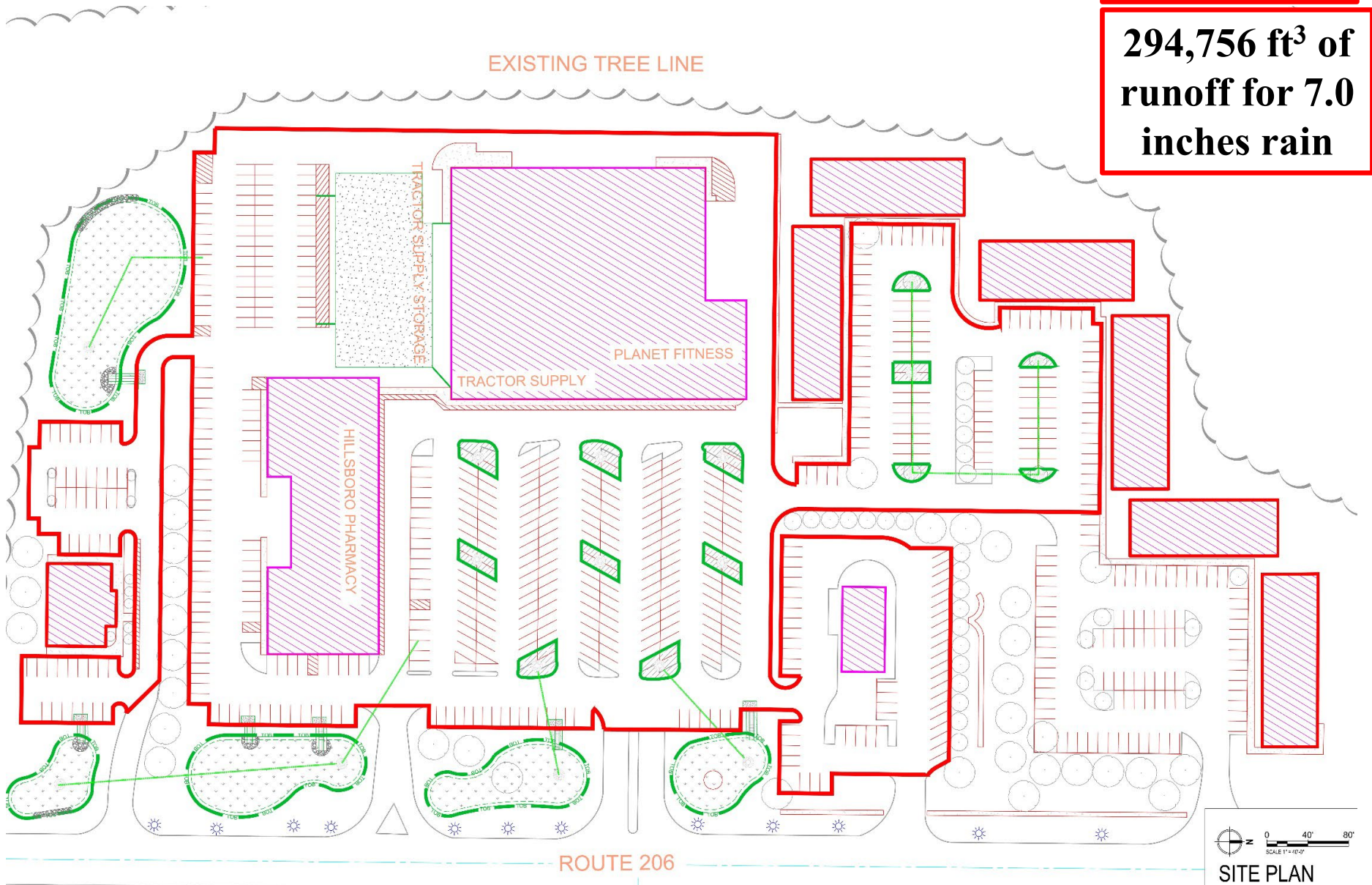


SITE PLAN

100-Year Storm Analysis 8.25 inches

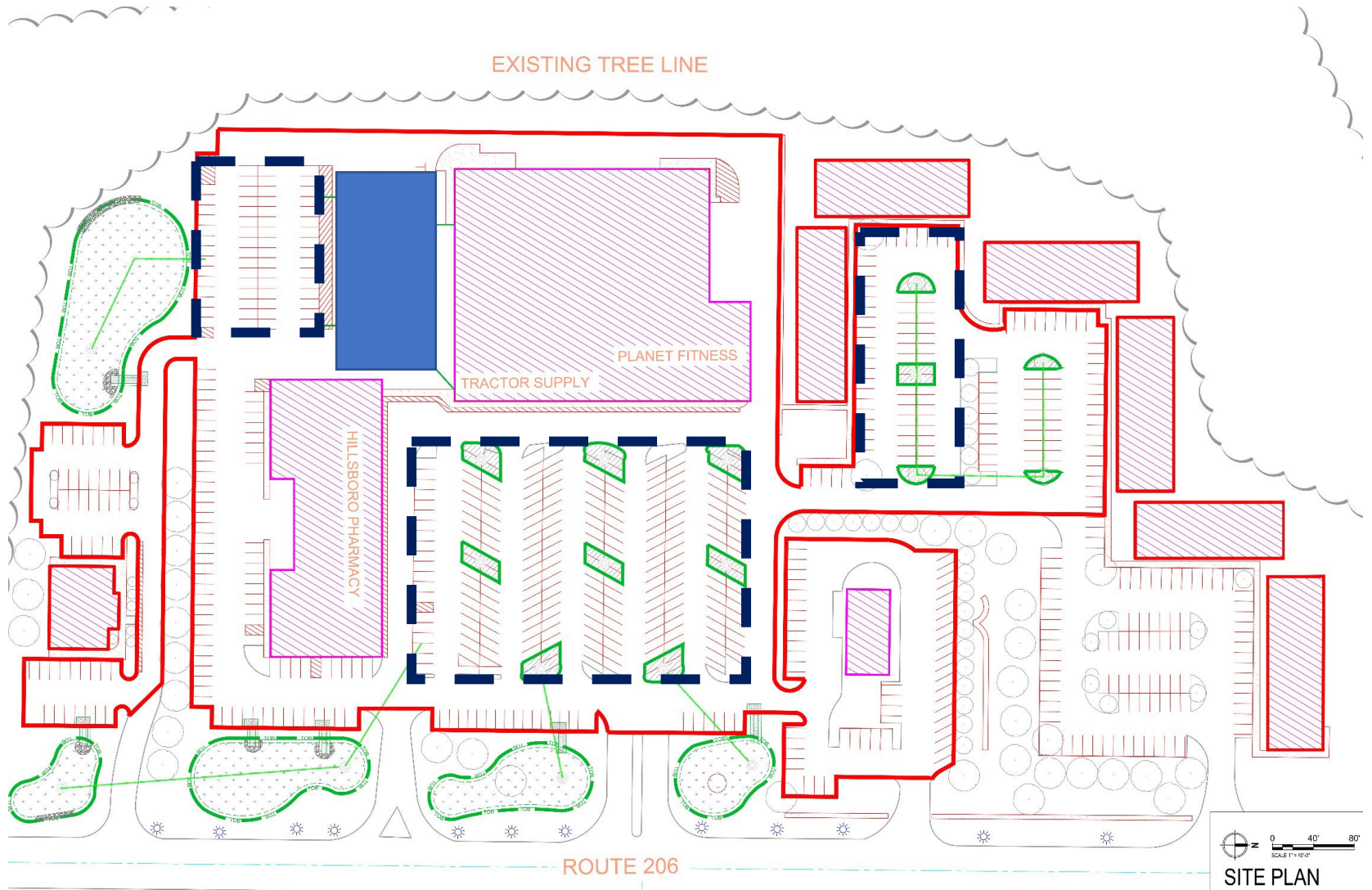
11.6 acres

294,756 ft³ of runoff for 7.0 inches rain



SITE PLAN

Green and Gray Infrastructure Practices



Next Steps: Public Outreach

Stakeholder Engagement and Collaboration

- Municipalities, non-governmental organizations (NGOs), individual residents and homeowners

Public Demonstration Projects

- Use the Hillsborough Plaza Green Infrastructure Project as a primary case study. Specify that this project serves as a demonstration for citizens to learn about sustainable stormwater management and local pollinator ecology

Residential and Private Land Outreach

- How to do your part with homeowner rain gardens: Focus on educating residents about installing individual household rain gardens

New Jersey Blue Acres Program

- The state buys homes located in high-risk flood areas
- Some homeowners may not be legally permitted to elevate their homes
- The offered price may not be sufficient for people looking to purchase a new home



BLUE ACRES

Can we expand the scope of the Blue Acres Program?



- Look to buy land at higher elevations rather than purchasing homes in high-risk flood zones
- Construct water management systems (i.e., stormwater parks) to hold water for longer periods
- Reduce the peak flooding experienced downstream

Questions?

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