Green Infrastructure Master Strategy and Implementation Roadmap

NEWEA/NYWEA Joint Spring Meeting, Saratoga Springs, NY

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June 9, 2023

Overview

- Introduction
- Green infrastructure survey results
- Green infrastructure opportunity assessments
- Creation of New Bedford standard green infrastructure design tools
- Example conceptual designs

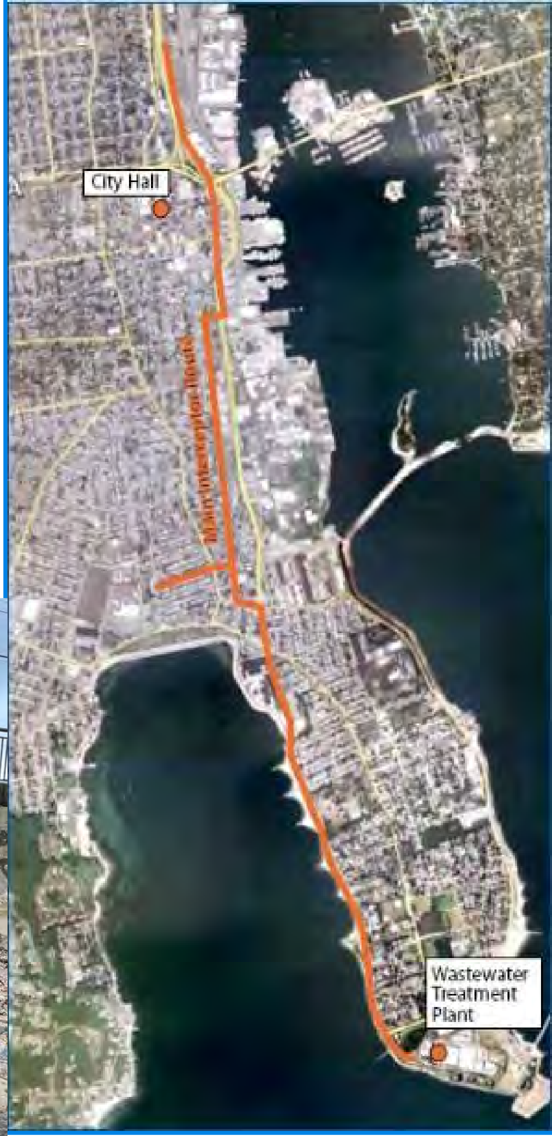
Master Strategy and Roadmap Overview

- Municipal Vulnerability Preparedness (MVP) Action Grant funding
- Coordinated with LTCP and Integrated Plan
- Coordinated with other City projects (roadway projects, developments)
- Environmental Justice opportunities prioritized
- Standard green infrastructure details and specifications developed

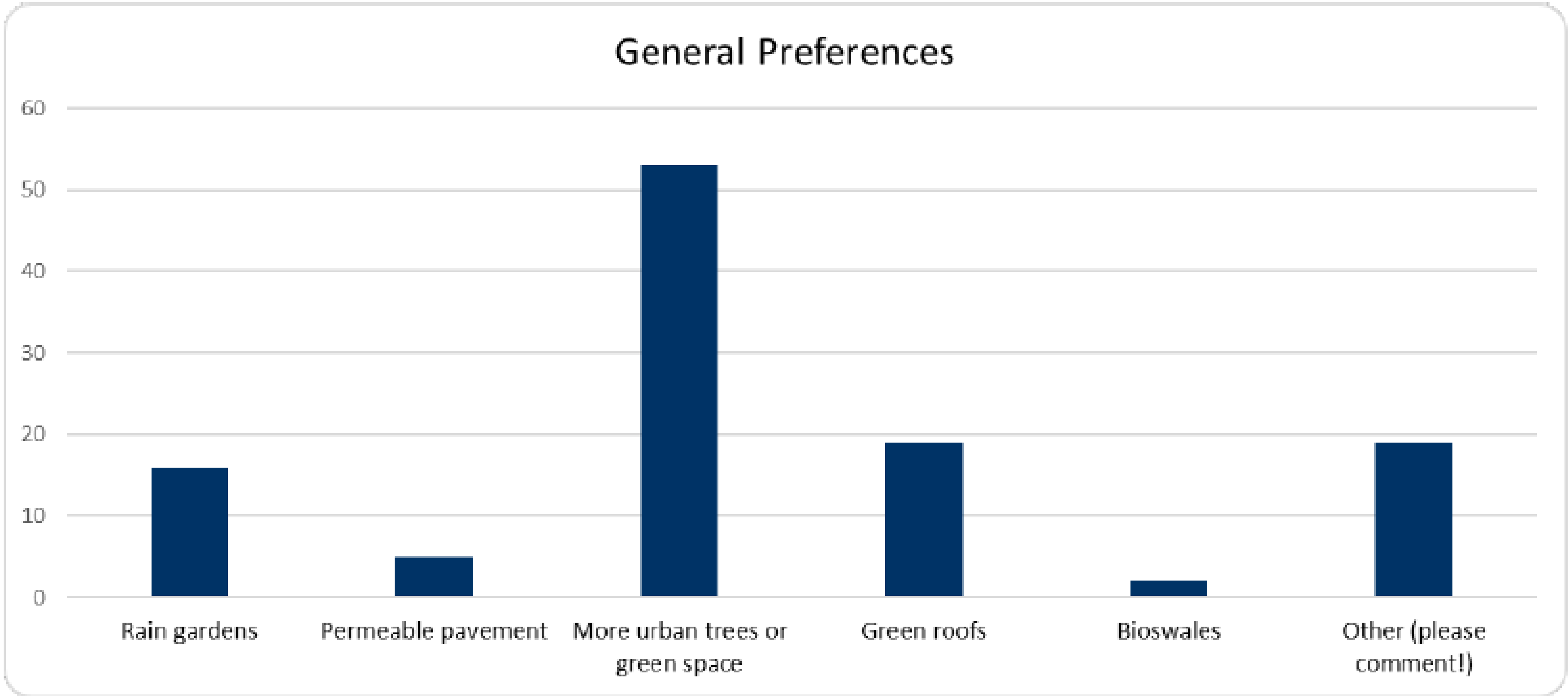
MVP
Municipal Vulnerability Preparedness

New Bedford Collection System 101

- System constructed primarily between 1850s and 1960s
- 420 miles of pipe ranging in size from 6-in to 96-in
  - 254 miles of sewer pipe (sanitary and combined)
  - 164 miles of storm drains
- 29 pumping stations
  - 12 miles of force mains
- 74 regulators flowing to 27 outfalls
- 358 stormwater outfalls

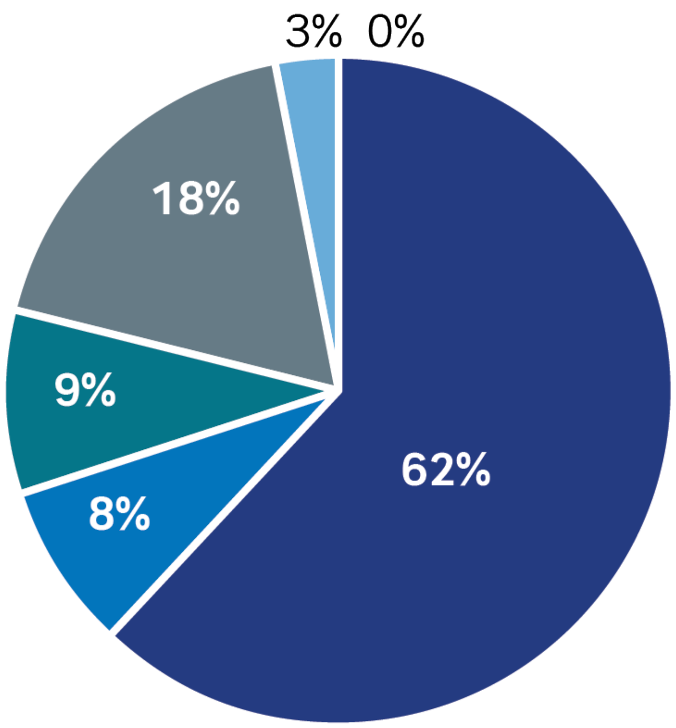


Green Infrastructure Survey Results
Preferred Types of Green Infrastructure



KIM LUNDGREN ASSOCIATES, INC.

Green Infrastructure Survey Results
Preferred Locations and Importance of Climate Impact Mitigation



- As part of the street (sidewalks, curb strip, parking strip, etc.)
- In public parks
- At homes and businesses
- On city-owned facilities (schools, fire stations, libraries)
- Coastal and waterfront areas
- I do not want to see green infrastructure

81%

Think it is *very important* to prioritize implementing green infrastructure in neighborhoods experiencing severe climate impacts

70%

Feel *very concerned* that climate change will worsen impacts like flooding and urban heat

Green Infrastructure Opportunity Assessments

Green Infrastructure Techniques – Areas With Limited Space

Porous Pavements

Blue Roof

Subsurface Storage and Infiltration

Green Roof and Rainwater Harvesting

Bioretention / Rain Gardens / Street Planters

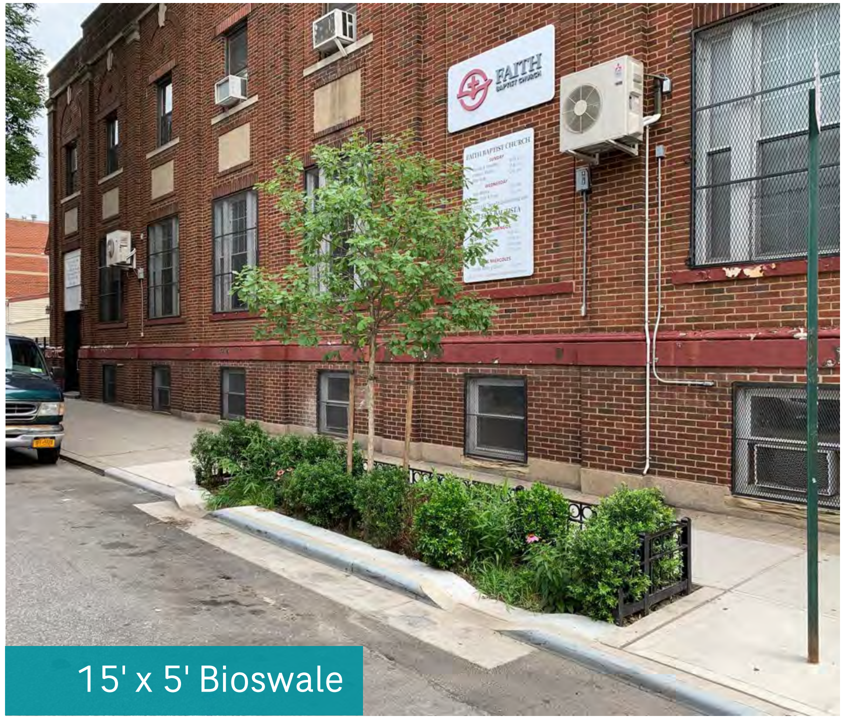
Right-of-Way Bioswales

CDM Smith
PVSC - Right-of-Way Green Infrastructure Pilot Program
Newark City Hall
June 2018

CDM Smith
PVSC - Right-of-Way Green Infrastructure Pilot Program
Jersey City Columbia Park
June 2018

Right-of-Way Bioswales

20' x 5' Bioswale

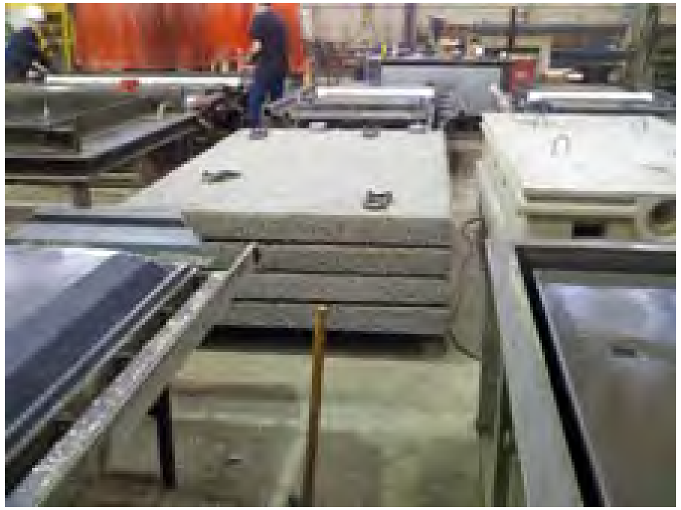


15' x 5' Bioswale

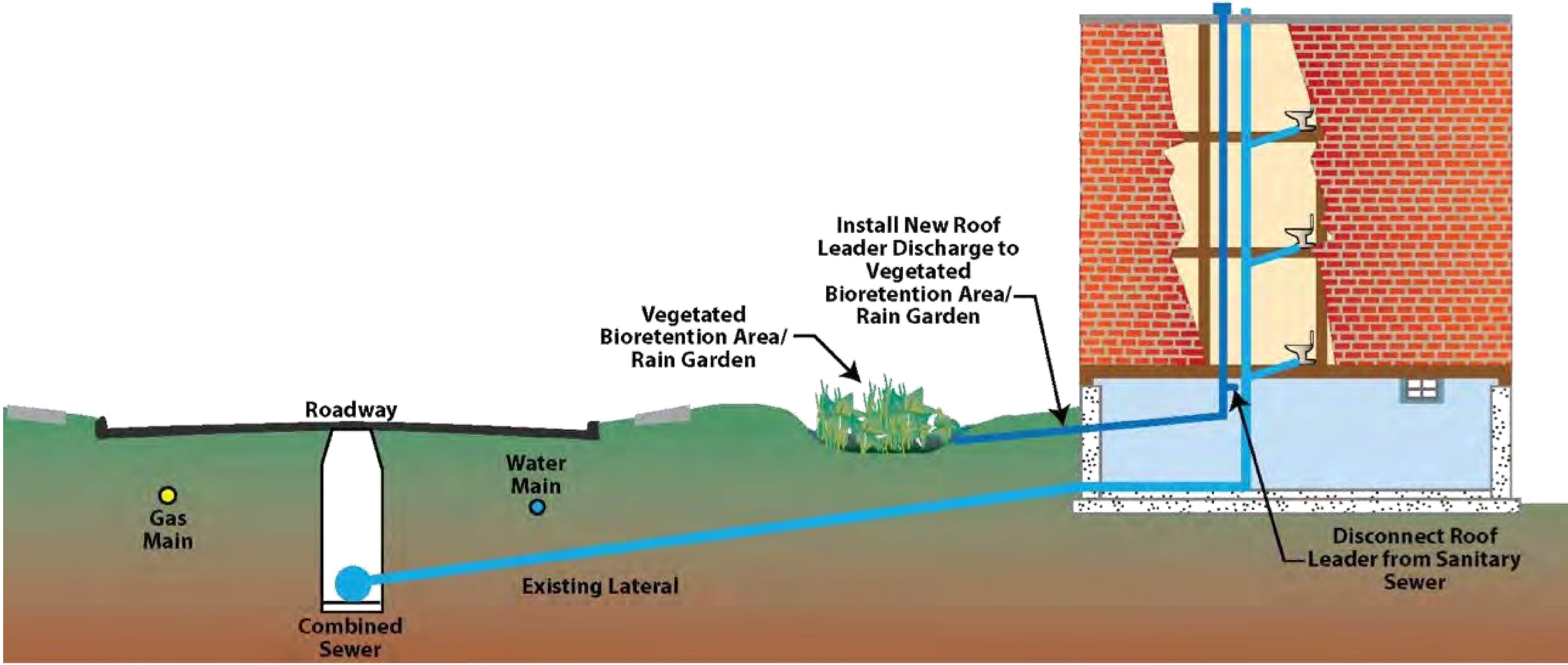
10' x 5' Bioswales

Precast Pervious Concrete Panels

Easy to Install and Maintain



Alternative Rooftop Solution
Redirect Runoff to Green Infrastructure

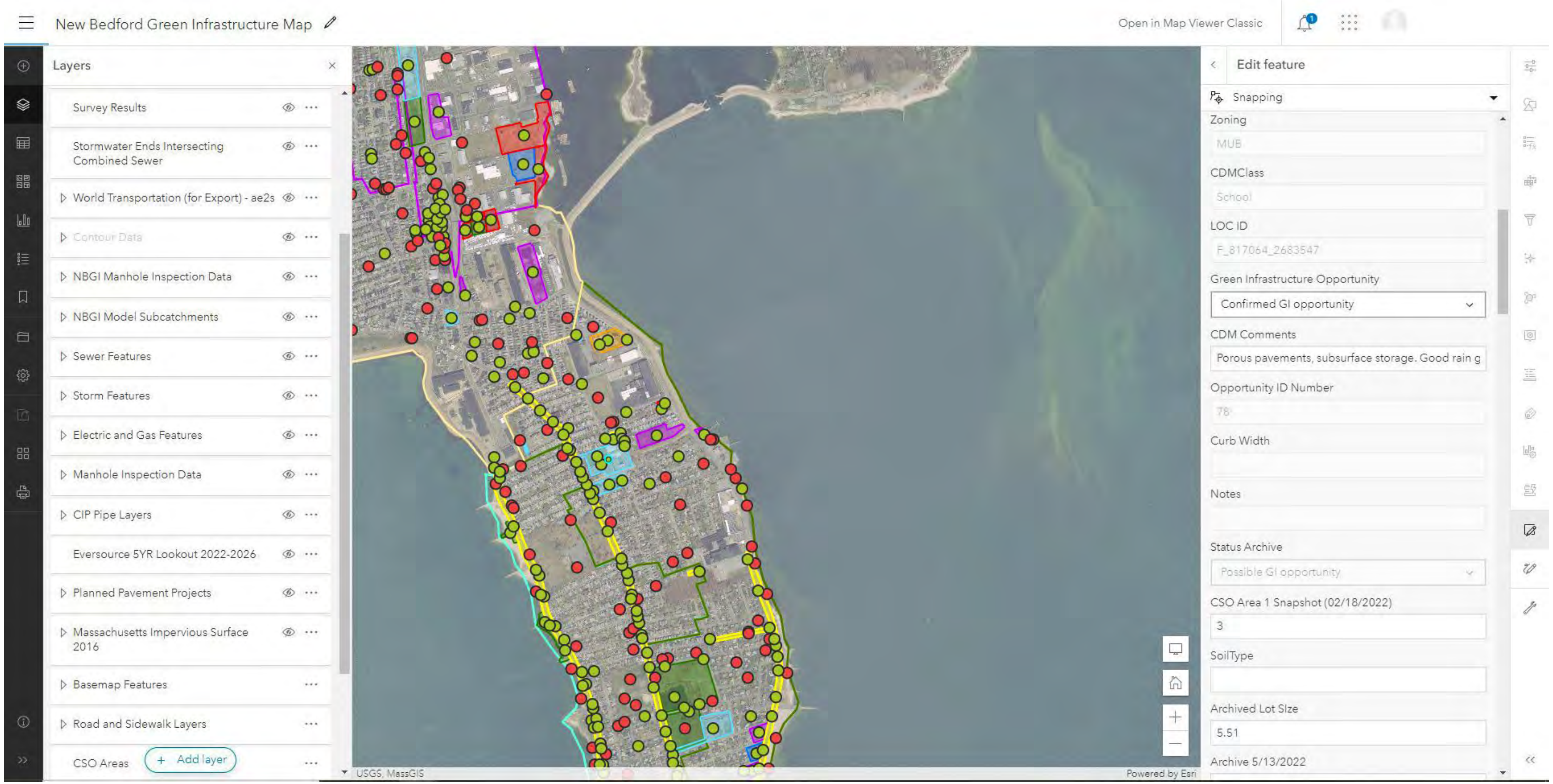


Green Infrastructure Techniques – Large Open Spaces

Subsurface Storage and Infiltration

Maximize Storage for Flood Control

Developed Mobile App for Site Visit Data Collection in Real Time



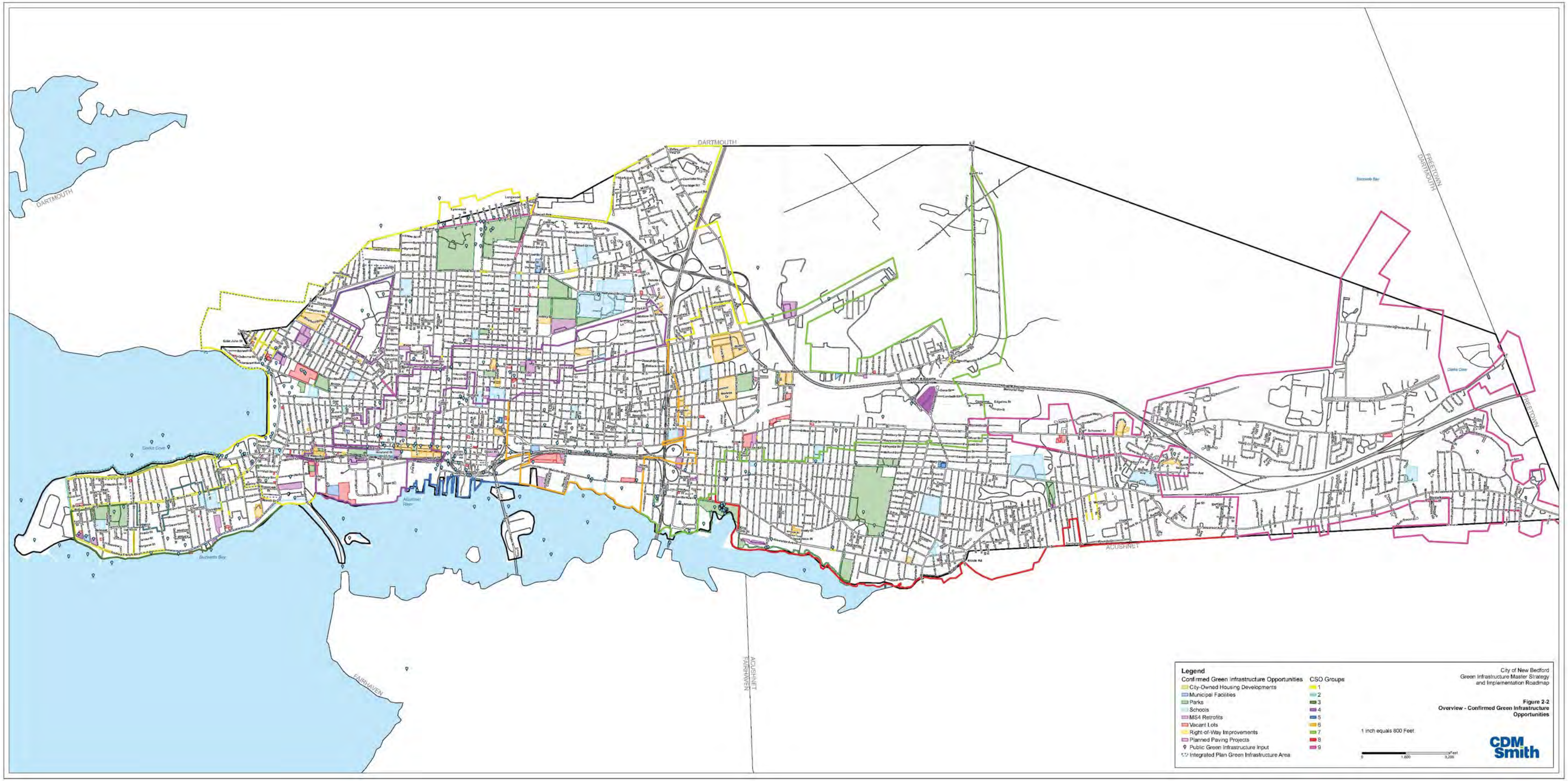
Screening Criteria

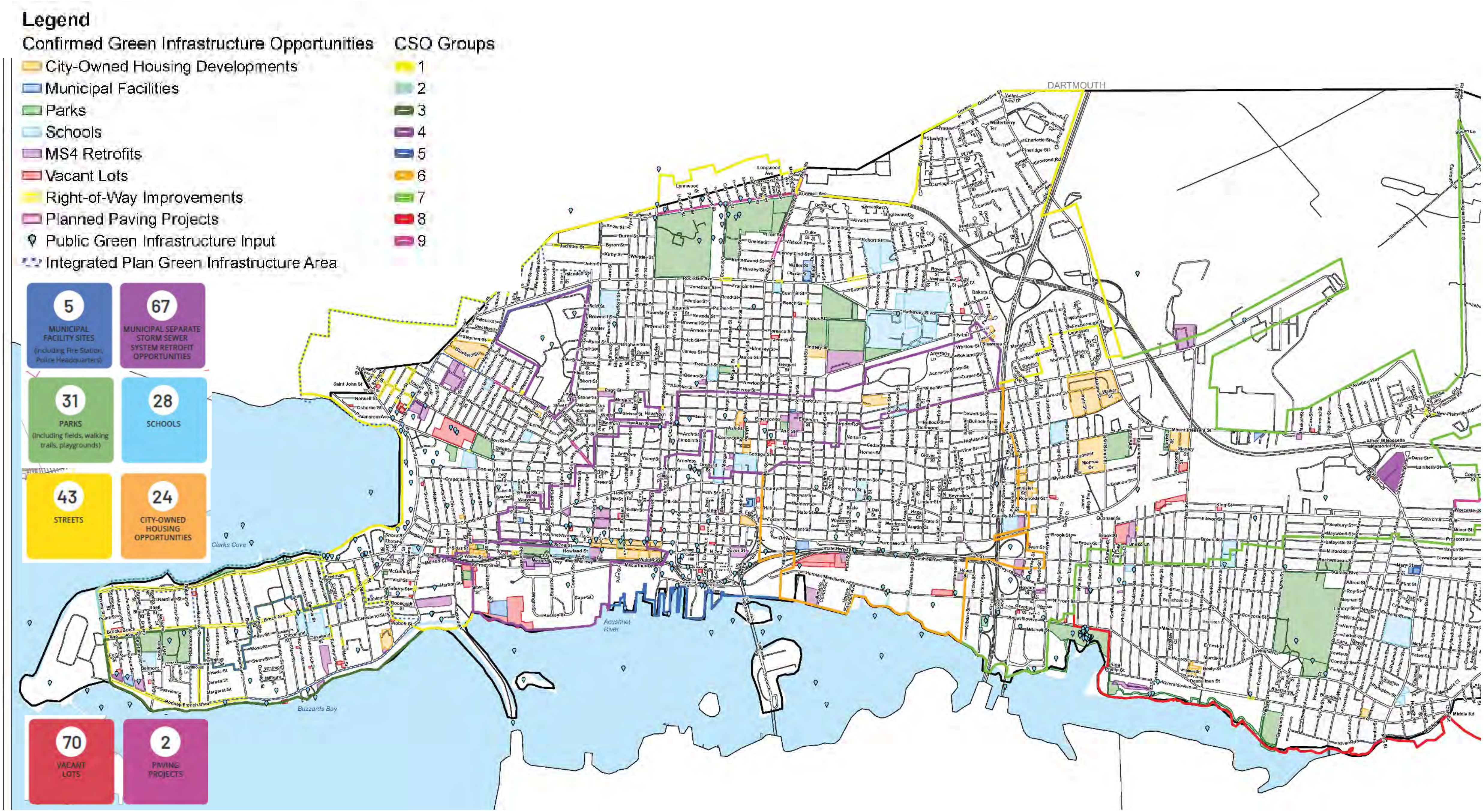
- Preferred site features
  - Large open areas
    - Little mature tree cover
    - No structures
    - Large impervious areas
  - Slopes less than five percent
  - Parcels that favor visible demonstration of green infrastructure
    - Education opportunities
  - Large parcels to provide increased opportunities for green infrastructure under one property owner

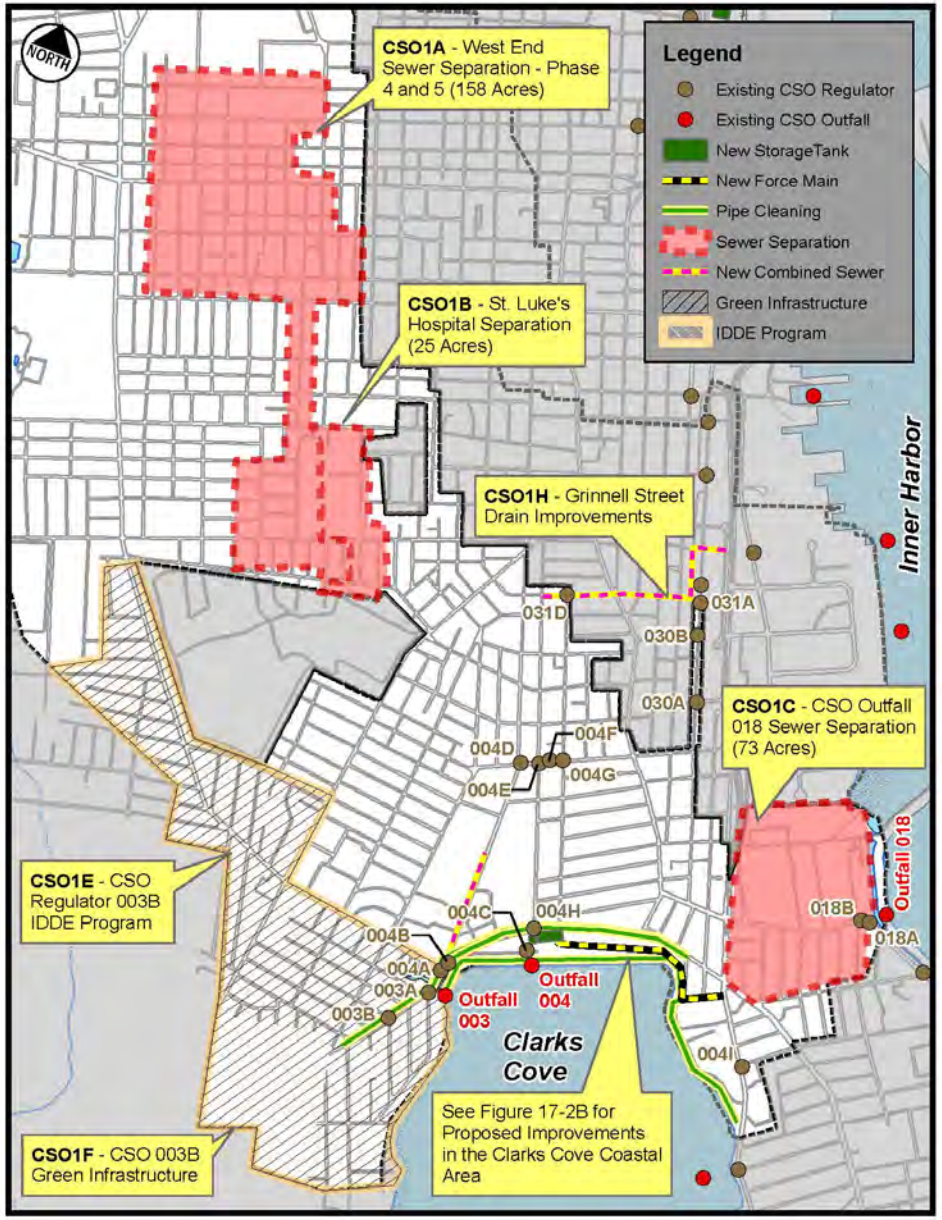
Screening Criteria

- Separated areas upstream of existing combined sewer systems maximize volume reduction
  - Flood reduction opportunities
- Locations within MS4 areas help meet permit requirements
- Public properties preferred over private

Confirmed Green Infrastructure Opportunities



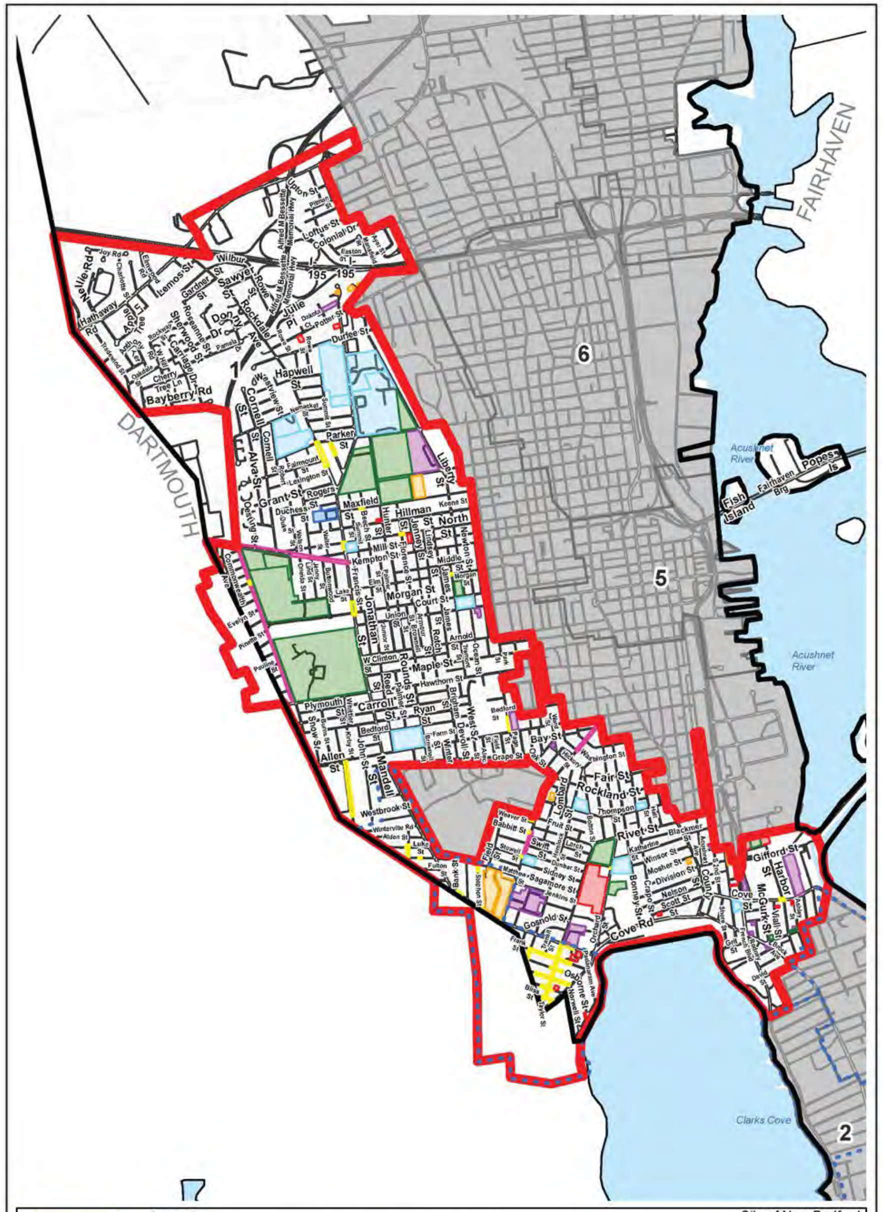

Legend
Confirmed Green Infrastructure Opportunities
City-Owned Housing Developments
Municipal Facilities
Parks
Schools
MS4 Retrofits
Vacant Lots
Right-of-Way Improvements
Planned Paving Projects
Public Green Infrastructure Input
Integrated Plan Green Infrastructure Area
CSO Groups
1
2
3
4
5
6
7
8
9
5 MUNICIPAL FACILITY SITES (including Fire Station, Police Headquarters)
67 MUNICIPAL SEPARATE STORM SEWER SYSTEM RETROFIT OPPORTUNITIES
31 PARKS (including fields, walking trails, playgrounds)
28 SCHOOLS
43 STREETS
24 CITY-OWNED HOUSING OPPORTUNITIES
70 VACANT LOTS
2 PAVING PROJECTS
DARTMOUTH
Clarks Cove
Acushnet River
Buzzards Bay



City of New Bedford, Massachusetts
Long Term CSO Control and Integrated Capital Improvements Plan

CDM Smith

Figure 17-2A
CSO Group 1 Proposed Improvements



City of New Bedford
Green Infrastructure Master Strategy and Implementation Roadmap

Figure 2-3
CSO Group 1
Confirmed Green Infrastructure Opportunities

Opportunities Exceeded

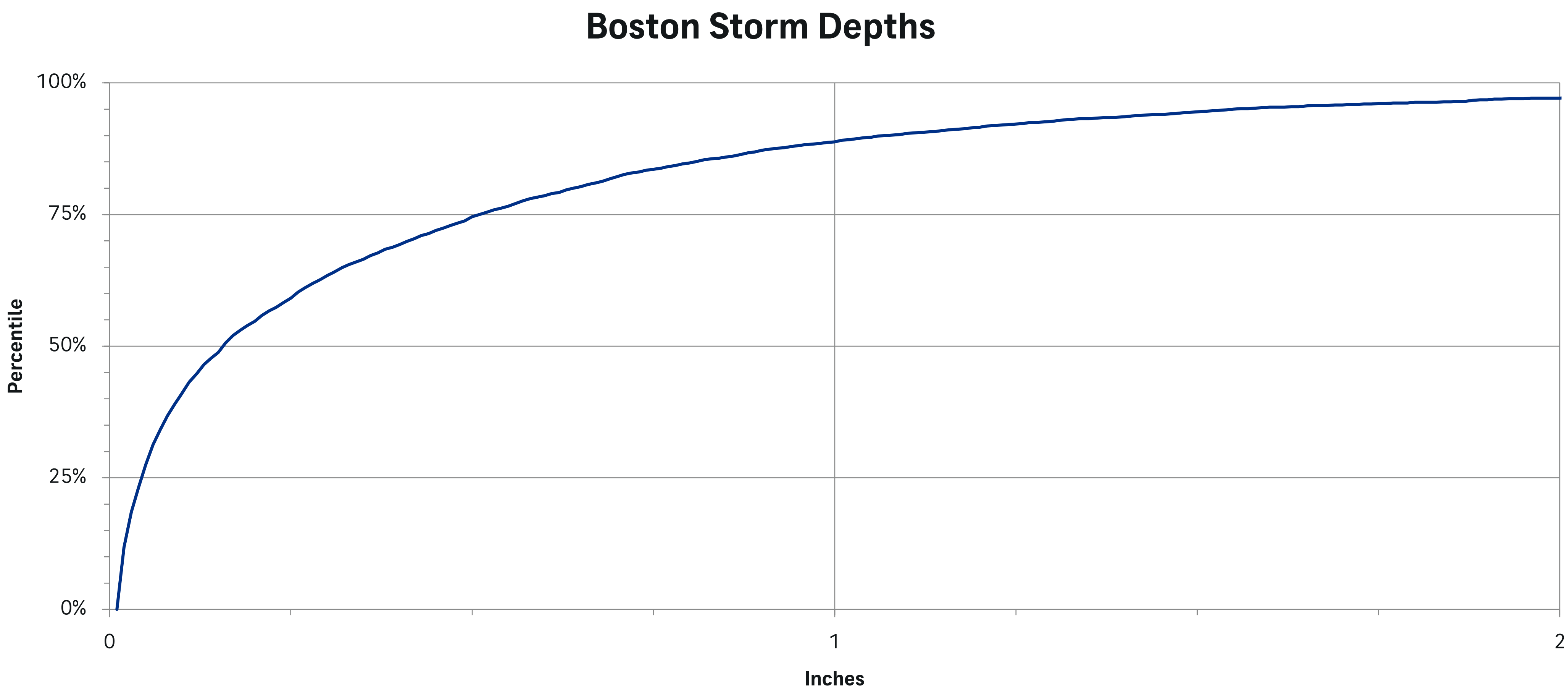
Green Infrastructure Goals in Integrated Plan

Drainage Analysis by CSO Group

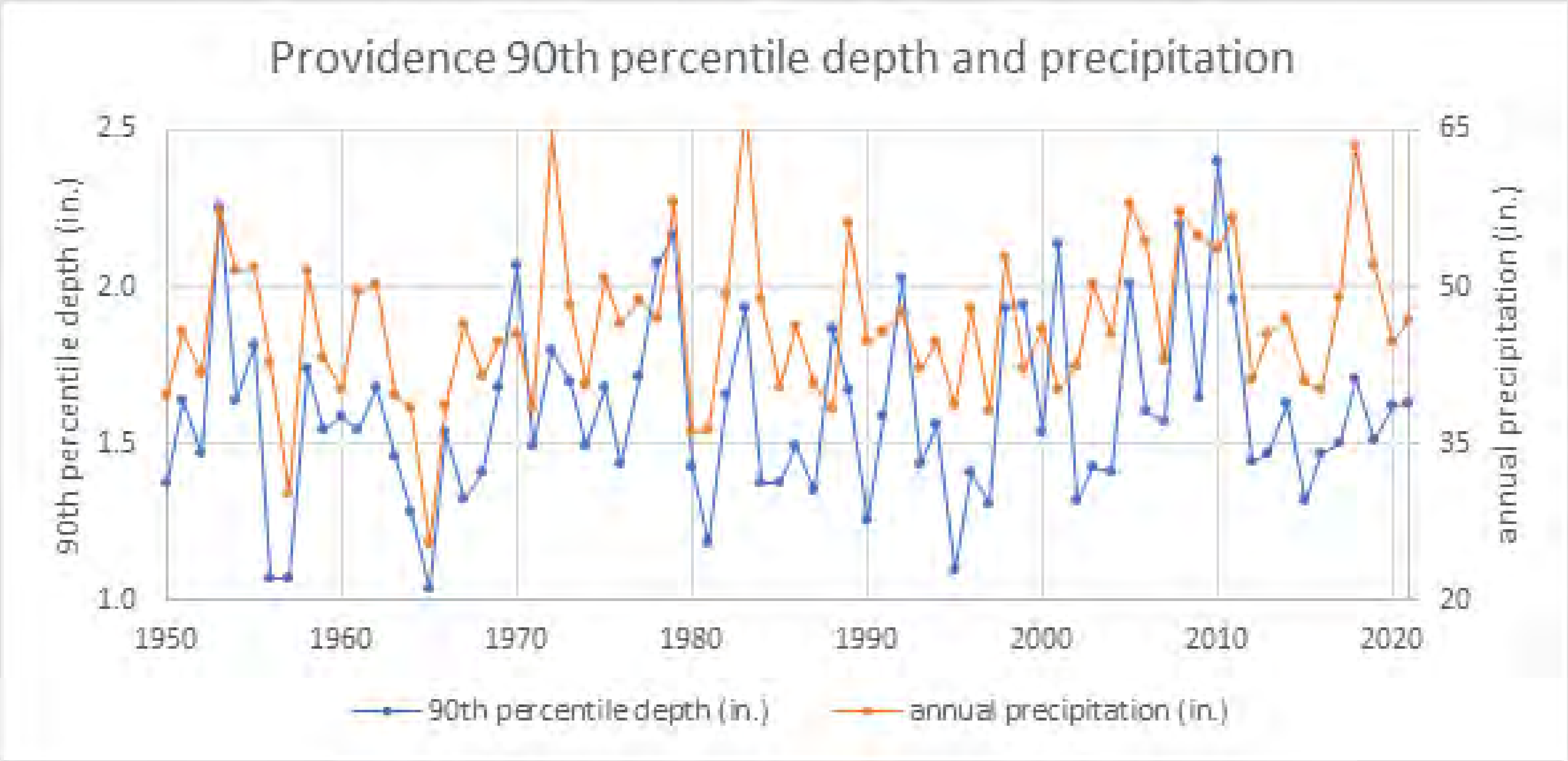
CSO Group	Impervious Area Treated Goal (ac)	Total Impervious Area Treated (ac)
1	65	157
2	20	20
3	60	75
4		30
5		3
6		17
7		227
8		33
9		6
Total		**569**

Green Infrastructure Sizing and Decision Tool

All Storms Included – 90% Storm is 1 Inch (State Standard)
Storms Greater Than 0.1 Inch Included – 90% Storm is 1.7 Inches



90% Storm Depth Steady While Annual Precipitation Generally Increased

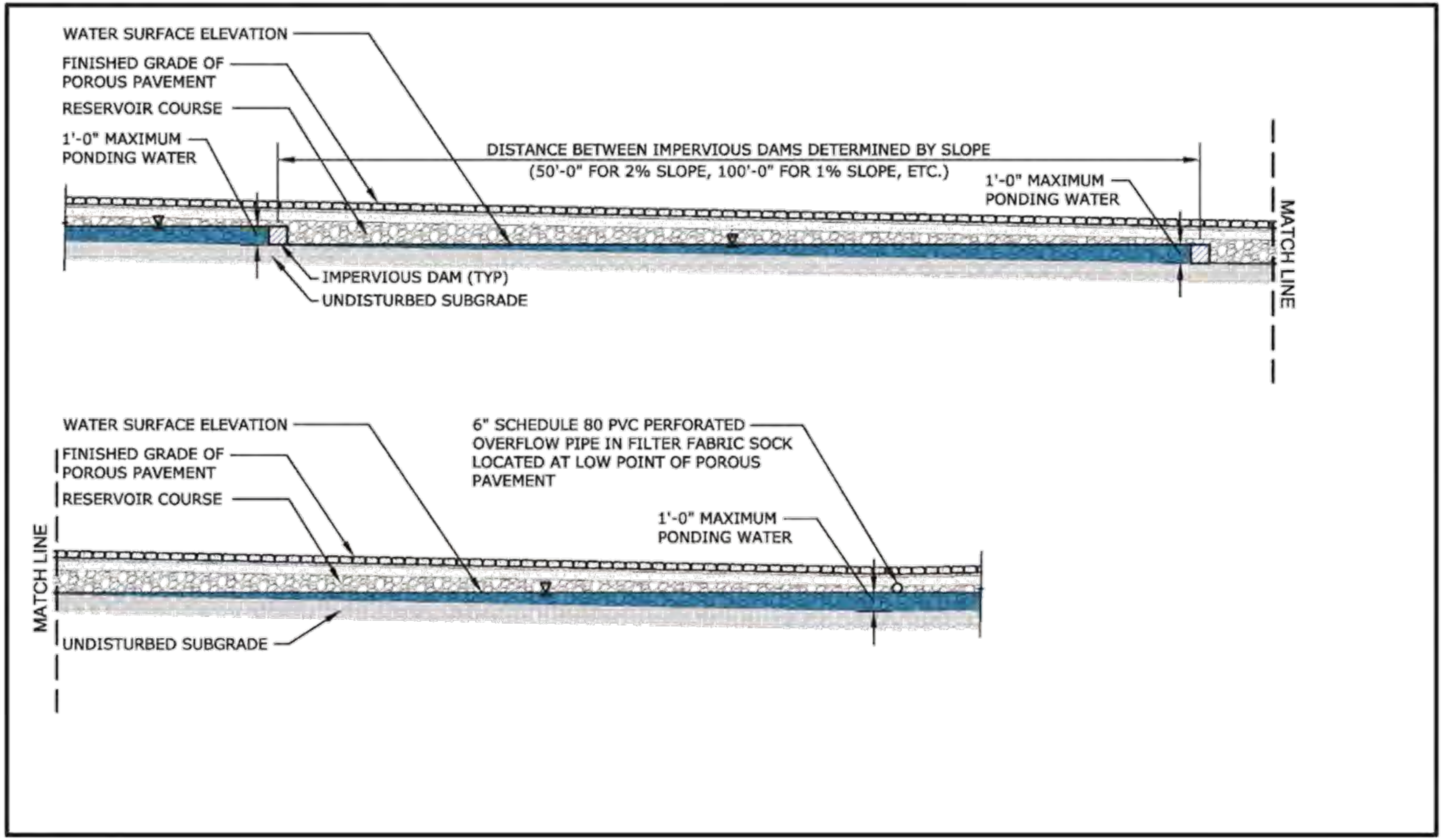


Green Infrastructure Sizing Tool

Green Infrastructure Practice	Stone Depth (in)	Stone Voids	Triangle Factor	Soil Depth (in)	Soil Voids	Ponding Depth (in)	Multiplier (Flow Depth, ft)
Permeable Pavers on Aggregate Base	29	0.35	0.5	1	1	1	0.42
Precast Pervious Concrete on Aggregate Base	27	0.35	0.5	1	1	1	0.39
Cast-in-Place Pervious Concrete	26	0.35	0.5	1	1	1	0.38
Porous Asphalt on Aggregate Base	28	0.35	0.5	1	1	1	0.41
Synthetic Turf Field	24	0.35	0.5	1	1	1	0.35
Rain Garden/Vegetated Bioretention Area	30	0.35	1	24	0.2	3	1.53
Tree Infiltration Chamber	26	0.35	1	24	0.2	1	1.24
Right-of-Way Bioswale	27	0.35	1	24	0.2	3	1.44
Linear Rain Garden	30	0.35	1	24	0.2	6	1.78
Subsurface Chambers (SC-740)	18	0.35	1	NA	NA	36	3.53
Subsurface Storage (Precast Concrete)							3.48
Sediment Forebay							1

Triangle Factor

Use Available Storage in Porous Pavement – Mitigate Breakout



Green Infrastructure Sizing Tool

						Volume of Runoff		Green Infrastructure Practices, 1-in Storm							
Name	Location	CSO Group	Lot Size (AC)	Hydrologic Soil Group	Impervious Area (AC)	Runoff Volume 1-in Storm (CF)	Runoff Volume 1.7-in Storm (CF)	Permeable Pavers on Aggregate Base (SF)	Precast Pervious Concrete on Aggregate Base (SF)	Cast-in-Place Pervious Concrete on Aggregate Base (SF)	Porous Asphalt on Aggregate Base (SF)	Synthetic Turf Field (SF)	Rain Garden/ Vegetated Bioretention (SF)	Tree Infiltration Chamber (SF)	No. of Tree Infiltration Chambers
Athletic Fields	0 Es Hunter St	1	0.74	A	0.02	66	113	157	168	175	162	189	43	53	1
Athletic Fields	134 Hunter St	1	17.27	A	2.27	8,233	13,995	19,466	20,908	21,712	20,161	23,522	5,398	6,630	111
Athletic Fields	543 Maxfield St	1	6.88	A	1.76	6,403	10,885	15,140	16,261	16,887	15,681	18,294	4,199	5,157	86
Athletic Fields	90 Hathaway Blvd	1	11.30		4.33	15,729	26,739	37,191	39,946	41,483	38,520	44,939	10,314	12,668	211
Athletic Fields And Parking Lot	0 Es Orchard St	1	1.76		0.20	721	1,226	1,705	1,831	1,902	1,766	2,060	473	581	10
	0 Es Mohawk Ct	1	0.17		0.05	189	322	447	480	499	463	541	124	152	3
Athletic Fields/Courts	0 Ws Liberty St	1	2.19		1.54	5,603	9,524	13,248	14,229	14,776	13,721	16,007	3,674	4,512	75
City Parking	0 Es Page St	1	1.08		1.10	3,995	6,792	9,447	10,146	10,537	9,784	11,415	2,620	3,218	54
Baseball Field	0 Ss Blackmer St	1	1.00		0.22	793	1,348	1,875	2,014	2,092	1,942	2,266	520	639	11
Bioretention or Subsurface Storage	0 Ns Brock Ave	1	0.13		0.08	307	522	726	780	810	752	877	201	247	4
Large vacant industrial lot	0 Ns Cove St	1	4.30		0.44	1,581	2,687	3,737	4,014	4,169	3,871	4,516	1,036	1,273	21
Open Grass Area	0 Ns Delano St	1	0.08		0.01	41	69	96	103	107	100	116	27	33	1
Casa De Saudade Library	0 Ns Thompson St	1	0.50		0.36	1,313	2,232	3,104	3,334	3,462	3,215	3,751	861	1,057	18
Grass	0 R Ss Union St	1	0.01		0.01	21	36	49	53	55	51	60	14	17	0
Buttonwood Park	0 Buttonwood Park	1	25.37		0.89	3,246	5,518	7,674	8,243	8,560	7,948	9,273	2,128	2,614	44
Buttonwood Park	0 Ss Kempton St	1	3.65	D	0.39	1,419	2,412	3,355	3,604	3,742	3,475	4,054	931	1,143	19
Buttonwood Park	0 Ss Kempton St	1	3.77	D	0.25	898	1,527	2,124	2,281	2,369	2,200	2,567	589	723	12
Buttonwood Park	425 Hawthorn St	1	48.78		1.79	6,495	11,041	15,357	16,495	17,129	15,906	18,557	4,259	5,231	87
John Devalles School	0 Ss Katharine St	1	2.57		2.31	8,367	14,225	19,785	21,251	22,068	20,492	23,907	5,487	6,739	112
City-Owned Dirt Lot	0 Ss Union St	1	0.41		0.38	1,377	2,341	3,256	3,497	3,631	3,372	3,934	903	1,109	18
Large grass area	0 Ws Apache Ct	1	0.62		0.00	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Small lot - bioretention	0 Ws Ashley St	1	0.06		0.00	4	7	10	10	11	10	12	3	3	0

Green Infrastructure Decision Tool

Location	Alternatives by Type of Green Infrastructure	Maintenance (25%)	Ease of Installation (5%)	Aesthetics (15%)	Environmental Impacts (10%)	Volume Managed (15%)	Cost (30%)	Score
Parking Lots	Porous Asphalt	3	3	3	3	3	4	3.30
	Cast-in-Place Pervious Concrete	3	2	3	3	3	3	2.95
	Precast Pervious Concrete	4	4	3	3	3	2	3.00
	Permeable Pavers	4	4	4	3	3	3	3.45
	Rain Garden/Vegetated Bioretention Area	2	4	5	5	4	5	4.05
	Subsurface Storage	4	2	2	4	5	5	4.05
Roadways	Right-of-Way Bioswale	2	3	5	5	4	2	3.10
	Tree Infiltration Chamber	3	4	4	4	4	1	2.85
	Linear Rain Garden	2	4	5	5	4	5	4.05
	Subsurface Storage Under Sidewalks	4	2	2	4	5	5	4.05
	Precast Pervious Concrete Gutters	4	4	3	3	3	2	3.00
Playgrounds	Synthetic Turf Field	1	4	4	3	3	4	3.00
	Subsurface Storage	4	2	2	4	5	5	4.05
	Rain Garden/Vegetated Bioretention Area	2	4	5	5	4	5	4.05
Plazas/Building Entrance Areas	Porous Asphalt	3	3	3	3	3	4	3.30
	Cast-in-Place Pervious Concrete	3	2	3	3	3	3	2.95
	Precast Pervious Concrete	4	4	3	3	3	2	3.00
	Permeable Pavers	4	4	4	3	3	3	3.45
	Rain Garden/Vegetated Bioretention Area	2	4	5	5	4	5	4.05
Rooftops	Blue Roof	3	3	3	3	2	1	2.25
	Green Roof	1	2	5	5	1	1	2.05
	Redirect Roof Runoff to Green Infrastructure (From External Roof Leaders)	4	3	5	5	3	3	3.75
	Rainwater Harvesting	4	2	2	3	2	2	2.60

Green Infrastructure Life Cycle Costs Tool

Construction Costs and Annual Maintenance Costs Per Impervious Acre Treated

Table 3-1. Estimated Green Infrastructure Construction Costs per Impervious Acre Treated

Green Infrastructure Practice	Estimated Construction Cost ($/impervious acre treated, June 2022 ENR 13,110)
Precast Concrete Subsurface Storage Chambers	$118,100
Subsurface Storage Chambers	$130,500
Rain Garden/Vegetated Bioretention Area	$153,800
Linear Rain Garden	$163,900
Synthetic Turf Field	$220,700
Porous Asphalt	$245,800
Cast-In-Place Pervious Concrete	$309,000
Permeable Pavers	$481,600
Right-of-Way Bioswale	$600,900
Precast Pervious Concrete	$616,100
Tree Infiltration Chamber	$1,469,000
Green Roof	$3,348,200

Table 3-2. Estimated Maintenance Costs for Green Infrastructure Practices

Green Infrastructure Practice	Estimated Yearly Maintenance Cost (June 2022 $/acre treated)
	Annual Maintenance Cost per Acre Treated (June 2022 ENR 13110)
Subsurface Storage Chambers	$3,400
Precast Concrete Subsurface Storage Chambers	$3,400
Synthetic Turf Field	$4,400
Permeable Pavers	$4,600
Precast Pervious Concrete	$4,600
Cast-in-Place Pervious Concrete	$4,600
Porous Asphalt	$4,600
Tree Infiltration Chamber	$6,000
Green Roof	$6,000
Rain Gardens/Vegetated Bioretention Areas	$8,000
Right-of-Way Bioswale	$8,000
Linear Rain Garden	$8,000

Life Cycle Cost Estimating Tool

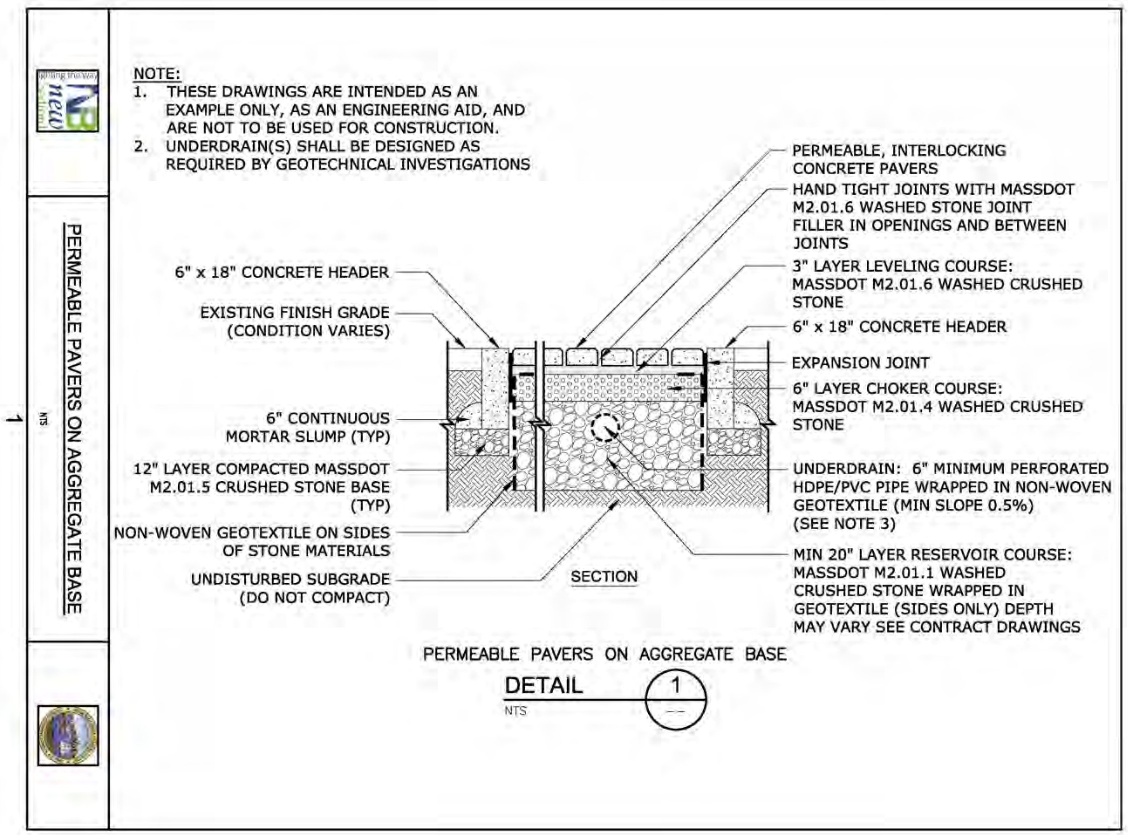
Table 3-3 Cost Estimate Summary

Site	Green Infrastructure Practice	Impervious Area Treated (sf)	Estimated Construction Cost (June 2022 $)	Estimated Annual Maintenance Cost (June 2022)	Estimated Lifespan (Years)	Equivalent Annual Cost (June 2022) Annual Cost Method Init. Cost* (A/P, i, t) + Ann. Maint.	Equivalent Annual Cost Per Treated Acre (June 2022)
BLUE MEADOWS HOUSING AUTHORITY SITE							
	RAIN GARDEN/VEGETATED BIORETENTION AREA	80,300	$ 283,600	$ 14,800	25	$ 34,900	$ 19,000
	PRECAST PERVIOUS CONCRETE	38,400	$ 542,600	$ 4,100	20	$ 47,600	$ 54,100
Total			**$ 826,200**	**$ 18,900**			
BOA VISTA HOUSING AUTHORITY SITE							
	RAIN GARDEN/VEGETATED BIORETENTION AREA	59,900	$ 211,500	$ 11,100	25	$ 26,100	$ 19,000
Total			**$ 211,500**	**$ 11,100**			
BOLTON STREET AREA SITE							
	LINEAR RAIN GARDEN	48,300	$ 181,700	$ 8,900	25	$ 21,800	$ 19,700
Total			**$ 181,700**	**$ 8,900**			
BROCK AVENUE FROM BUTLER STREET TO EMMA STREET SITE							
	RIGHT-OF-WAY BIOSWALES	56,400	$ 778,100	$ 10,400	25	$ 65,600	$ 50,700
	LINEAR RAIN GARDEN	15,600	$ 58,700	$ 2,900	25	$ 7,100	$ 19,700
Total			**$ 836,800**	**$ 13,300**			
BROOKLAWN STREET SITE							
	PRECAST PERVIOUS CONCRETE	114,700	$ 1,622,100	$ 12,200	20	$ 142,300	$ 54,100
Total			**$ 1,622,100**	**$ 12,200**			

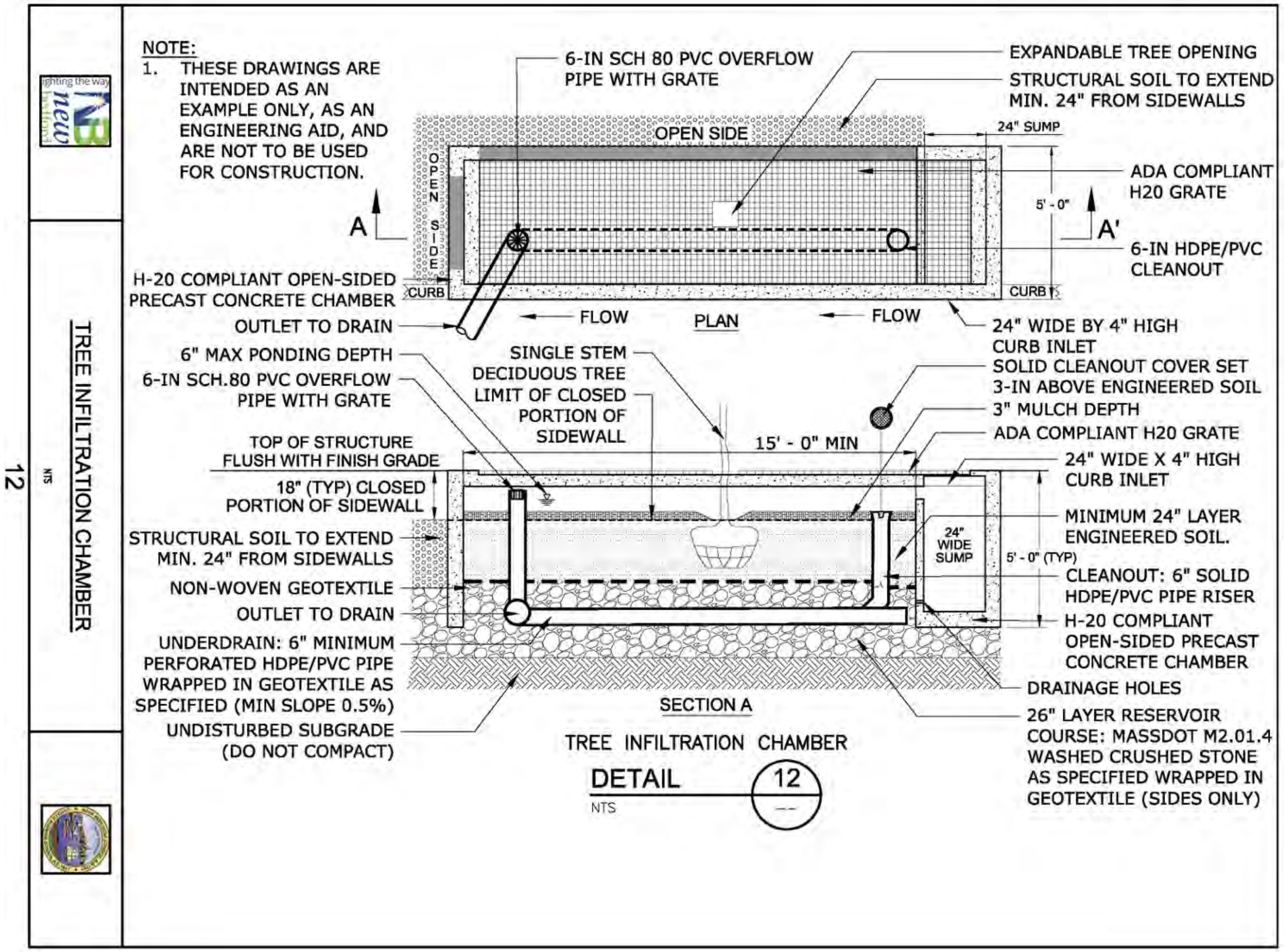
Standard Design Details and Specifications, O&M Manual

Created Standard Green Infrastructure Design Tools
New Bedford Standard Details and Specifications

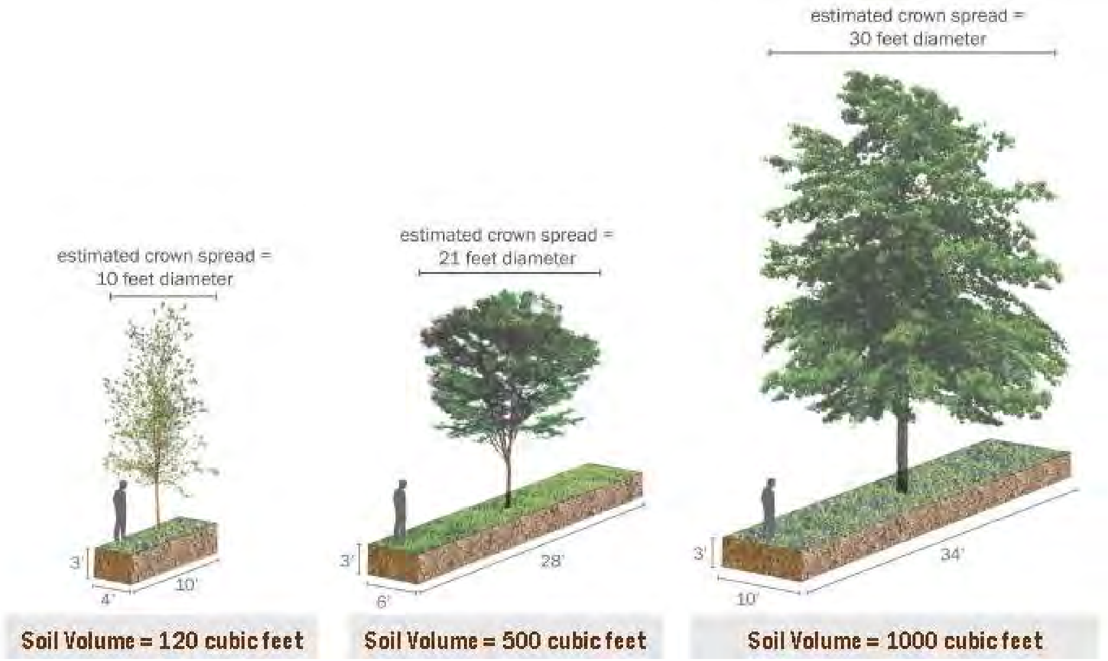
- Standard design details and specifications
  1. Permeable pavers
  2. Precast pervious concrete
  3. Cast-in-Place pervious concrete
  4. Porous asphalt
  5. Synthetic turf field
  6. Green roof
  7. Subsurface storage chambers
  8. Precast concrete subsurface storage chambers
  9. Outlet control structure
  10. Rain garden/vegetated bioretention area
  11. Vegetated bioretention overflow structure
  12. Tree infiltration chamber
  13. Right-of-Way bioswale
  14. Linear rain garden



Tree Infiltration Chamber
Right-Sized, Less Concrete

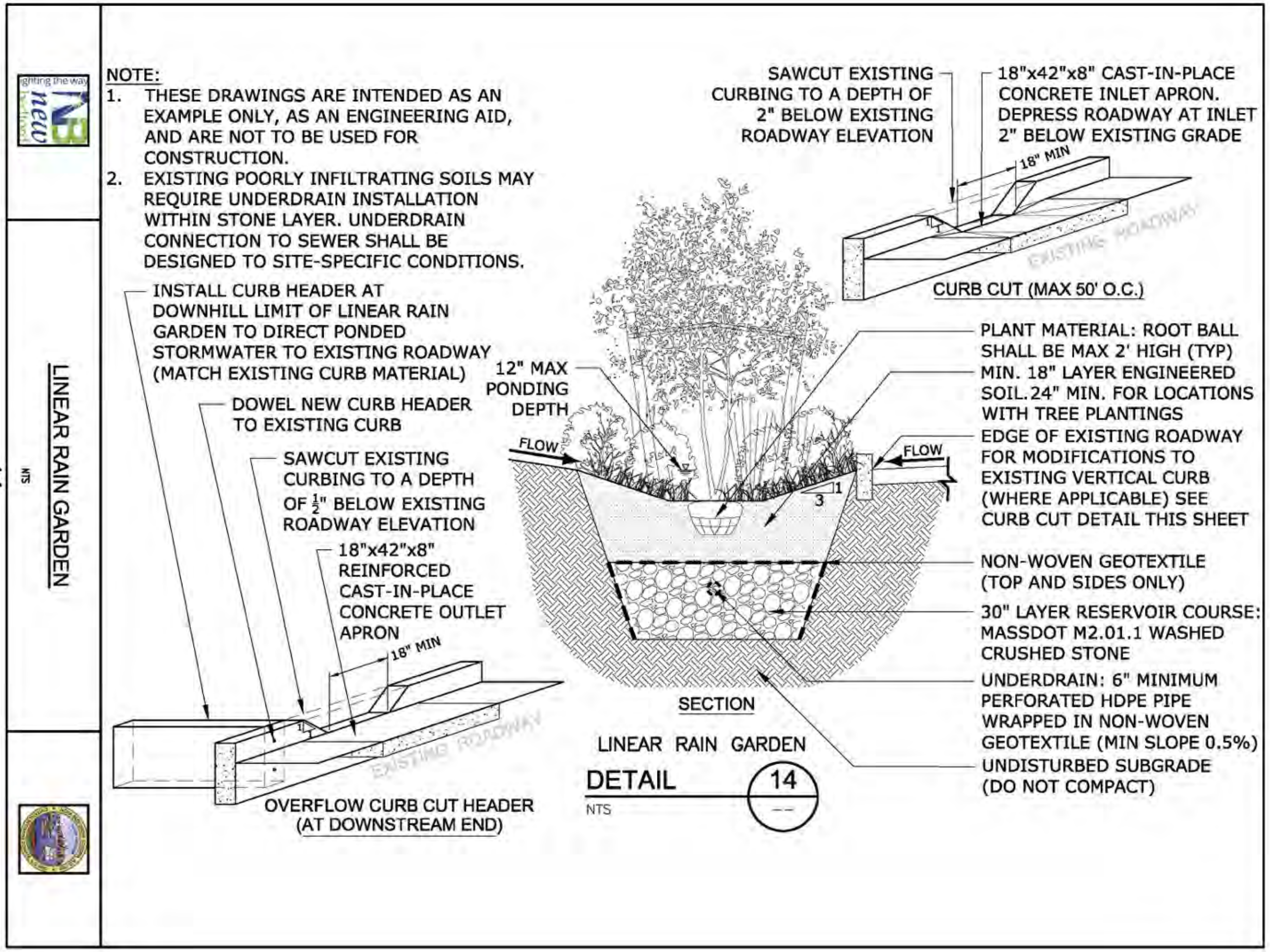


- Plant for your maximum growing conditions



Source: Casey Trees, Washington DC

Linear Rain Garden



Operation and Maintenance Manual

3.4 Operation and Maintenance

Following are operation and maintenance guidelines for the New Bedford standard green infrastructure practices developed in this master plan.

3.4.1 Porous Asphalt

The following maintenance activities are recommended for porous asphalt:

- One to two times per year check for standing water on the surface of the porous asphalt within 30 minutes after a precipitation event. If standing water remains, use a power washer or compressed air blower at an angle of 30 degrees or less, in combination with a vacuum or vacuum sweeper to dislodge the material clogging the porous asphalt.

Figure 3-38. Porous Asphalt

3.4.4 Rain Gardens/Vegetated Bioretention Areas

The following maintenance activities are recommended for rain gardens/vegetated bioretention areas, including right-of-way bioswales and linear rain gardens:

- Annually, check that the filter surface remains well-draining after storm events. If filter bed is clogged, is draining poorly, or has standing water that covers more than 50 percent of the surface 48 hours after a precipitation event, then remove top few inches of material, and till, or rake remaining material as needed. Upon failure, excavate rain garden/ bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch.
- In vegetated bioretention areas, inspect annually any flared end inlets and weir outlets for evidence of deterioration, such as cracking, subsidence, spalling or erosion. Repair or replace any damaged parts.
- In vegetated bioretention areas, as applicable, check annually the flared end inlets and weir outlets for leaves and debris. Rake in and around the system to clear it of debris.

Figure 3-41. Rain Gardens/Vegetated Bioretention Areas

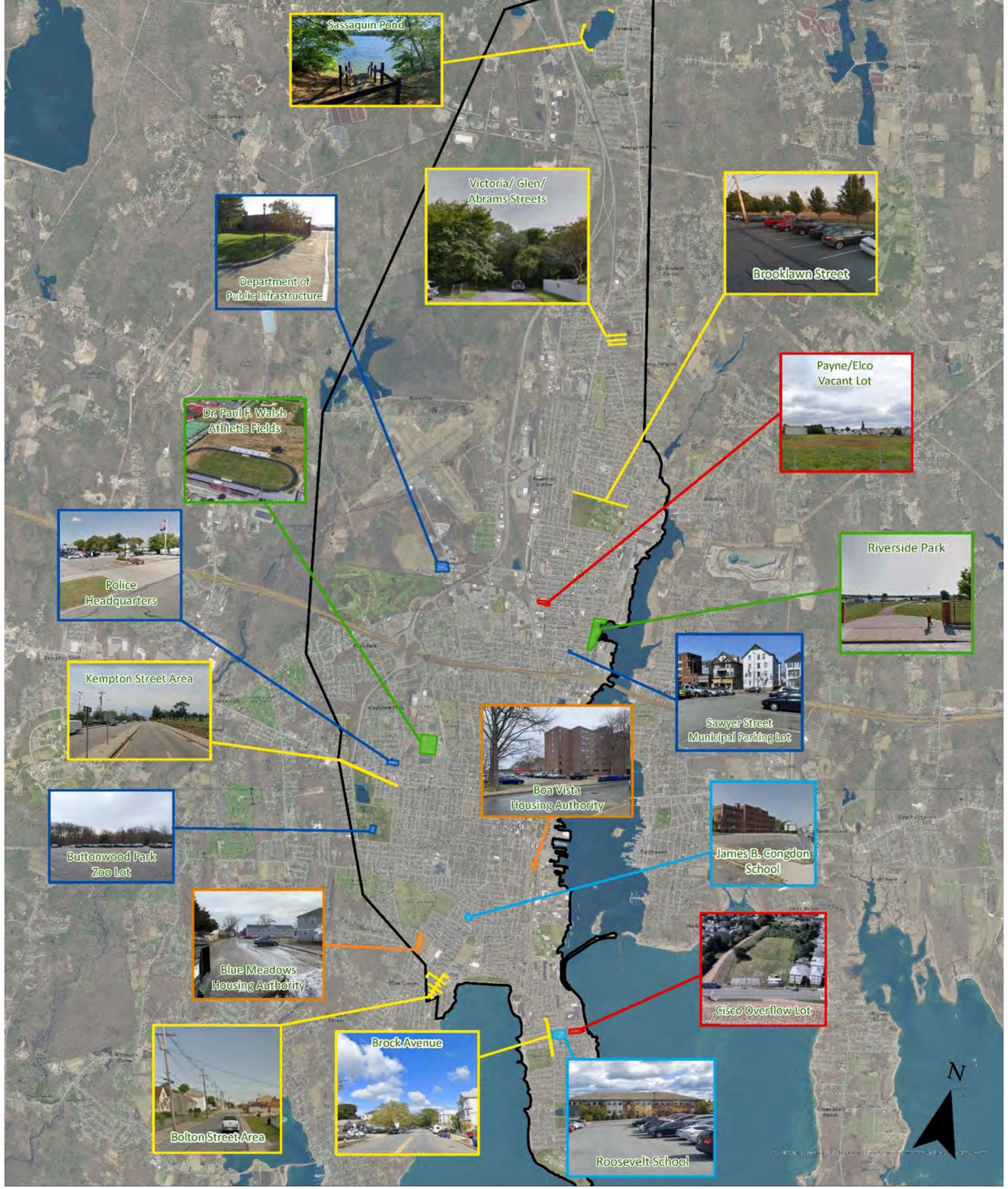
Example Conceptual Designs

Conceptual Designs

Legend

Conceptual Design Type

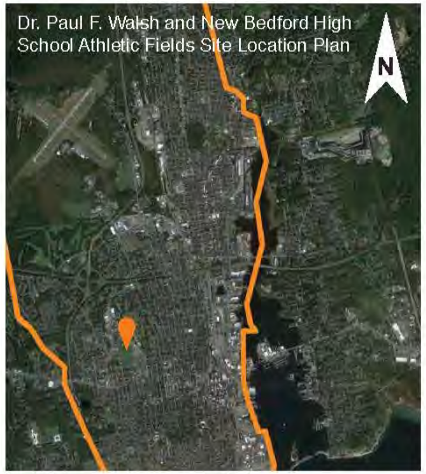
- Housing Development
- Municipal
- Park
- Public School
- Right-of-Way
- Vacant Lot
- City Limit

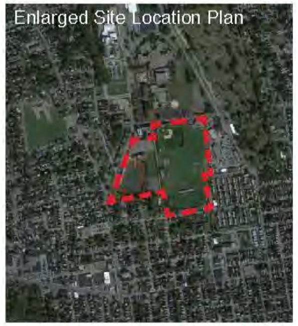


Conceptual Design Summaries

Park Conceptual Design Summary

Dr. Paul F. Walsh and New Bedford High School Athletic Fields Green Infrastructure





City Outline

Site Location

Site Boundary

Existing Conditions
This 35-acre athletic field site is mostly lawn. The high school is located north of the park and has experienced flooding problems.

Proposed Conditions
Convert natural turf soccer fields to 100,000 square feet of synthetic turf. Relatively clean runoff from the School Public Facilities Building at 256 Parker Street can be directed to the stone reservoir under the field. Divert off-site stormwater runoff from New Bedford High School to 20,000 square feet of precast concrete subsurface storage to reduce flooding. Add 17,000 square feet of rain gardens/vegetated bioretention areas to collect runoff from existing on-site drainage system draining paved areas on west side of site.

Green Infrastructure in CSO Group 1

Proposed Green Infrastructure:
Synthetic Turf Field / Precast Concrete Subsurface Storage / Rain Gardens/Vegetated Bioretention Areas

Estimated June 2022 Construction Cost: $5,551,800
ENR Index: 13,110

Address: 543 Maxfield Street

Estimated 2022 Maintenance Cost: $166,700

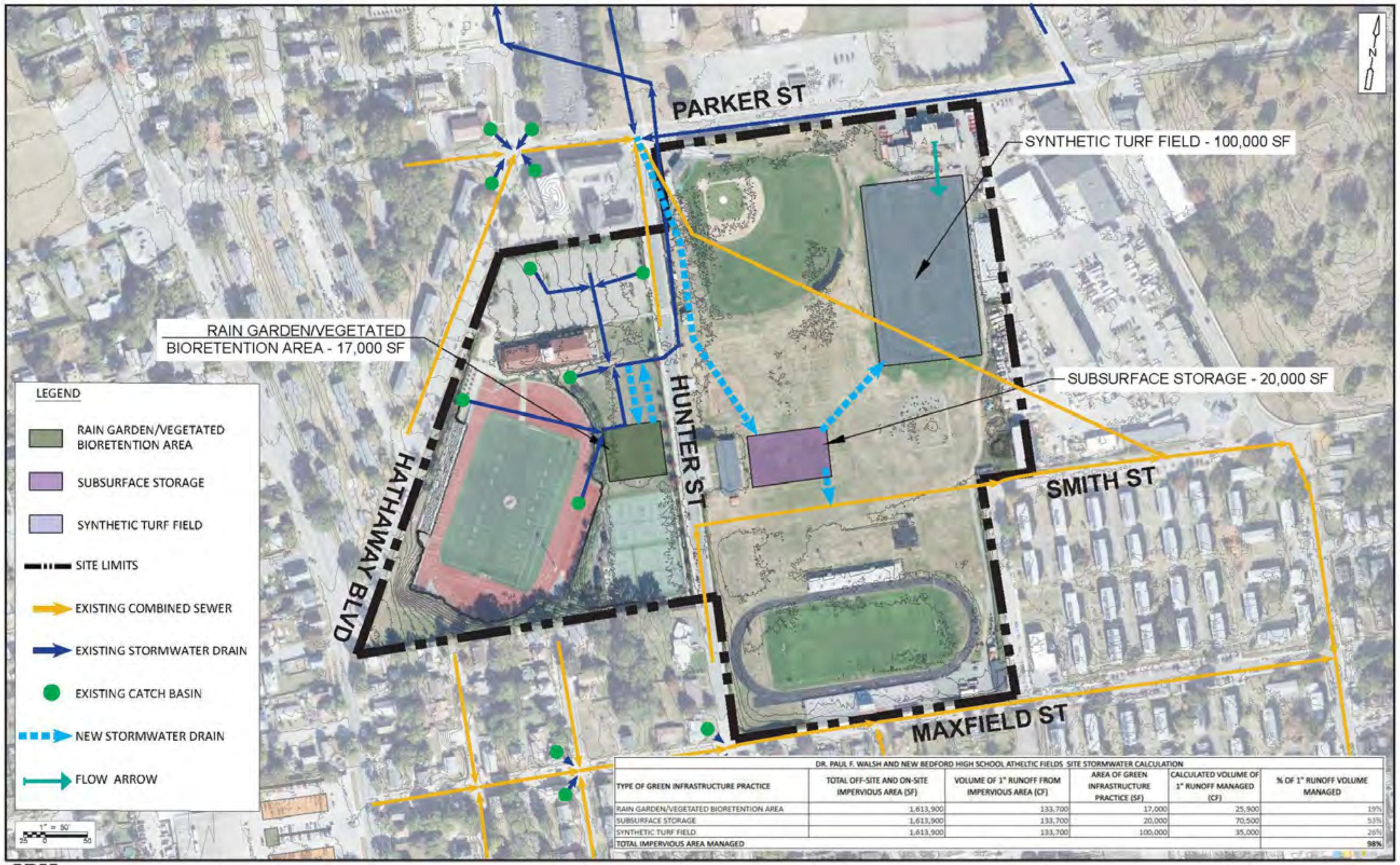
Tributary Impervious Area Managed: 37 acres

CDM Smith

Figure 3 - 24

June 2022

Conceptual Designs

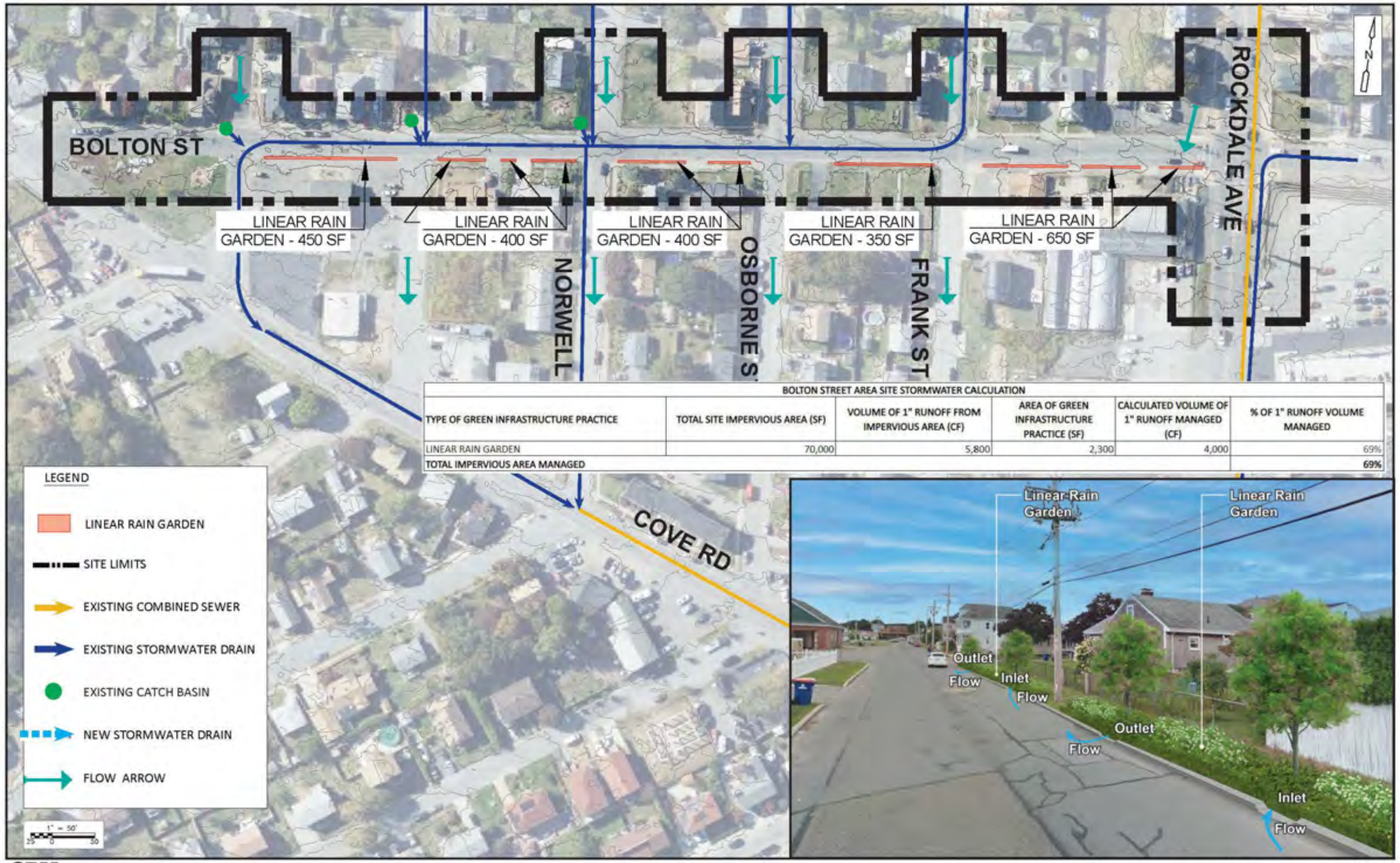


DR. PAUL F. WALSH AND NEW BEDFORD HIGH SCHOOL ATHELTIC FIELDS SITE STORMWATER CALCULATION

TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL OFF-SITE AND ON-SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RAIN GARDEN/VEGETATED BIORETENTION AREA	1,613,900	133,700	17,000	25,900	19%
SUBSURFACE STORAGE	1,613,900	133,700	20,000	70,500	53%
SYNTHETIC TURF FIELD	1,613,900	133,700	100,000	35,000	26%
TOTAL IMPERVIOUS AREA MANAGED					98%

CDM Smith Figure 3 - 25 Dr. Paul F. Walsh & New Bedford High School Athletic Fields Conceptual Design Plan

Bolton Street Area
Linear Rain Gardens



BOLTON STREET AREA SITE STORMWATER CALCULATION

TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
LINEAR RAIN GARDEN	70,000	5,800	2,300	4,000	69%
TOTAL IMPERVIOUS AREA MANAGED					69%

CDM Smith Figure 3 - 7 Bolton Street Area Conceptual Design Plan

Brooklawn Street
Precast Pervious Concrete

BROOKLAWN STREET SITE STORMWATER CALCULATION					
TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
PRECAST PERVIOUS CONCRETE	100,200	8,300	24,000	9,500	114%
TOTAL IMPERVIOUS AREA MANAGED					114%

CDM Smith Figure 3 - 11 Brooklawn Street Conceptual Design Plan

White’s Pond Stream Corridor
Vegetated Green Infrastructure

VICTORIA STREET SITE STORMWATER CALCULATION					
TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RIGHT-OF-WAY BIOSWALES	17,000	1,400	300	400	29%
RAIN GARDEN/VEGETATED BIORETENTION AREA	17,000	1,400	1,000	1,500	107%
SEDIMENT FOREBAY	17,000	1,400	600	600	43%
TOTAL IMPERVIOUS AREA MANAGED					179%

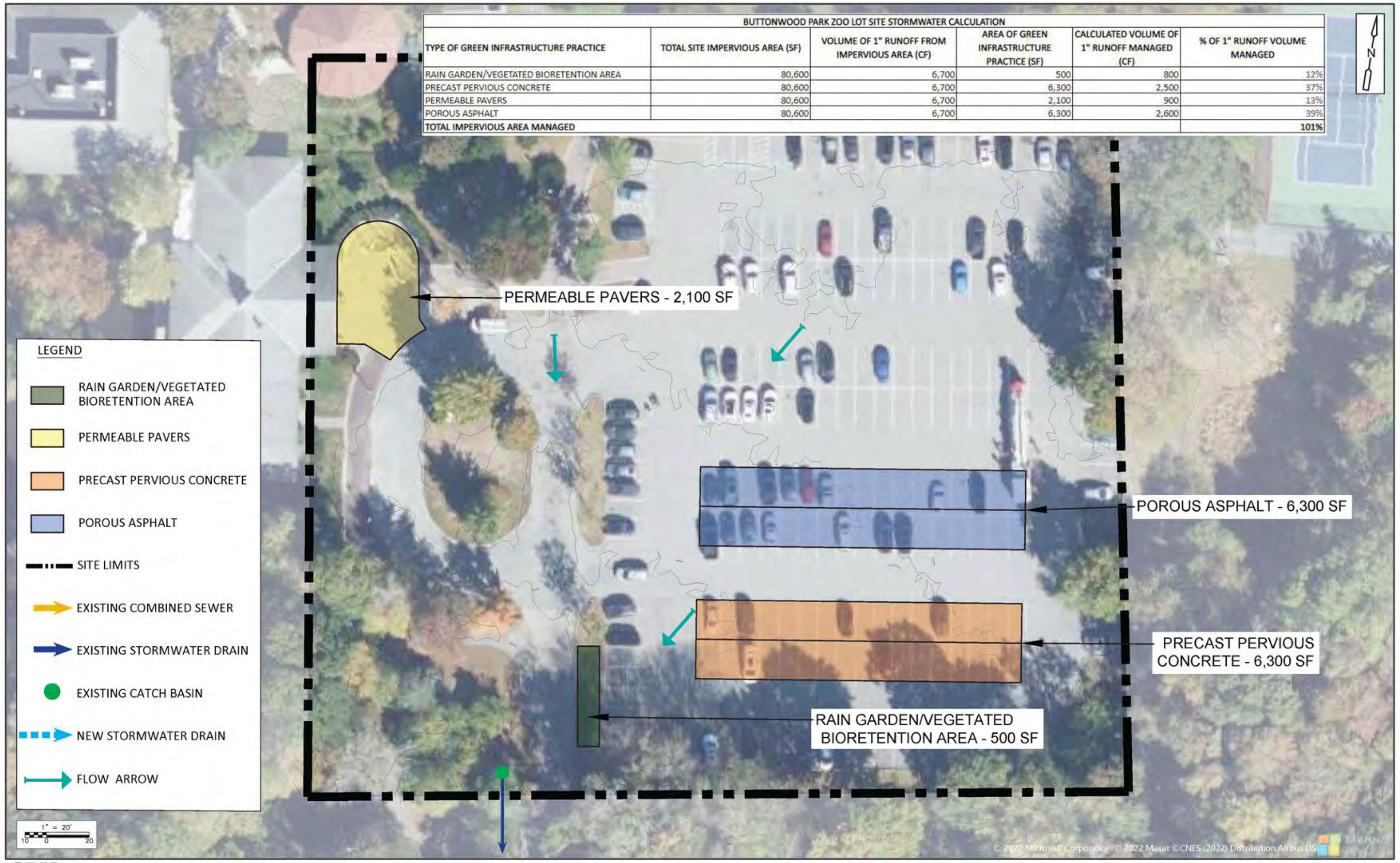
GLEN STREET SITE STORMWATER CALCULATION					
TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RAIN GARDEN/VEGETATED BIORETENTION AREA	10,000	800	1,000	1,500	188%
TOTAL IMPERVIOUS AREA MANAGED					188%

ABRAMS STREET SITE STORMWATER CALCULATION					
TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RAIN GARDEN/VEGETATED BIORETENTION AREA	15,000	1,300	1,000	1,500	115%
TOTAL IMPERVIOUS AREA MANAGED					115%

CDM Smith Figure 3 - 15 Victoria Street/Glen Street/Abrams Street Conceptual Design Plan

Buttonwood Park Zoo

Porous Pavements and Rain Garden/Vegetated Bioretention Area



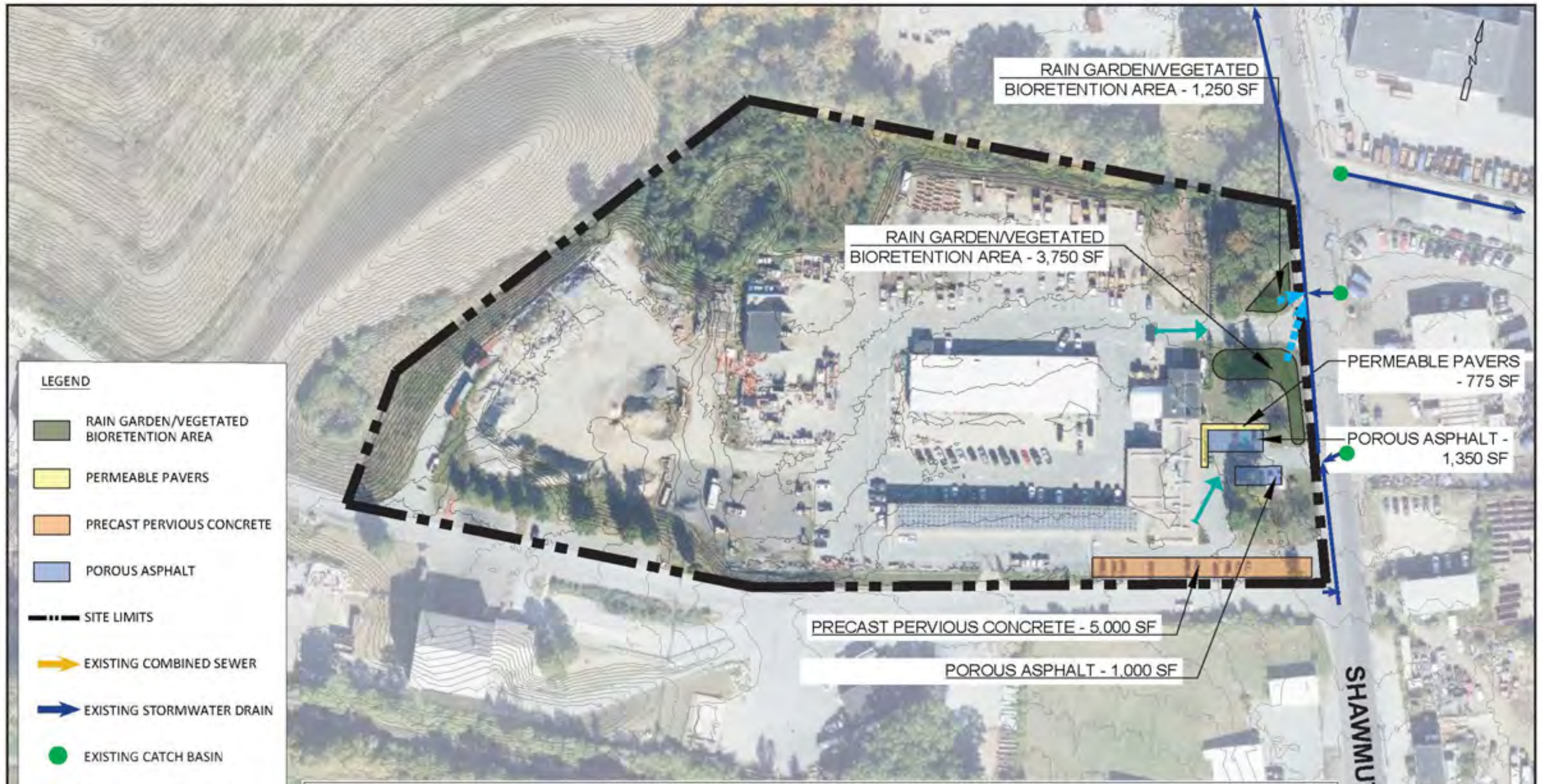
BUTTONWOOD PARK ZOO LOT SITE STORMWATER CALCULATION

TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RAIN GARDEN/VEGETATED BIORETENTION AREA	80,600	6,700	500	800	12%
PRECAST PERVIOUS CONCRETE	80,600	6,700	6,300	2,500	37%
PERMEABLE PAVERS	80,600	6,700	2,100	900	13%
POROUS ASPHALT	80,600	6,700	6,300	2,600	39%
TOTAL IMPERVIOUS AREA MANAGED					101%

CDM Smith Figure 3 - 37 Buttonwood Park Zoo Conceptual Design Plan

Department of Public Infrastructure

Green Infrastructure Demonstration Site



NEW BEDFORD DEPARTMENT OF PUBLIC INFRASTRUCTURE SITE STORMWATER CALCULATION					
TYPE OF GREEN INFRASTRUCTURE PRACTICE	TOTAL SITE IMPERVIOUS AREA (SF)	VOLUME OF 1" RUNOFF FROM IMPERVIOUS AREA (CF)	AREA OF GREEN INFRASTRUCTURE PRACTICE (SF)	CALCULATED VOLUME OF 1" RUNOFF MANAGED (CF)	% OF 1" RUNOFF VOLUME MANAGED
RAIN GARDEN/VEGETATED BIORETENTION AREA	141,600	11,800	5,000	7,600	64%
PERMEABLE PAVERS	141,600	11,800	800	300	3%
PRECAST PERVIOUS CONCRETE	141,600	11,800	5,000	2000	17%
POROUS ASPHALT	141,600	11,800	2,400	1,000	8%
TOTAL IMPERVIOUS AREA MANAGED					92%

CDM Smith Figure 3 - 33 New Bedford Department of Public Infrastructure Conceptual Design Plan

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Discussion