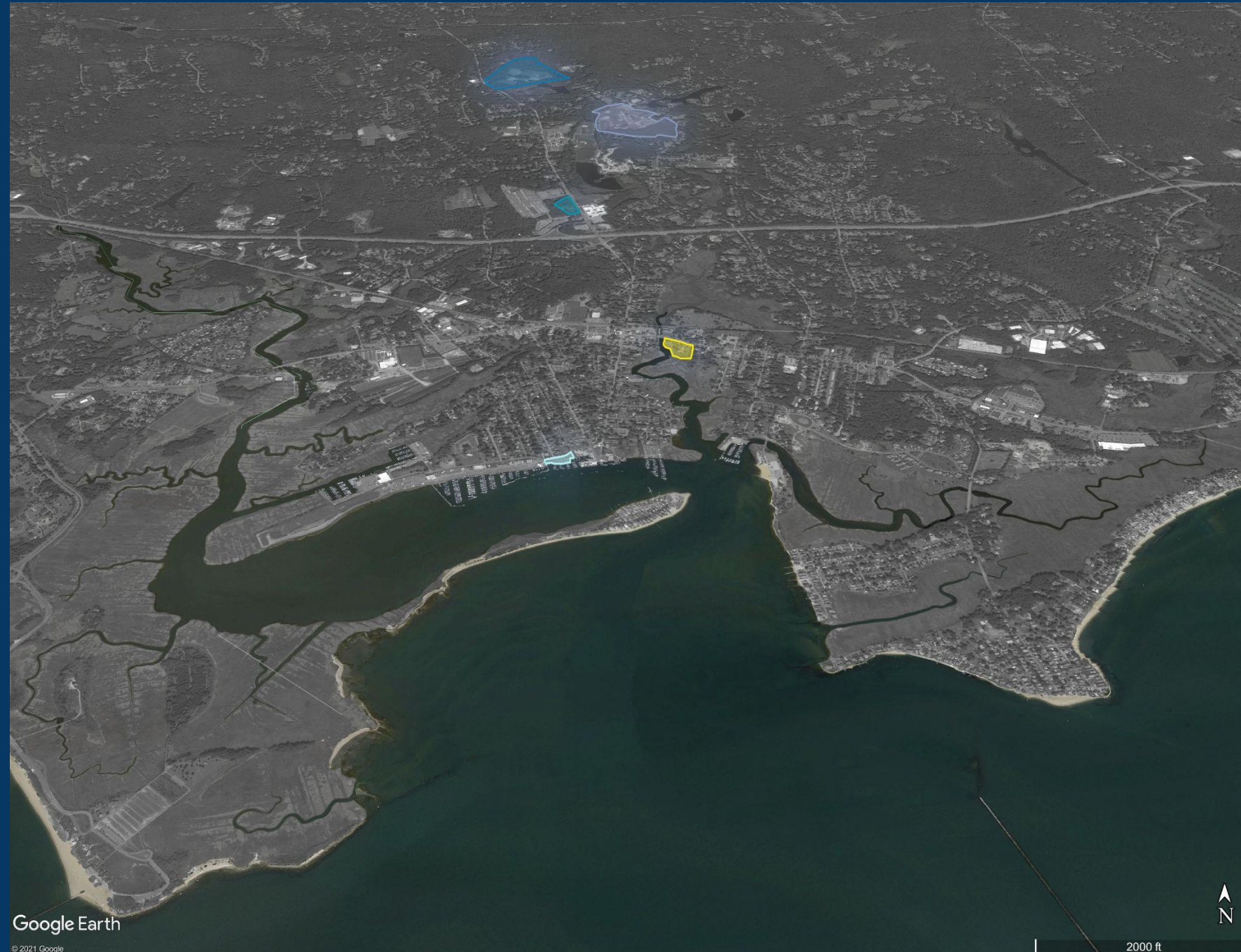


Stormwater Runoff Reduction Plan - Clinton, CT



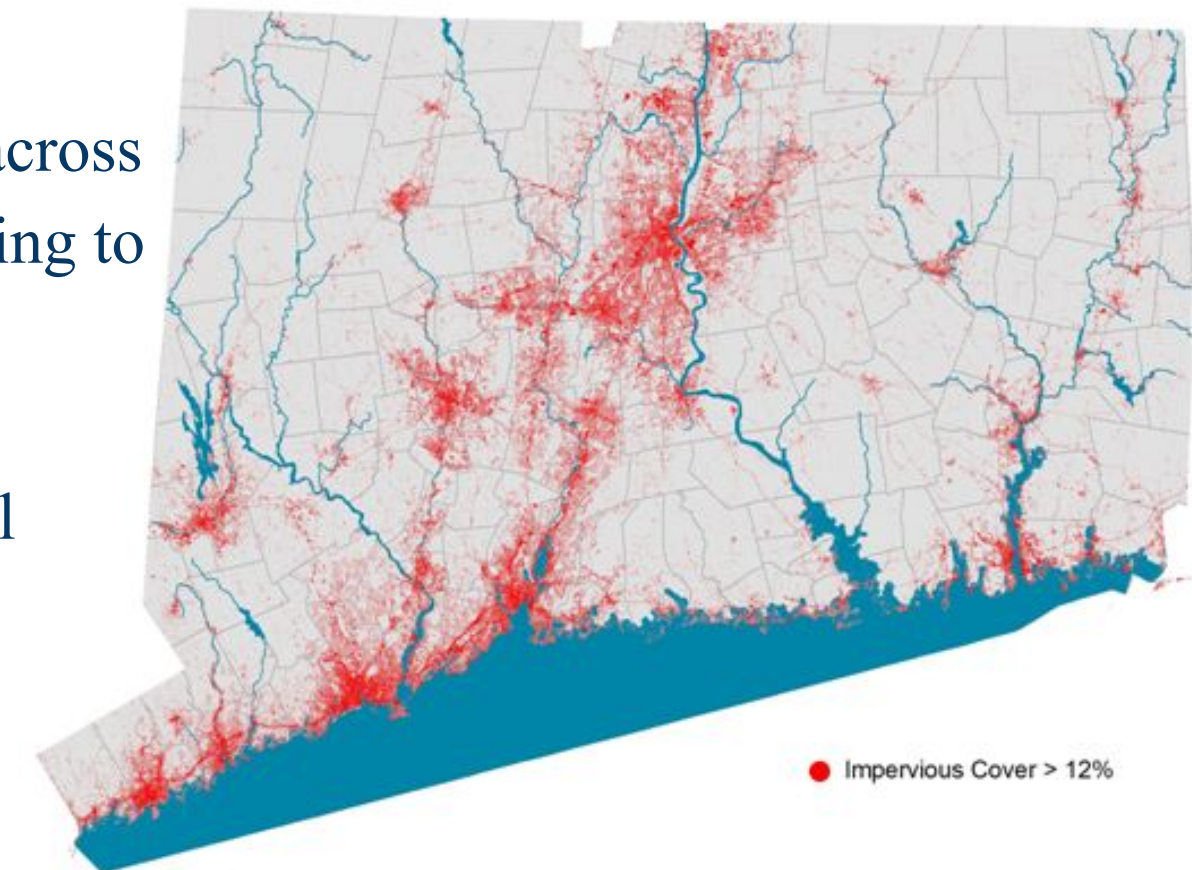
Created by: Ben Zaccara, Fiona Casey, and Rachael Ruggiero - UConn Undergraduate Students
Mike Deitz , David Dickson, Chet Arnold and Josh Snarski - UConn Center for Land Use Education & Research

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Impervious Surfaces & Runoff

- Increase in urban development leads to increase in *impervious cover*
 - *Impervious cover*- any surface which prevents the natural infiltration of stormwater into soil
 - *Ecological impact*- Runoff collects pollutants as it flows across impervious cover where it gains volume and velocity leading to erosion, sedimentation, and increased flooding.
 - Increased runoff enters city sewer systems where it is discharged into water bodies having adverse ecological consequences
- *Green Stormwater Infrastructure (GSI)* disconnects stormwater runoff from city sewer systems allowing for infiltration into the ground



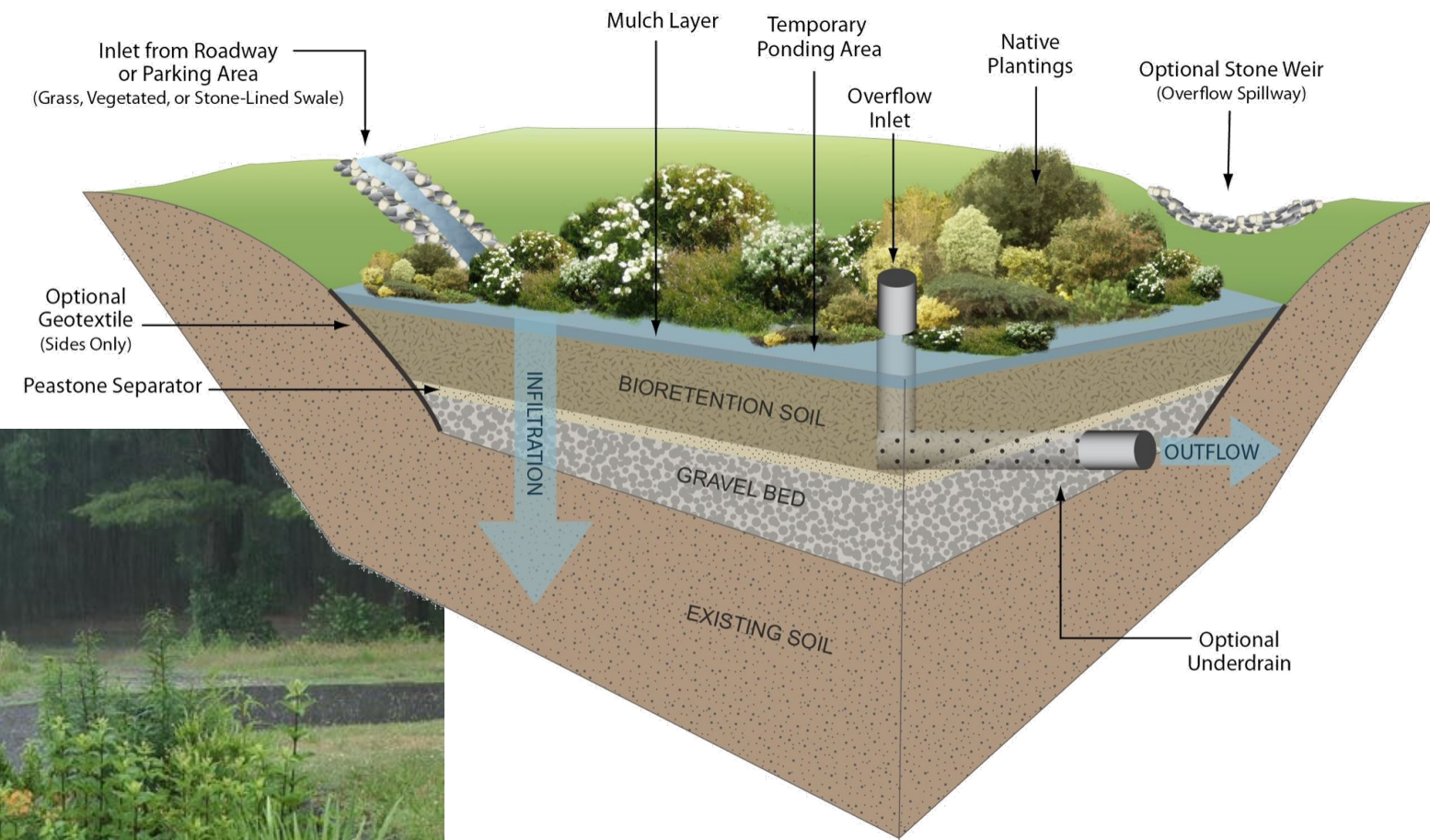
MS4 Requirements- Municipal Separate Storm Sewer Systems Permitting Program

- 2004- DEEP recognizes need for regulation of stormwater runoff
 - ***Nonpoint Source Pollution***: stormwater runs across impervious surfaces, collecting pollutants as it flows into storm drains.
 - Permitting program encourages use of ***Low Impact Development*** practices to mitigate pollution in waterways. These practices are designed to maintain or recreate ***pre-development hydrology***, with an emphasis on ***treatment of stormwater onsite***.

- 2016- DEEP issues additional MS4 requirements
 - As part of the development of stormwater management plans, along with subsequent monitoring and reporting, municipalities are required to ***disconnect 2% of directly connected impervious cover***.
 - ***Directly connected impervious cover*** is any impervious surface which conducts stormwater into the city sewer system, and which eventually flows into lakes, streams, and the ocean.

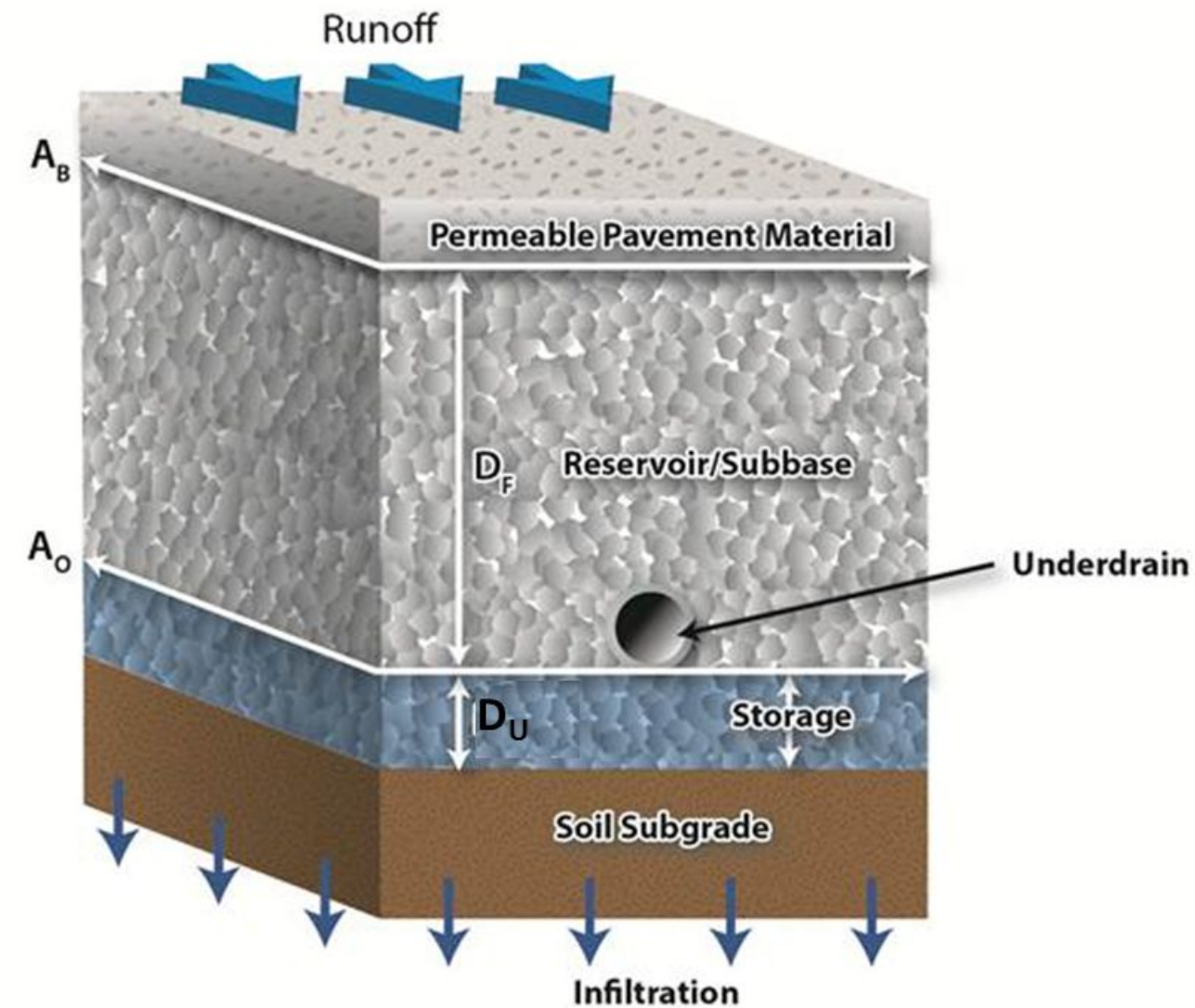
Rain Gardens and Bioretention

- Shallow depression which collects runoff from impervious cover
- Facilitates infiltration of runoff while filtering out pollutants and recharging groundwater
- Supports wildlife by providing food and shelter

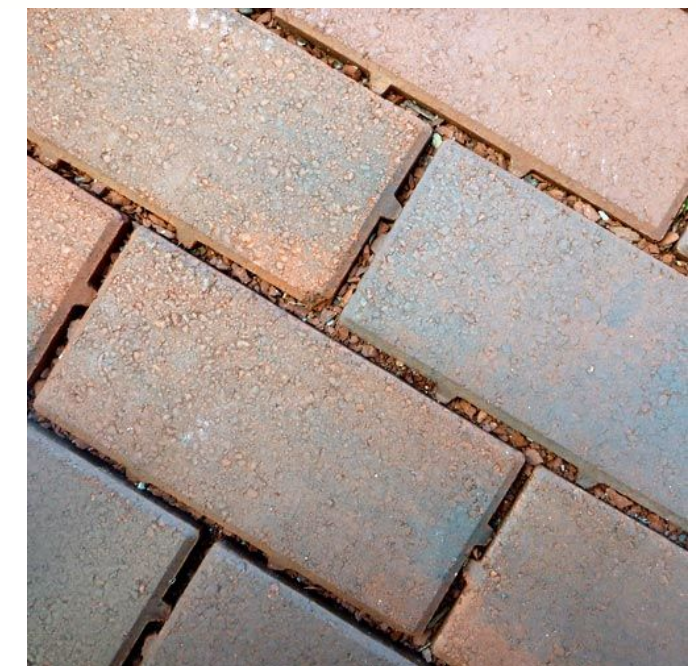


Pervious Paving

- Allows for runoff to infiltrate into soil by passing directly through pavement surface
- Can be used to treat additional runoff from nearby impervious cover
- Can be implemented in a variety of light traffic areas
- Many cost effective options exist to suit site-specific needs



Gravel Grid Pavement



Permeable Interlocking Concrete Pavers

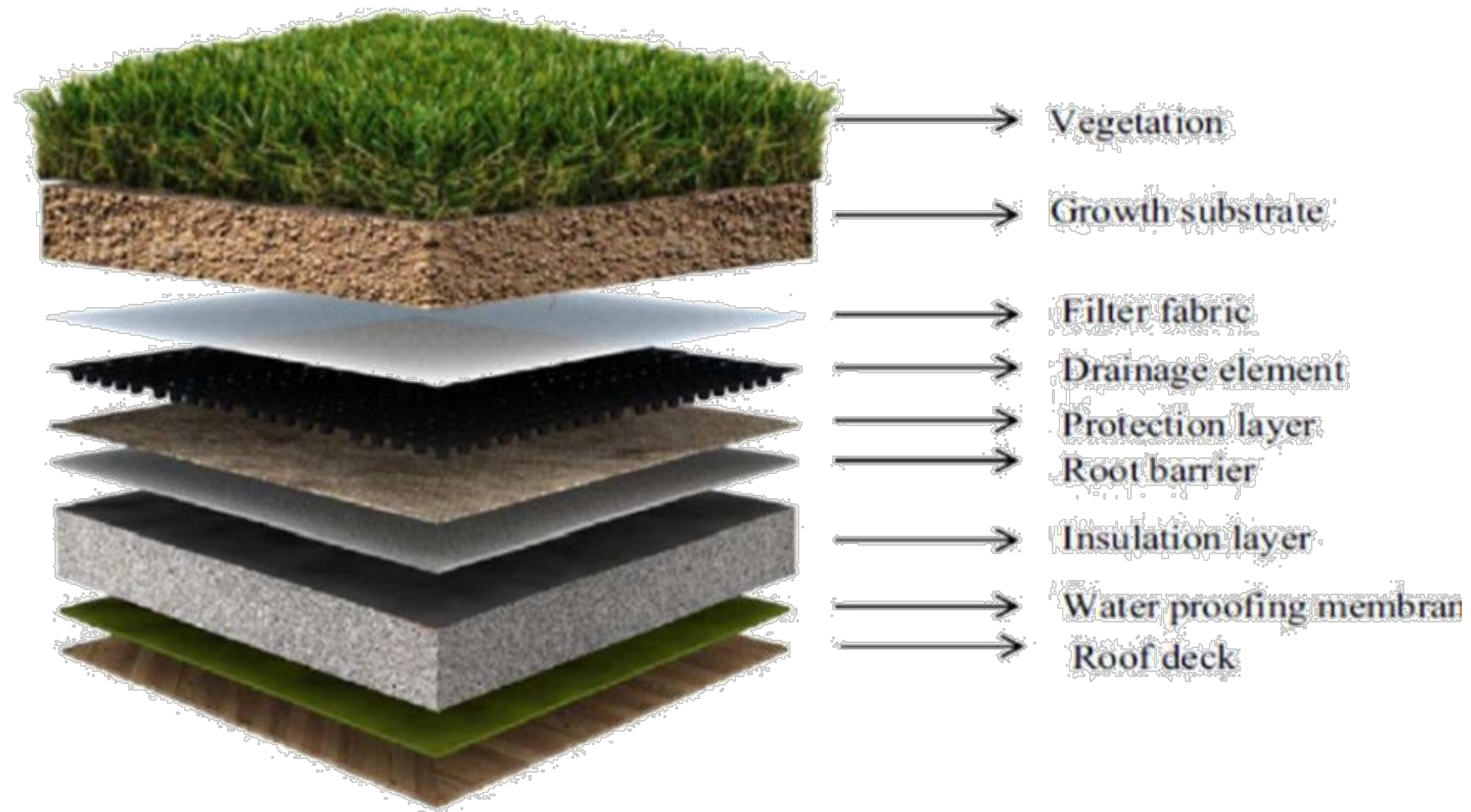
Tree Box Filters

- Consist of a precast/cast in place concrete box filled with soil and filtration media
- Commonly used along sidewalks and roadways
- Runoff is contained within soil and consumed by tree, with overflow exiting the system via underdrain



Green Roofs

- Consist of a layered system with plant material and filtration media separated from the existing roof by a layer of waterproofing and root repellent
- Extensive-Intensive: varied degrees of complexity; from simple, inaccessible systems with low plant diversity, to accessible, highly diverse designs
- Feasibility dependent upon structural integrity of building



Rainwater Harvesting

- Runoff from rooftop conducted through downspouts to collection units, commonly rain barrels and cisterns
- Used for watering gardens, livestock, fire safety, domestic use, and long term storage
- Amount of runoff disconnected depends on use and use frequency



Explanation of Calculations

- **Drainage Area-**

- The potential watershed area for each potential retrofit was estimated using geospatial measurement tools in Google Maps and confirmed during site visits

- **Practice Sizing-**

- Sized for 1” rainfall event (around 90% of storms in CT)
 - Runoff volume based on watershed surface area, with dimensions of practice sized to accommodate total runoff volume

- **Nutrient Reductions-**

- Determined using estimated drainage area and nutrient export coefficients developed by Dr. Charles Fink
 - Point source pollution not factored into calculations

- **Gallons Treated-**

- Volume of stormwater treated determined by factoring CT’s 4 ft. annual rainfall into the drainage area for each potential retrofit

- **Cost-**

- Price range for GSI practices are estimated using industry literature, government websites/reports and installation manuals
 - Prices may vary as examples used are only of similar retrofits. Prices were not determined by consulting contractors

Green Stormwater Infrastructure (GSI) Practice Unit Pricing Table

Practice	Unit	Price Range		Notes	References
		Low	High		
Rain Garden	SF	\$ 4.00	\$ 16.00	Price varies with underdrain and vegetation	Houdeshel, 2011
Bioretention	SF	\$ 5.00	\$ 30.00	Price greatly varies with structures, underdrains, bank stabilization and depth	Brennan, 2011; MassDEP, 2018
Vegetated Swale	LF	\$ 4.50	\$ 20.00	Not Included: Structures, bank stabilization, clearing/grubbing, curbs, underdrain	PDEP, 2006
Extensive Green Roof	SF	\$ 7.00	\$ 36.00	Not Included: Irrigation system, structural improvements, > 6" medium depth	PDEP, 2006; Peck and Kuhn, 2001; Manso, 2021, LID Center, 2005
Gravel Grid	SF	\$ 1.50	\$ 5.75	Includes the cost of installation	LID Center Website, 2007
Porous Asphalt	SF	\$ 3.50	\$ 8.00	Not included: Underdrain, >12" aggregate depth	LID Center, 2005
Porous Concrete	SF	\$ 5.00	\$ 13.50	Not included: Underdrain, >12" aggregate depth	LID Center, 2005
Permeable Pavers	SF	\$ 8.00	\$ 17.00	Not included: Underdrain, >12" aggregate depth	LID Center, 2005
Tree Box Filter	EA	\$ 7,000.00	\$ 18,000.00	Unit sizes and treatment volumes vary	PVPC, 2015; MassDEP, 2018
Rain Barrel/Cistern	EA	\$ 1,500.00	\$ 2,500.00	Not included: Cost of installation	National Tank Outlet, 2021

These unit prices have been gathered from published literature, government websites/reports, and installation manuals. Unit prices have not been normalized to current market values. The cost ranges were selected to best represent recommendation typically made by the University of Connecticut Stormwater Corps course and are for informational purposes only. Prepared by Joshua Snarski, University of Connecticut, Department of Natural Resources and the Environment, 2021.

Site Selection & Approach

- **Preliminary Analysis-**

- Web-based search to identify potential GSI project locations to conduct site visits
 - Research using town databases: identifying property ownership, prominent locations, and potential educational and community outreach opportunities
 - Geospatial analysis using aerial imagery from ArcGIS, Google Maps

- **On Location-**

- Site specific recommendations selected based on suitability for GSI practices
 - Identify location of existing storm drains or downspouts and their proximity to potential GSI practice area
 - Assess slope of surrounding land, determine drainage areas for storm drains and direction of runoff flow
 - Locate above and below ground obstructions
 - Determine best locations for visibility of practice, educational value, and potential community involvement

Clinton Parks & Rec
201 Killingworth Tpke

Lewin G. Joel School
137-B Glenwood Rd

Henry Carter Hull Library
10 Killingworth Tpke

I-95

Clinton Town Marina
37 Riverside Dr

Clinton Town Hall
50 East Main Street

Stormwater Retrofits

Clinton, CT



Clinton Parks & Rec

201 Killingworth Tpke
Clinton, CT

Notes:

- Large area of impervious cover ideal for disconnect
- High profile location with proximity to water body
- Great location for showcase of various GSI practices
- Total Potential Disconnect: 101,887 sq. ft.



IMPERVIOUS COVER

Potential disconnect of 10,240 sq. ft. of impervious cover with use of rain garden. High visibility near west parking lot.

Potential disconnect of 9,148 sq. ft. with use of pervious pavement

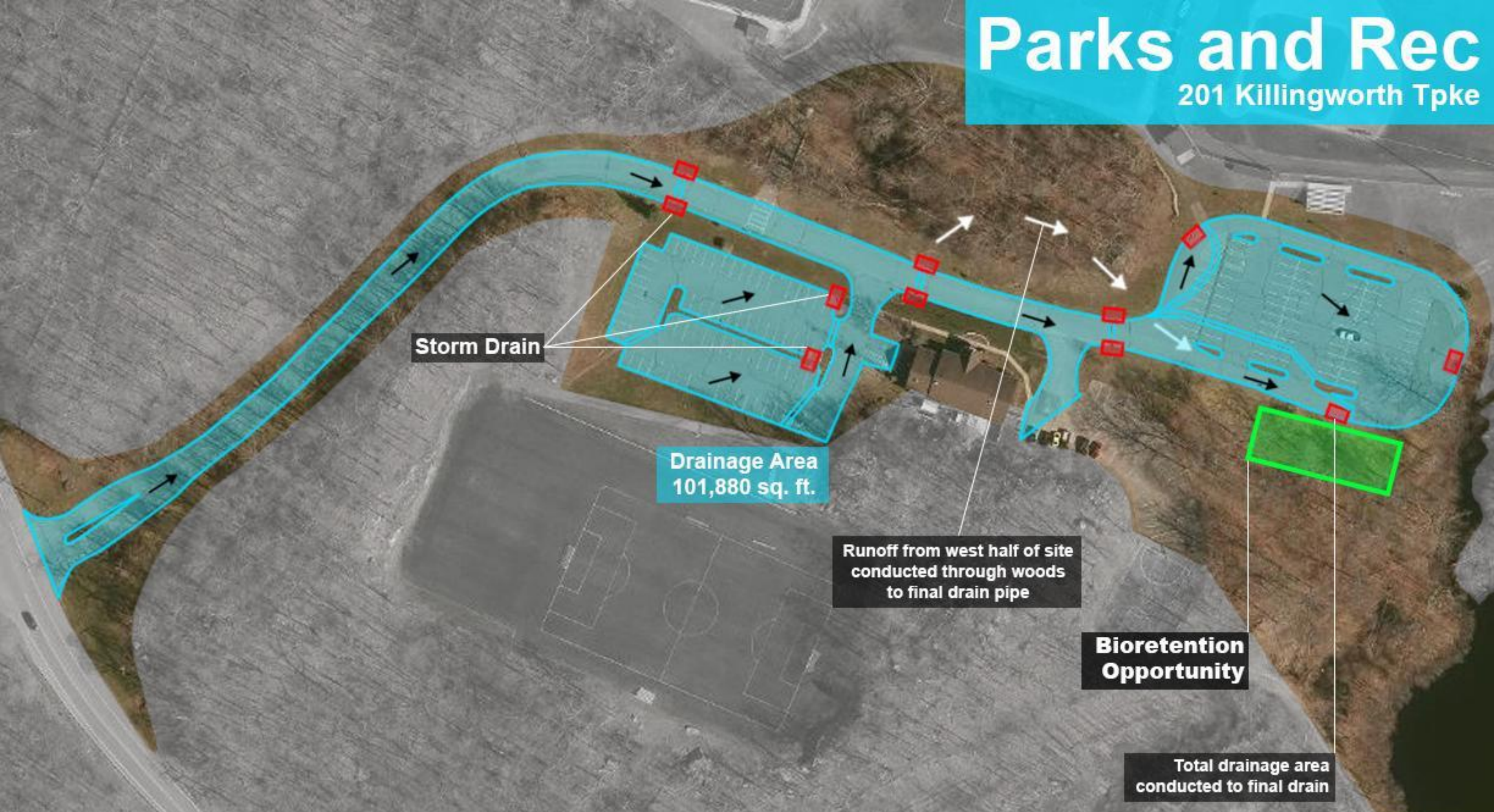


Potential disconnect of 10,541 sq. ft. of impervious cover with the use of tree box filters. Excellent location to create entryway with tree boxes.

Potential disconnect of 101,877 sq. ft. of impervious cover with the use of bioretention basin. Can be implemented with other suggested practices to offset total runoff volume. Basin designed for infiltration with no standing water; constructed wetland designs also possible if desired.

Parks and Rec

201 Killingworth Tpke



Suggested Practice

Bioretention

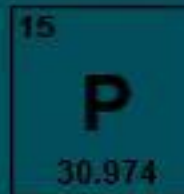
- 3' Depth

- 2,830 sq. ft.

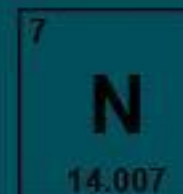
- \$11,320 - \$45,280



2,682,818 gal.
runoff treated
per year



Phosphorus
Reduction
3.54 lb/year



Nitrogen
Reduction
27.86 lb/year

Parks and Rec

West Parking Lot



Drainage Area
9,148 sq. ft.

Permeable
Pavement
Opportunity

Storm Drain

Suggested Practice
Permeable Pavement
-2,400 sq. ft.
-\$8,400 - \$19,200



273,745 gal.
runoff treated
per year



¹⁵
P
30.974

Phosphorus
Reduction
.32 lb/year

⁷
N
14.007

Nitrogen
Reduction
2.5 lb/year

Parks and Rec

West Parking Lot

Drainage Area
10,236 sq. ft.

Curb Cut



Rain Garden Opportunity

Storm Drain

Suggested Practice
Rain Garden
- 1,280 sq. ft.
- 8" Depth
- \$5,120 - \$20,480

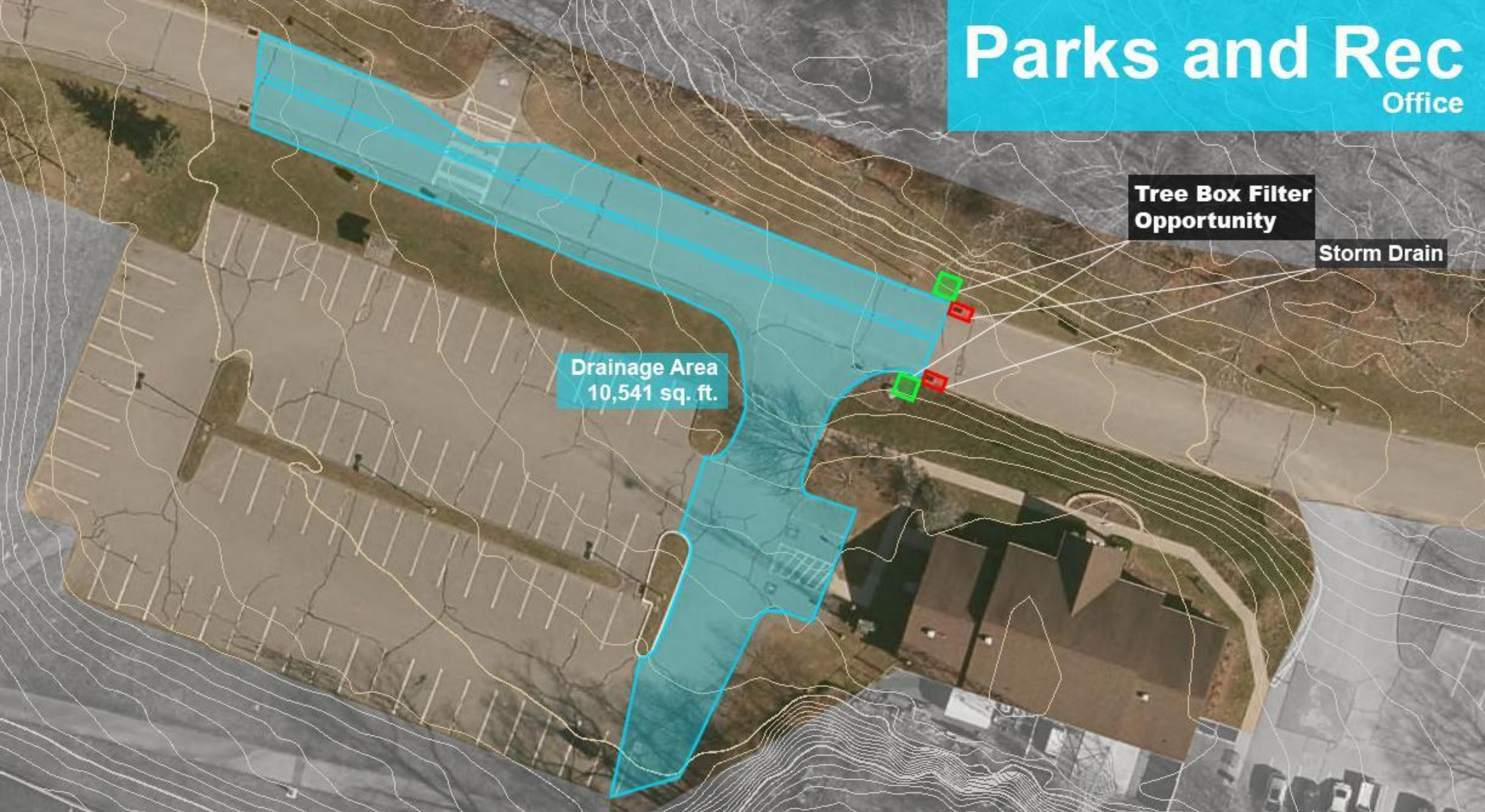
269,546 gal.
runoff treated
per year

Phosphorus
Reduction
.36 lb/year

15
P
30.974

Nitrogen
Reduction
2.80 lb/year

7
N
14.007



Drainage Area
10,541 sq. ft.

Tree Box Filter
Opportunity

Storm Drain

Suggested Practice
Tree Box Filters
- 2 @ 3'x3'
- \$6,000 - \$36,000



 **277,577 gal.**
runoff treated
per year

15
P
30.974

Phosphorus
Reduction
.37 lb/year

7
N
14.007

Nitrogen
Reduction
2.88 lb/year

Clinton Town Hall

50 East Main St
Clinton, CT

Notes:

-High profile location,
with excellent existing
landscaping

-Excellent educational
opportunity

-Runoff from site
empties directly into LI
Sound

-Total Potential
Disconnect:
3,485 sq. ft.

Runoff from most of the site conducted to storm drain emptying directly into Long Island Sound. On-site treatment of stormwater is of great ecological importance at this location.



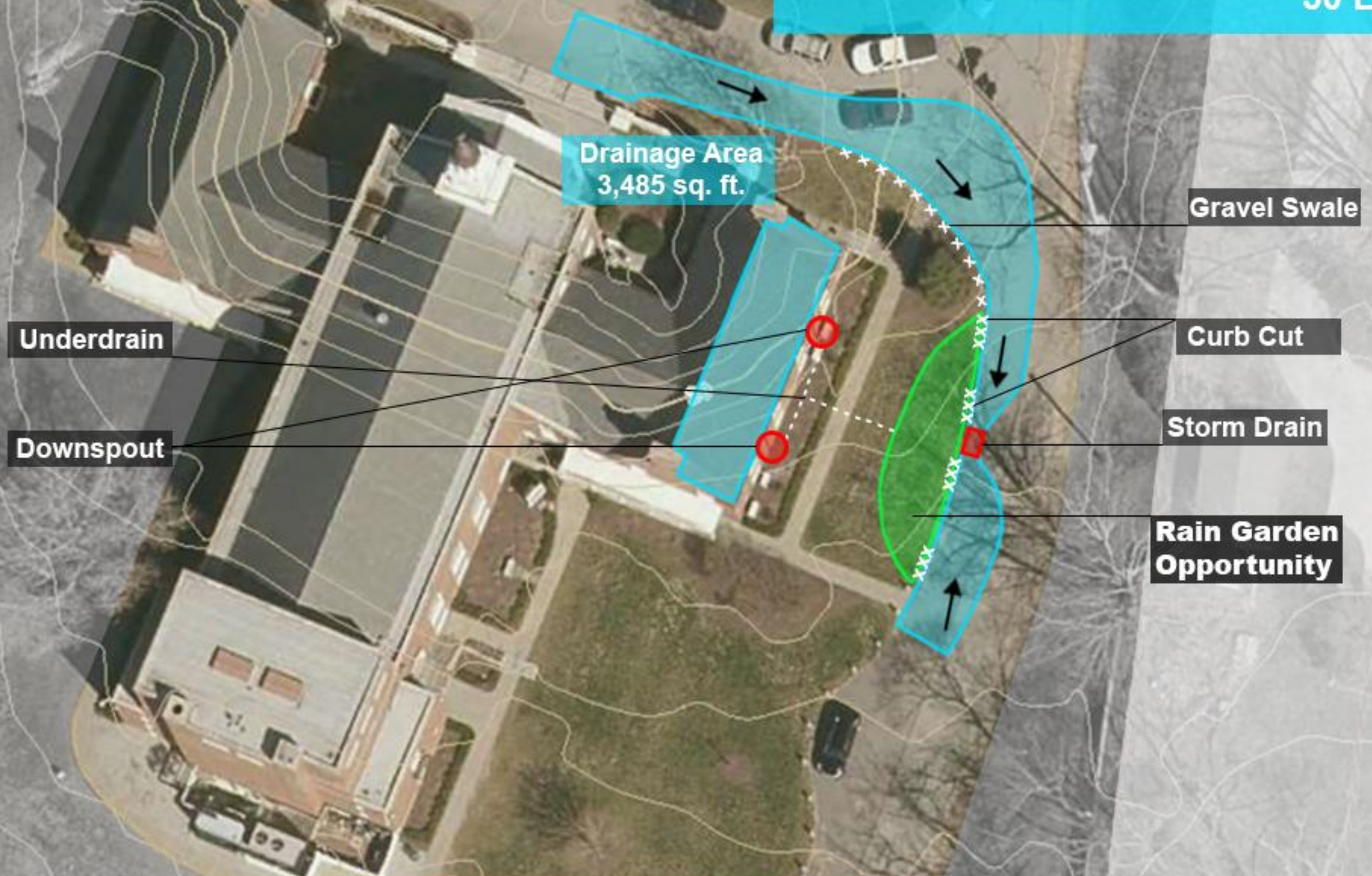
Potential disconnect of 3,485 sq. ft. of impervious cover with the use of rain garden. Gravel swale required to reduce erosion and conduct runoff from north lot. Underdrain required beneath sidewalk if roof runoff is to be conducted to rain garden.



IMPERVIOUS COVER

Clinton Town Hall

50 East Main St



Suggested Practice
Rain Garden
- 6" Depth
- 578 sq. ft.
- \$2,265 - \$9,060



91,766 gal.
runoff treated
per year

¹⁵
P
30.974

Phosphorus
Reduction
.12 lb/year

⁷
N
14.007

Nitrogen
Reduction
.95 lb/year

Clinton Town Marina

37 Riverside Dr

Notes:

-Large area of impervious cover ideal for disconnect

-High profile location, with proximity to Long Island Sound

-Great location for showcase GSI practice

-Total Potential Disconnect:
39,900 sq. ft.



IMPERVIOUS COVER



Possible disconnect of 13,591 sq. ft. of impervious cover with use of tree box filters. Two tree box filters at the entrance to boat launch would greatly improve aesthetics. Installing only tree box filters will treat 55% of total drainage area, together with rain garden treating 100%. Installation requires removal of one section of existing fence.

Possible disconnect of 26,310 sq. ft. of impervious cover with the use of rain garden. Gravel storage of 3' beneath system required to accommodate large drainage area. Existing trees to be replaced. Full drainage area empties directly into Long Island Sound.

Clinton Town Marina

37 Riverside Dr



Curb Cut

Storm Drain

Rain Garden Opportunity

Drainage Area
26,310 sq. ft.

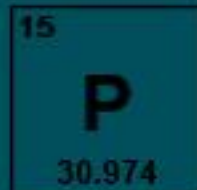
Suggested Practice

Rain Garden

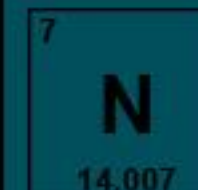
- 546 sq. ft. @ 1' depth
- 3' gravel storage
- \$2,090 - \$8,363



692,831 gal.
runoff treated
per year



Phosphorus
Reduction
.91 lb/year



Nitrogen
Reduction
7.19 lb/year

Clinton Town Marina

37 Riverside Dr



Suggested Practice

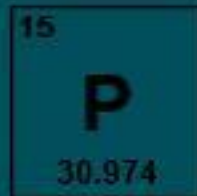
Combined



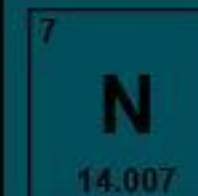
- 480 sq. ft. Rain Garden
- 2 @ 3'x3' Tree Box Filters
- \$15,924 - \$43,696



1,050,717 gal.
runoff treated
per year



Phosphorus
Reduction
1.38 lb/year



Nitrogen
Reduction
10.91 lb/year

Joel School

137-B Glenwood Rd
Clinton, CT

Notes:

-Large area of impervious cover ideal for disconnect

-Excellent educational opportunity, high visibility

-Excellent existing landscaping

-Total Potential Disconnect:
25,553 sq. ft.



IMPERVIOUS COVER



Potential disconnect of 20,500 sq. ft. of impervious cover with the implementation of a series of rain gardens. Large drainage area for two storm drains near front entrance; multiple GSI practices recommended due to runoff volume and lack of usable space. Excellent opportunity to add to the aesthetics of school entrance, with possible incorporation of practices into curriculum.

Potential disconnect of 5,053 sq. ft. of impervious cover with use of rain garden. High visibility and great educational opportunity at rear entrance to building.

Lewin G. Joel School

East Lot (North Section)



Rain Garden Opportunity

Drainage Area 2
2,200 sq. ft.

Curb Cut

Drainage Area 1
4,400 sq. ft.

Storm Drain

Suggested Practice
Rain Garden
- 1' Depth
- 548 sq. ft.
- \$2,195 - \$8,760



173,775 gal.
runoff treated
per year



Phosphorus
Reduction
.23 lb/year

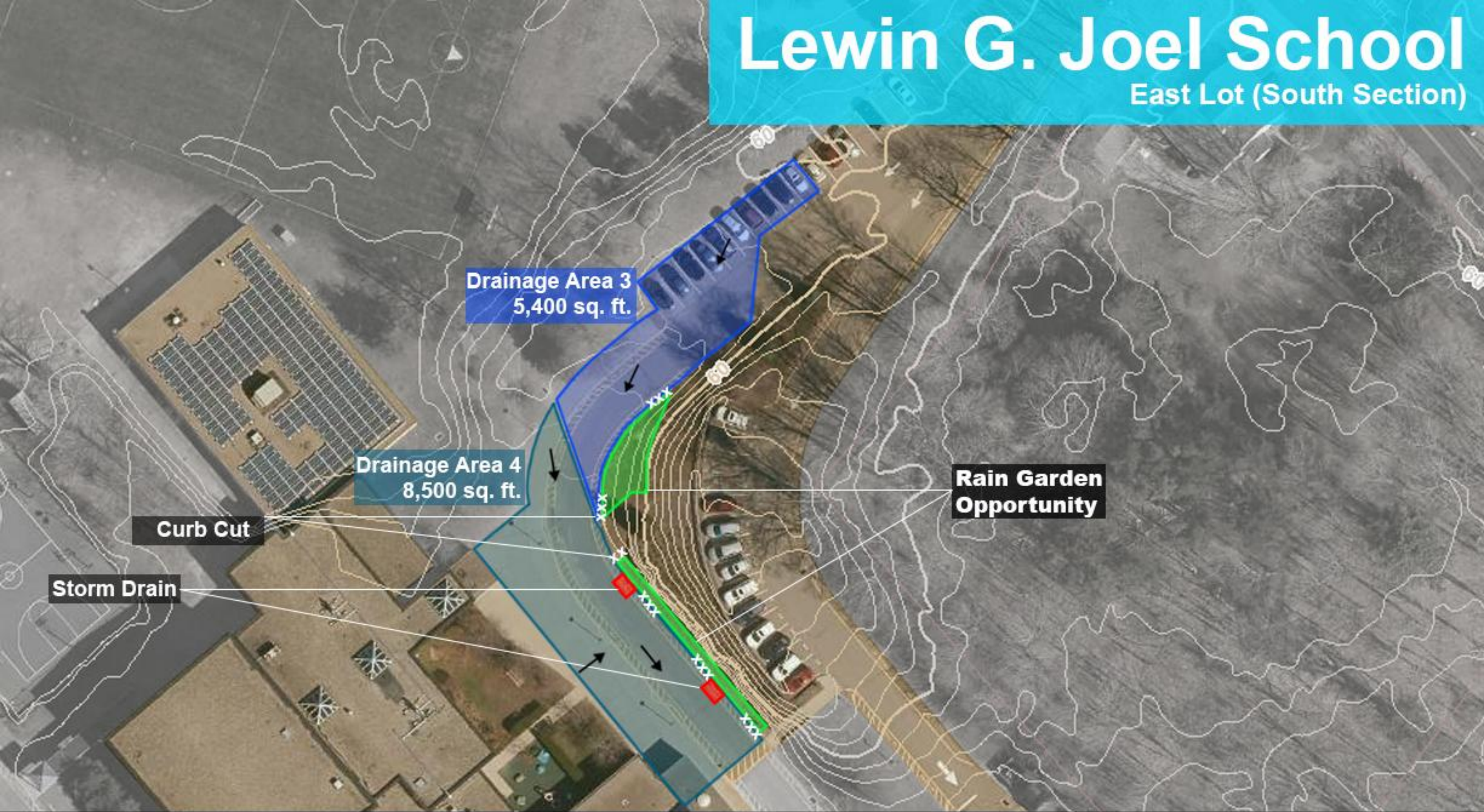
¹⁵
P
30.974

Nitrogen
Reduction
1.8 lb/year

⁷
N
14.007

Lewin G. Joel School

East Lot (South Section)



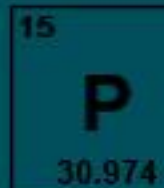
Suggested Practice

Rain Garden

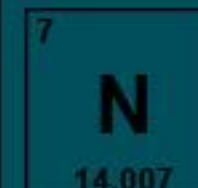
- 8" & 15" Depths
- 1,067 sq. ft.
- \$4,268 - \$13,728



365,980 gal.
runoff treated
per year



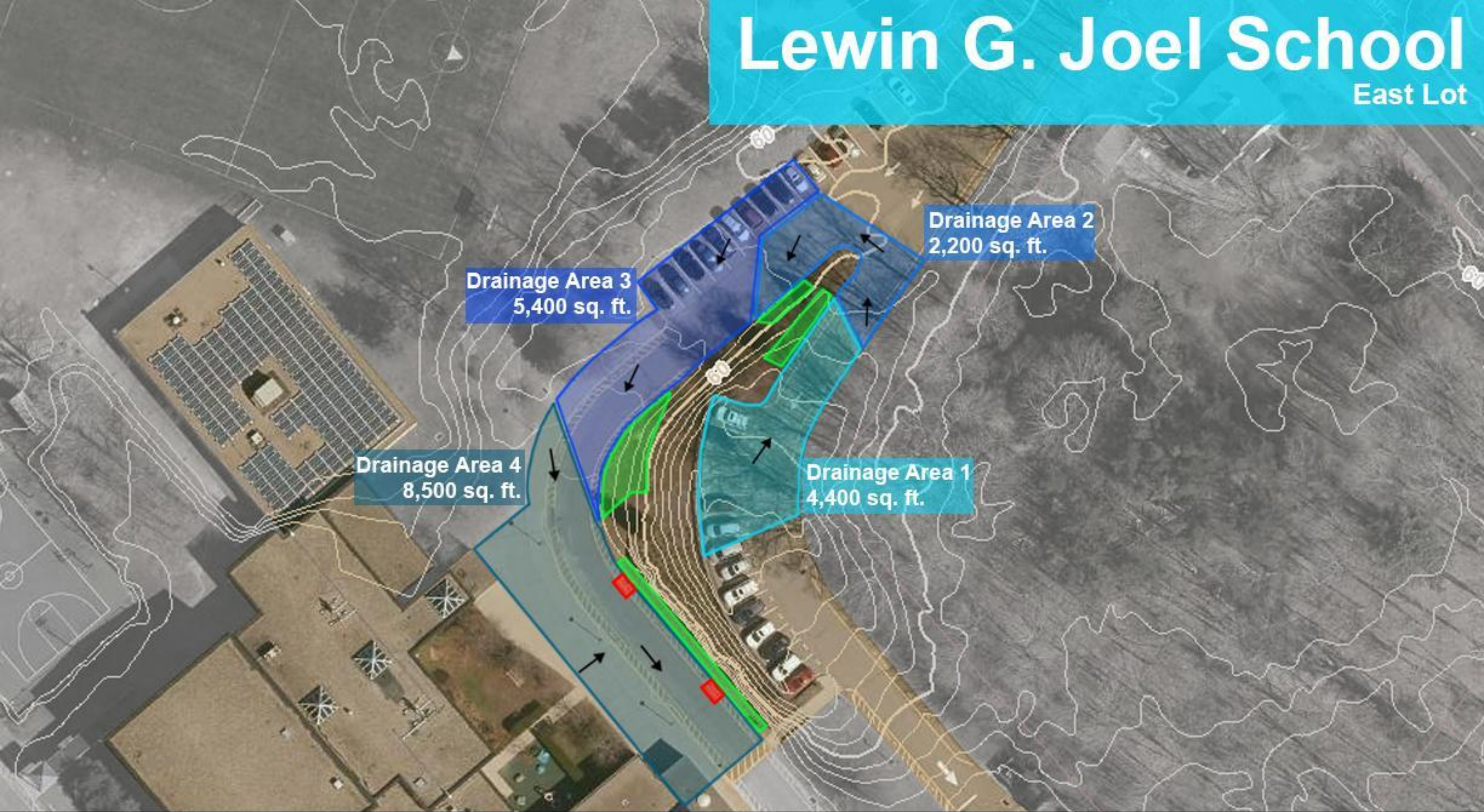
Phosphorus
Reduction
.48 lb/year



Nitrogen
Reduction
3.8 lb/year

Lewin G. Joel School

East Lot



Suggested Practice

Rain Garden

- 8" - 15" Depths

- 1,615 sq. ft.

- \$6,463 - \$25,840



539,755 gal.
runoff treated
per year

¹⁵
P
30.974

Phosphorus
Reduction
.71 lb/year

⁷
N
14.007

Nitrogen
Reduction
5.6 lb/year

Lewin G. Joel School

Rear Entrance



Drainage Area
5,053 sq. ft.

Downspout

Rain Garden
Opportunity

Storm Drain

Suggested Practice
Rain Garden
- 6" Depth
- 840 sq. ft.
- \$1,680 - \$6,720



133,122 gal.
runoff treated
per year



Phosphorus
Reduction
.18 lb/year

15
P
30.974

Nitrogen
Reduction
1.38 lb/year

7
N
14.007

Hull Library

10 Killingworth Tpke
Clinton, CT

Notes:

-Large area of impervious cover ideal for disconnect

-High profile location, with proximity to waterbody

-Excellent educational/community engagement opportunity

-Total Potential Disconnect:
13,068 sq. ft.



IMPERVIOUS COVER



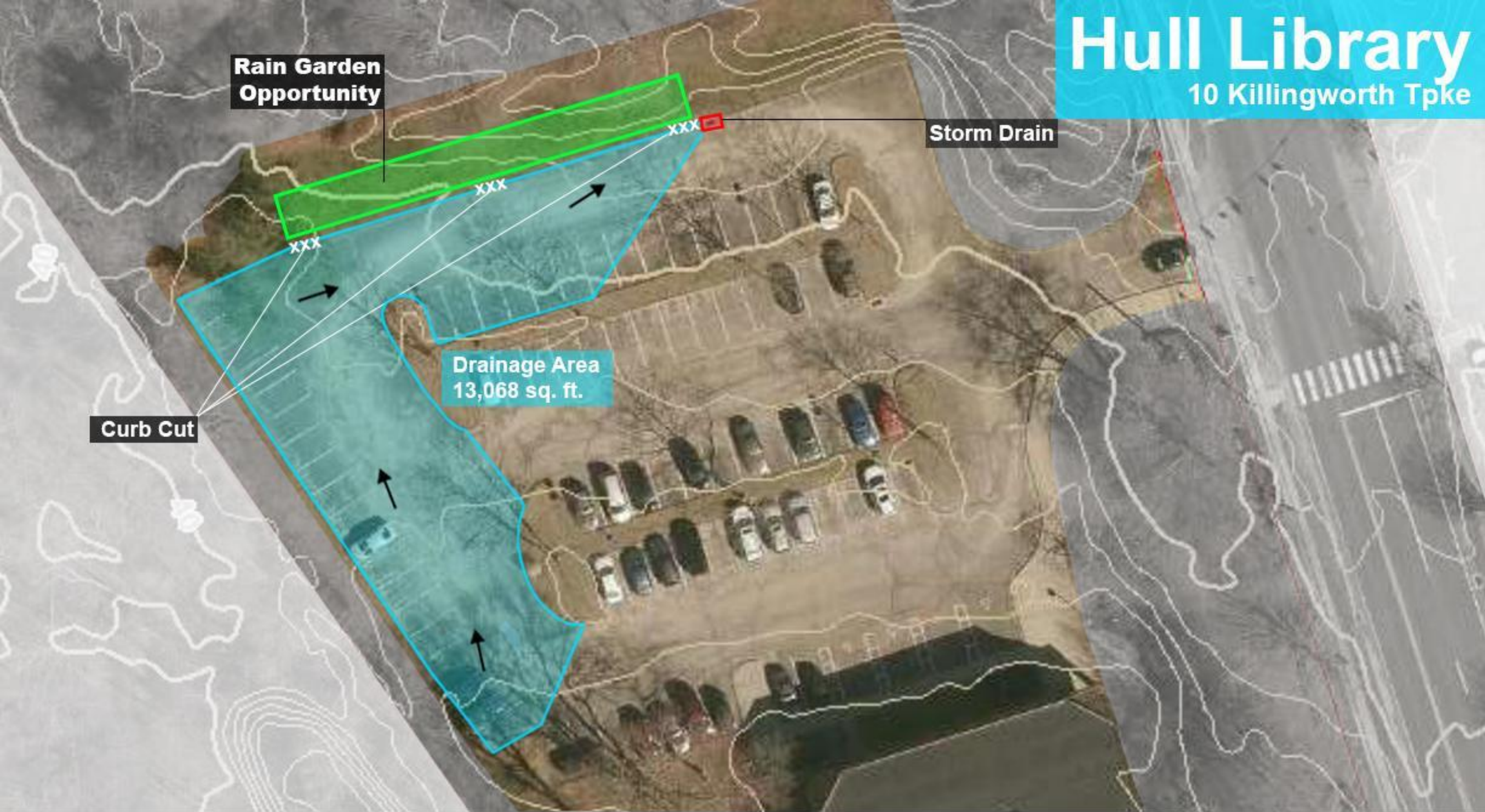
Potential disconnect of 13,068 sq. ft. of impervious cover with the use of rain garden. Practice can be incorporated into educational programming at library. Great location to involve community with installation.

Uneven slope at proposed GSI site. Outflow pipe from storm drain creates mound restricting rain garden to west side of drain. Slope also drops suddenly at rear of parking lot; a berm is required for stabilization.



Hull Library

10 Killingworth Tpke



Suggested Practice
Rain Garden
- 12" Depth
- 1,084sq. ft.
- \$4,336 - \$17,334



344,075 gal.
runoff treated
per year



Phosphorus
Reduction
.45 lb/year

15
P
30.974

Nitrogen
Reduction
3.57 lb/year

7
N
14.007

Site Recommendation Figures

		Total Disconnection (sq. ft)	Phosphorus Nutrient Reduction (lb P/yr)	Nitrogen Nutrient Reductions (lb N/yr)	Gallons Treated per Year	Estimated Cost
Clinton Parks and Rec	Southwest Parking Lot Area	9,148	0.32	2.5	273,745	\$8,400-19,200
	Northwest parking Lot Area	10,236	0.36	2.8	269,546	\$5,120-20,480
	Lower Office Driveway	10,541	0.37	2.88	277,577	\$6,000-36,000
	Southeast Bioretention	101,880	3.54	27.86	2,682,818	\$11,320-45,280
Clinton Town Hall	East Building Opportunity	3,485	0.12	0.95	91,766	\$2,265-9,060
Clinton Town Marina	Rain Garden	26,310	0.91	7.19	692,831	\$2,090-8,363
	Rain Garden and Tree Box	39,900	1.38	10.91	1,050,717	\$15,924-43,696
	There is no total for this site, you would be one practice or the other					
Lewin G. Joel School	Drainage Area 1	4,400	0.15	1.2	115,850	\$1,460-5,840
	Drainage Area 2	2,200	0.08	0.6	57,925	\$735-2,928
	Drainage Area 3	5,400	0.19	1.48	142,179	\$2,700-10,800
	Drainage Area 4	8,500	0.29	2.32	223,801	\$1,568-6,272
	Blue Roof Opportunity	5,052	0.18	1.38	133,122	\$1,680-6,720
	Total For All	25,552	0.89	6.98	672,877	\$8,143-32,560
Hull Library	Back of Parking Lot	13,068	0.45	3.57	344,075	\$4,336-17,344

Sites Not Chosen for Stormwater Retrofits

- **Clinton Police Department** - Disconnected with constructed wetland
- **Liberty Green** - Limited options and nearby state owned road
- **Clinton Town Beach** - Limited impervious surfaces and no erosion issues
- **Abraham Pierson School** - Current disconnection and possible future construction
- **Morgan High School** - New construction already treating runoff



Clinton Town Beach

Contact & Partners

This project was funded by a grant from the Long Island Sound Futures Fund of the National Fish and Wildlife Foundation. It is a partnership of the University of Connecticut Center for Land Use Education and Research (CLEAR) and Rutgers University Water Resource Program, and is adapted from a process developed by the latter.

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