Attachment A

Watershed Treatment Model
Model Parameter Values, Input Data, and Model Results

Table 1
Land Use and Impervious Cover in the Mill River Watershed
(Values in acres unless otherwise marked)

	Land Use	Percent Impervious (%)	Butterworth Brook/other Mill River Tributaries	Eaton Brook	Lake Whitney	Lower Mill River	Middle Mill River	Shepard Brook	Willow Brook Tributaries	Upper Mill River	Willow Brook	Watershed Total
Developed	Residential - High Density	46.7	2.4	0.0	208.1	278.9	142.0	85.4	4.0	1.7	13.6	736.0
Developed	Residential - Medium Density	32.5	17.2	8.9	814.0	63.1	841.2	206.0	48.5	134.5	572.3	2,705.5
Developed	Residential - Medium-Low	20.3	143.1	283.8	268.6	17.1	535.9	285.4	172.5	287.6	663.2	2,657.2
Developed	Residential - Low Density	10.2	1,091.6	1,049.9	136.4	18.1	1,003.1	941.7	2,194.5	527.4	730.4	7,693.1
Developed	Developed Recreation	1.1	433.3	0.0	172.0	0.0	56.3	0.0	645.3	208.4	186.0	1,701.3
Developed	Commercial	50.0	0.0	8.7	268.5	44.4	249.3	80.3	96.2	65.1	59.0	871.5
Developed	Industrial	52.6	0.0	0.0	123.4	128.4	3.0	178.0	0.0	0.0	25.4	458.1
Developed	Institutional	22.5	24.0	76.4	198.8	88.8	418.9	191.3	48.8	92.7	228.6	1,368.3
Developed	Roadway/Highway	61.5	99.6	0.0	0.0	217.2	50.0	0.0	114.2	130.2	236.0	847.2
Developed	Utilities	8.3	0.9	0.0	0.0	0.0	1.5	0.0	20.5	8.0	3.4	34.3
Rural	Cropland	8.9	41.5	0.0	0.0	0.0	0.0	0.0	22.3	76.6	97.4	237.9
Rural	Open Space	1.8	1,129.4	75.2	382.3	219.1	1,056.7	68.6	1,220.5	203.0	881.2	5,236.0
Rural	Water	0.4	0.0	0.0	0.0	61.0	0.0	0.0	4.6	0.7	7.2	73.6
	Sub-watershed Total		**2,983.0**	**1,502.9**	**2,572.0**	**1,136.0**	**4,358.0**	**2,036.6**	**4,592.0**	**1,735.8**	**3,703.8**	**24,620.1**

Table 2
Mill River Watershed Land Use Mapped to Modeled Land Uses

	Land Use	Modeled Land Use	Examples and Notes
Developed	Residential - High Density	High Density Residential	≥8 Dwelling Units[1] (DU)/acre (1/8-acre lots)
	Residential - Medium Density	Medium Density Residential	2-8 DU/acre (1/2- to 1/8-acre lots)
	Residential - Medium-Low	N/A	1-2 DU/acre (1- to 1/2-acre lots) Assigned equally to Medium and Low Density Residential
	Residential - Low Density	Low Density Residential	1 or fewer DU/acre (>1-acre lots)
	Developed Recreation	Open Space	Modeled as Open Space land use, but with FC value below Low Density Residential
	Commercial	Commercial	General trades, services, offices, motels, etc.
	Industrial	Industrial	
	Institutional	Commercial	Schools, government buildings, churches, etc. Assumed to be same as commercial
	Roadway	Highway	
	Utilities	Rural	Transmission lines, cell towers, electric substations, water pumping stations, etc.
Rural	Agriculture	Cropland	
	Open Space	Forest	Reflects forested areas, wetlands, streams
	Water	Open Water	

Notes

Dwelling units were included in NVCOG parcel-based land use data. For SCRCOG, 2010 census data for occupied housing units was used. This analysis was conducted at the block level and reflects only the residential land use areas within each subwatershed.

Table 3
Developed Land Uses - Event Mean Concentrations
(TN, TP, TSS in mg/L and Fecal Coliform in MPN/100ml)

Land Use	WTM Default Values				Regional Values[1]				Selected Values			
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC
Low Density Residential	2.1	0.31	49	20,000	3.18	0.27	34	2,950	3.18	0.27	34	2,950
Medium Density Residential	2.1	0.31	49	20,000	3.5	0.41	49	12,360	3.5	0.41	49	12,360
High Density Residential	2.1	0.31	49	20,000	3.81	0.64	102	16,901	3.81	0.64	102	16,901
Highway	-	-	-	-	2.65	0.43	141	600	2.65	0.43	141	600
Commercial	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Institutional	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Industrial	2.2	0.25	81	20,000	4	0.11	42	1,467	4	0.11	42	1,467

Notes:
TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform
Sources:
[1]BETA Group, Inc. (2006). Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts.
Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

Table 4
Rural Land Uses - Export Coefficients
(TN, TP, and TSS in lb/ac/yr and Fecal Coliform in billion/ac/yr)

Land Use	WTM Default Values				Regional Values				Selected Values				Comments
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC	
Forest	2.0	0.2	100	12	2.5 [1]	0.2 [1]	100 [1]	12 [1]	2.5	0.2	100	12	Selected regional values
Rural	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Open Water	12.8	0.5	155	-	0.4 [1]	0.03 [1]	2 [1]	0.4 [1]	0.4	0.03	2	0.4	Selected regional values
Cropland	-	-	-	-	Pasture 1.9 [1] 7.7 [2] 5.6 [3] Row Crops 14.4 [2] 15.7 [3]	Pasture 0.1 [1] 1.3 [2] 0.5 [3] Row Crops 4.0 [2] 0.94 [3]	Pasture 47 [1] 591 [3] Row Crops 1997 [3]	Pasture 7 [1] Row Crops -	10	0.8	300	39	Selected TN, TP, and TSS based on regional sources for pasture and row crops; FC assumed same as Rural land use

Notes:

TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform

Conversion equation used for Pasture/Orchard

NSQD (2005) and MA DEP QAPP do not provide rural land use data.

Cropland export coefficients are based on regional values. This category includes both pasture and crop land. Pasture land and hay fields are about as prevalent as nurseries and row crops in the Mill River Watershed, so the selected coefficients represent an approximate average of those values.

Sources:

Maestre & Pitt and Center for Watershed Protection (2005). The National Stormwater Quality Database, Version 1.1.

Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

Regional values identified by number:

1. BETA Group, Inc. (2006). Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts. Converted values presented in mg/L into lb/ac/yr assuming 0% impervious area for Forest and 2% impervious area, 46 inches of rain per year, for agricultural land uses.
2. Reckhow et al. (1980): "Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients." From Lin, J. (2005) Review of Published Export Coefficient and Event Mean Concentration (EMC) Data. Converted values from kg/ha/yr to lb/ac/yr.
3. CH2M HILL (2001). PLOAD version 3.0, An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects: User's Manual.

Table 5
Sources and Model Assumptions

Parameter	Sources	Model Assumptions & Notes
Primary Sources		
Subwatershed Boundary	CTDEEP – Local basins	Smaller local basins with similar characteristics were grouped for this analysis. Where subwatershed boundaries do not follow local basins, they reflect impaired uses and follow contours based on 2000 LiDAR data
Land Use	NVCOG – Land Use 2016 SCRCOG – Land Use 2017 US Census 2010 CTECO – 2016 3-inch Orthophotography	NVCOG land use classifications were simplified for input into WTM. Acreage for various classifications was determined in ArcGIS by intersecting the land use with the Subwatersheds. NVCOG land use classifications include Medium-Low Density Residential, which was equally divided and split between Medium Density and Low Density Residential. Residential density is based on dwelling units per acre. This information was included in NVCOG parcel-based land use data. For SCRCOG, 2010 census data for occupied housing units was used. This analysis was conducted at the census block level and reflects only the residential land use areas within the Mill River watershed. SCRCOG land use included two categories of Other and Mixed Use. These areas were manually assigned to modeled land uses via aerial imagery. Most "Other" areas were combined with open space. Mixed Use was combined with Commercial. Where roadways were not included in land use coverage, the difference in area between subwatersheds and subwatershed land use coverage was assigned to the "Highway" category. Some municipalities classify this land use based on the surrounding land use (e.g. a residential street is classified as Residential)
Pollutant Event Mean Concentrations (EMCs) and Export Coefficients	WTM Default Values, Selected Regional Values used in MA Watershed Based Plan (2006)	Selected regional EMCs were used for residential, transitional, commercial, highway, and industrial land use categories. WTM default values were used for rural, powerlines, and open water land use categories.
Impervious %	CT ECO 2016	The impervious surface data set was available from CT Environmental Conditions Online (CTECO) as a statewide dataset representing impervious surfaces digitized from 2012 orthophotography. The percent impervious for land use classes in each subwatershed was determined by intersecting the raster with available land use data.
Annual Rainfall	Northeast Regional Climate Center	Weather station on Mt Carmel, Hamden. Period of record 1936-2018.
Stream Length	CTDEEP Hydrography Line	Stream lengths in each subwatershed were calculated based on intersecting the CTDEEP Hydrography Line data layer with the Subwatershed boundaries.

Parameter	Sources	Model Assumptions & Notes
Soils Information	CTDEEP Soils Data – NRCS SSURGO-Certified Soils 2009	Hydrologic Soils Group data were available from SSURGO and matched to CTDEEP soils data based on the Soil Map Unit Key (MUKey) field. Where the sum of category percentages is less than 100%, the balance is water, which does not receive HSG classification, but is most similar in infiltration characteristics to Category D. An estimate of the depth to groundwater was made by converting USDA drainage classes, which are essentially an estimate of seasonal high water table. Depth to groundwater was estimated at 3-5 ft across the watershed.
Runoff Coefficients	Virginia Erosion & Sediment Control Handbook, 1980.	Runoff coefficients for Rural Land Uses were selected from a range of values listed in the Virginia Erosion & Sediment Control Handbook. Values for Cropland ranged from 0.15 to 0.4 and from 0.12 to 0.35 for Pasture/Orchard, etc.
Secondary Sources		
General Sewage Data	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division, NVCOG parcel-based land use and WTM defaults	Watershed parcels in residential areas were excluded based on proximity to sanitary sewer piping.
Nutrient Concentration in Stream Channels	Haith et al. 1992	A mid- range value of 0.15 was used for Soil P (%) and Soil TN (%). See figures 4.1 and 4.2 in the WTM 2013 Documentation.
On-Site Sewage Disposal (OSDS)	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division, NVCOG parcel-based land use, Local Health Districts, and WTM defaults	All dwelling units assumed to be served by OSDS unless the parcel is within an area served by sanitary sewers. Unsewered areas were set to Clay/Mixed Soils. A failure rate of 1% was selected based on regional estimates and data on local system failure from Quinnipiac and Chesprocott Health Districts. Septic system type was set to 100% conventional, with medium maintenance. Typical separation from groundwater was assumed to be 3-5 ft. The OSDS density was set at 1-2 per acre based on calculated dwelling unit density in unsewered areas.
CSOs	GNHWPCA Consent Order WC5509 Annual Progress Report 2017 West River Watershed Based Plan, 2015	Three CSOs exist in the Mill River watershed, all within the Lower Mill River subwatershed. Meters installed at these outfalls in 2012 monitor discharge volumes for each storm event that causes a discharge. Sufficient data has now been collected for the WPCA to estimate a "typical year" of discharges based on both precipitation and on average monthly overflow events. Rather than use the default CSO contribution calculated by the WTM by applying the Simple Method, the availability of data in this watershed, coupled with estimates of pollutant concentrations applied in the neighboring West River Watershed Based Plan, allowed for the direct estimation of annual loading from CSOs.
SSOs	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division	SSOs must be reported in MS4 Annual Reports. Per these reports and in discussion with relevant municipal personnel, SSOs were only reported in the GNHWPCA sanitary sewer area. In the past three years, 150 gallons of sanitary sewage has been discharged to the storm sewer system. An annual discharge of 50 gallons was assumed, and distributed evenly across all subwatersheds served by GNHWPCA.

Parameter	Sources	Model Assumptions & Notes
Illicit Connections	NVCOG Parcel-based land use 2016, Aerial imagery, Google Maps	In sewered areas, 0.5/1000 residential connections and 5% of business connections assumed to be illicit. Model defaults used for pollutant concentrations and percent wash water.
Stream Channel Erosion	NA to Non-urban watersheds.	Method 1 was selected as the method to estimate channel erosion which assumes that some fraction of the total watershed load comes from stream channel erosion. A stream degradation value of "medium" (50% of the total sediment load) was applied to each subwatershed.
Livestock	Aerial imagery	Livestock operations were sparse in this mainly urban/suburban watershed. The entire Mill River watershed was visually examined for livestock operations at a scale of ~1:5,000. Head counts were based on aerial imagery, which was sufficiently detailed to distinguish between grazing livestock types and obtain an approximate number. Nutrient loads converted from daily loads in kilograms (Ruddy et al., 2006). E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).
Road Sanding	Winter Highway Maintenance Operations, 2015 UConn MAGIC – Connecticut Roads (2010) Municipal MS4 Annual Reports	Based on the CTDOT report, state agencies switched from sand to sodium chloride. An anonymous survey of 31 municipalities in Connecticut showed that 6.143 tons/lane mile of sand was used. This rate was multiplied by the lane miles under municipal jurisdiction to determine the amount of road sand applied per Subwatershed/WTM Area. Road miles were determined by intersection of the Connecticut Roads layer with the shape file containing the respective Subwatershed/WTM Area. Only Cheshire, Prospect, and Hamden use a mixture of sand and salt. No information is available for the ratio of sand to salt used in de-icing operations for these municipalities, so an even mixture of sand and salt was assumed. Other municipalities no longer use sand. Lane miles were doubled, because all municipal roads were assumed to be two-lane roads. The fraction of roads that are open is determined by dividing the amount of roadway that is open by the amount of road that drains to catch basins. Open sections do not have catch basins. Based on the urban/suburban nature of the study area, the length of road within the Municipal Separate Storm Sewer System (MS4) regulated area was used to estimate that 10-20% of roads were classified as open, on the assumption that urbanized areas are more likely to have closed section roads than more rural areas.
Non-Stormwater Point Sources	EPAs ICIS web data service	Daily discharge values of reported effluent concentrations on the EPA ICIS website were used for evaluating the contributing load from this source. Within the subwatersheds, most facilities do not have sampling requirements for their discharges. Several others were construction-related permits and monitored turbidity only. The rest monitored metals. Two in the Lower Mill River subwatershed, at Yale University, monitored bacteria.

Borel, K, R Karthikeyan, TA Berthold, and K Wagner. 2015. Estimating E. coli and Enterococcus loads in a coastal Texas watershed. Texas Water Journal 6: 33-44.

Haith, DA, R Mandel, and RS Wu. 1992. Generalized Watershed Loading Functions, Version 2.0 User's Manual. Department of Agricultural and Biological Engineering, Cornell University, Ithaca, NY.

Northeast Regional Climate Center. 2015. CLIMOD2: Woodbury, CT Precipitation Record 1967 – 2008.

Ruddy, BC, DL Lorenz, and DK Mueller. County-level estimates of nutrient inputs to the land surface of the conterminous United States, 1982-2001. USGS SIR 2006-5012.

Scarnecchia, DL. 1985. The animal-unit and animal-unit equivalent concepts in range science. Journal of Range Management 38: 346-349.

USGS. 2011. National Land Cover Dataset.

Virginia Erosion and Sediment Control Handbook, 1980. Virginia Soil and Water Conservation Committee.

Wagner, K and E Moench. 2009. Education Program for Improved Water Quality in Copano Bay: Task Two Report. Texas Water Resources Institute Technical Report 347.

Winter Highway Maintenance Operations, 2015. Connecticut Academy of Science and Engineering report to the Connecticut Department of Transportation.

Table 6
Additional Model Inputs

	Butterworth Brook/other Mill River Tributaries	Eaton Brook	Lake Whitney	Lower Mill River	Middle Mill River	Shepard Brook	Willow Brook Tributaries	Upper Mill River	Willow Brook	Watershed Total
Road Sanding (lbs/yr) - Entire Watershed	62,625	107,975	320,982	2,756	329,598	171,934	177,291	125,152	271,683	1,567,997
% With storm drains	80	80	80	90	80	80	80	80	80	80
% Without storm drains	20	20	20	10	20	20	20	20	20	20
Total length of streams (miles)	9.61	4.11	5.49	2.77	10.91	4.30	18.20	6.08	9.22	105.19
Dwelling units	878	1,388	6,775	5,664	8,246	4,100	1,640	1,397	3,519	33,607
Percentage of dwelling units un-sewered	25.7	11.3	0.0	0.0	6.5	0.5	82.6	31.6	30	10.8
Percentage of dwelling units with onsite septic within 100 ft of surface water[1]	3.13	8.39	0.0	0.0	3.27	0.21	9.81	3.75	3.00	1.89
Residential Sewered units	652	1,231	6,775	5,664	7,792	4,079	285	970	2,463	29,962
Commercial/Business Sewered units	0	161	120	175	90	85	0	40	2	673
Hydrologic Soil Group (Percent)										
A	0.5	14.0	24.3	34.6	10.9	4.7	12.3	2.5	13.2	
B	38.2	39.1	32.7	12.2	42.6	49.9	46.0	30.6	48.8	
C	30.7	25.8	5.9	5.1	19.7	25.6	16.4	47.7	18.9	
D[2]	29.9	21.1	27.4	42.4	25.6	19.6	24.9	19.0	18.5	

[1] Dwelling units with septic systems are assumed to be located within 100 feet of a waterbody based on a review of parcel-based land use and hydrography.

[2] Hydrologic soil group designation does not consider surface water. This area has been included under Group D which has the most similar infiltrative properties.

Table 7
Livestock Pollutant Loading Rates/Export Coefficients

Livestock	Nitrogen[1] (lbs/animal/year)	Phosphorus[1] (lbs/animal/year)	E. coli[2] (billion cfu/AU/year)
Bovine	164	26	1,966
Equine	102	18	84
Ovine	18.5	3.2	7,165
Poultry	1.1	0.4	85

[1] Ruddy et al (2006). Loads converted from daily loads in kilograms.

[2] E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).

Table 8
Estimated Head of Livestock by Drainage Basin

Livestock	Butterworth Brook/other Mill River Tributaries	Willow Brook
Bovine	0	0
Equine	45	10
Ovine	0	0
Poultry	0	0

Notes:

Head counts were based on aerial imagery, which was sufficiently detailed to distinguish among grazing livestock types and obtain an approximate number. It was assumed that most but likely not all head of livestock were grazing when aerial imagery was captured. This incorporates Giant Valley Polo Club and two hobby farms.

Table 9.1
Modeled Pollutant Loads in the
Butterworth Brook and other Mill River Tributaries Subwatershed

Source	Existing Loads to Surface Waters FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	Percent of total load FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	66,271	21,494	4,373	186,168	3,151	71.07	86.32	93.88	40.00	93.84
Low Density Residential	39,282	16,056	2,808	87,899	2,295	59.28	74.70	64.20	47.21	72.83
Medium Density Residential	20,710	2,224	536	15,940	289	31.25	10.35	12.27	8.56	9.16
High Density Residential	942	81	28	1,104	10	1.42	0.37	0.64	0.59	0.30
Commercial		-	-	-	-	-	-	-	-	-
Highway	1,707	2,859	956	77,894	490	2.58	13.30	21.85	41.84	15.56
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	3,629	274	46	3,331	67	5.48	1.27	1.04	1.79	2.13
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	4	4	124,753	-	-	0.02	0.08	26.80	-
Road Sanding	-	-	-	28,647	-	-	-	-	6.15	-
Forest	13,553	2,824	226	112,941	162	14.53	11.34	4.85	24.27	4.82
Rural Land	1,657	420	34	12,557	45	1.78	1.69	0.73	2.70	1.35
Livestock	28	103	12	-	-	0.03	0.41	0.26	-	-
Illicit Connections	11,448	15	3	101	-	12.28	0.06	0.05	0.02	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	296	40	7	267	-	0.32	0.16	0.14	0.06	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	81,509	23,222	4,571	452,516	3,358	87.41	93.27	98.13	97.22	100.00
Total Non-Storm Load	11,744	1,677	87	12,918	-	12.59	6.73	1.87	2.78	-
Total Load to Surface Waters	93,253	24,899	4,658	465,435	3,358	100.00	100.00	100.00	100.00	100.00

Table 9.2
Modeled Pollutant Loads in the Eaton Brook Subwatershed

Source	Existing Loads to Surface Waters FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	Percent of total load FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	87,684	17,819	3,518	115,628	2,584	62.52	98.28	98.61	49.69	99.62
Low Density Residential	39,238	13,733	2,543	79,888	1,955	44.75	77.07	72.27	69.09	75.67
Medium Density Residential	35,012	3,219	822	24,520	416	39.93	18.06	23.37	21.21	16.12
High Density Residential	-	-	-	-	-	-	-	-	-	-
Commercial	2,000	129	23	1,670	32	2.28	0.72	0.65	1.44	1.22
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	11,434	738	130	9,550	181	13.04	4.14	3.71	8.26	6.99
Channel Erosion	-	2	2	51,810	-	-	0.01	0.04	22.27	-
Road Sanding	-	-	-	56,847	-	-	-	-	24.43	-
Forest	902	188	15	7,520	10	0.64	1.04	0.42	3.23	0.38
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	51,450	94	28	693	-	36.68	0.52	0.80	0.30	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	212	28	5	186	-	0.15	0.15	0.13	0.08	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	88,586	17,914	3,530	231,052	2,594	63.16	98.81	98.95	99.30	100.00
Total Non-Storm Load	51,667	216	38	1,631	-	36.84	1.19	1.05	0.70	-
Total Load to Surface Waters	140,254	18,130	3,568	232,684	2,594	100.00	100.00	100.00	100.00	100.00

Table 9.3
Modeled Pollutant Loads in the Lake Whitney Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	372,531	29,728	5,428	374,912	4,536	75.98	96.34	97.86	46.11	99.05
Low Density Residential	8,041	2,325	335	18,644	350	2.16	7.82	6.17	4.97	7.71
Medium Density Residential	200,627	15,240	3,027	160,003	2,084	53.86	51.27	55.76	42.68	45.93
High Density Residential	75,978	4,595	1,309	92,244	577	20.40	15.46	24.11	24.60	12.72
Commercial	56,584	3,017	415	53,820	780	15.19	10.15	7.64	14.36	17.21
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	4,249	3,108	145	24,471	372	1.14	10.45	2.67	6.53	8.20
Institutional	27,052	1,443	198	25,731	373	7.26	4.85	3.65	6.86	8.23
Channel Erosion	-	5	5	155,060	-	-	0.02	0.08	19.07	-
Road Sanding	-	-	-	243,768	-	-	-	-	29.98	-
Forest	4,587	956	76	38,228	43	0.94	3.10	1.38	4.70	0.95
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	113,193	169	38	1,176	-	23.09	0.55	0.68	0.14	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	-	-	-	-	-	-	-	-	-	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	377,118	30,210	5,487	808,146	4,579	76.91	97.90	98.91	99.39	100.00
Total Non-Storm Load	113,198	647	61	4,999	-	23.09	2.10	1.09	0.61	-
Total Load to Surface Waters	490,316	30,857	5,547	813,145	4,579	100.00	100.00	100.00	100.00	100.00

Table 9.4
Modeled Pollutant Loads in the Lower Mill River Subwatershed

Source	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
	Existing Loads to Surface Waters					Percent of total load				
Urban Land	152,322	12,013	2,205	313,435	2,039	33.66	88.13	92.63	64.68	98.68
Low Density Residential	823	173	21	1,673	30	0.54	1.44	0.96	0.53	1.45
Medium Density Residential	15,705	867	147	10,984	135	10.31	7.21	6.65	3.50	6.62
High Density Residential	105,454	4,633	1,125	112,277	663	69.23	38.56	51.00	35.82	32.50
Commercial	9,689	375	44	8,082	111	6.36	3.12	1.99	2.58	5.42
Highway	3,542	3,049	715	146,858	627	2.33	25.38	32.42	46.85	30.75
Industrial	4,575	2,431	97	23,108	331	3.00	20.24	4.38	7.37	16.24
Institutional	12,533	486	57	10,454	143	8.23	4.04	2.58	3.34	7.01
Channel Erosion	-	4	4	140,355	-	-	0.03	0.18	28.96	-
Road Sanding	-	-	-	1,363	-	-	-	-	0.28	-
Forest	2,629	548	44	21,912	27	0.58	4.02	1.84	4.52	1.32
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	110,102	174	43	1,231	-	24.33	1.27	1.80	0.25	-
Septic Systems	-	-	-	-	-	-	-	-	-	-
Open Water	24	24	2	122	-	0.01	0.18	0.08	0.03	-
CSOs	187,395	868	83	6,197	-	41.42	6.37	3.47	1.28	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Point Source Discharges	0	-	-	-	-	0.00	-	-	-	-
Total Storm Load	342,371	13,183	2,325	481,194	2,066	75.67	96.72	97.65	99.29	100.00
Total Non-Storm Load	110,107	448	56	3,422	-	24.33	3.28	2.35	0.71	-
Total Load to Surface Waters	452,478	13,630	2,381	484,616	2,066	100.00	100.00	100.00	100.00	100.00

Table 9.5
Modeled Pollutant Loads in the Middle Mill River Subwatershed

Source	Existing Loads to Surface Waters: FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	Percent of total load: FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	477,689	43,111	8,327	501,532	6,691	77.38	93.63	96.83	45.61	97.95
Low Density Residential	42,062	12,285	1,874	92,709	1,804	8.81	28.50	22.50	18.49	26.96
Medium Density Residential	257,722	19,774	4,161	195,390	2,638	53.95	45.87	49.97	38.96	39.42
High Density Residential	56,688	3,463	1,045	65,426	424	11.87	8.03	12.55	13.05	6.34
Commercial	57,430	3,093	451	51,928	781	12.02	7.18	5.41	10.35	11.67
Highway	860	1,030	300	38,669	181	0.18	2.39	3.60	7.71	2.71
Industrial	112	83	4	613	10	0.02	0.19	0.05	0.12	0.14
Institutional	62,814	3,383	493	56,796	854	13.15	7.85	5.92	11.32	12.76
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	7	7	230,190	-	-	0.01	0.08	20.93	-
Road Sanding	-	-	-	260,222	-	-	-	-	23.66	-
Forest	12,680	2,642	211	105,670	139	2.05	5.74	2.46	9.61	2.03
Rural Land	59	7	1	151	1	0.01	0.02	0.01	0.01	0.02
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	126,157	181	37	1,246	-	20.44	0.39	0.43	0.11	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	730	95	16	636	-	0.12	0.21	0.18	0.06	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	490,428	44,442	8,483	1,087,182	6,831	79.45	96.52	98.64	98.87	100.00
Total Non-Storm Load	126,887	1,601	117	12,464	-	20.55	3.48	1.36	1.13	-
Total Load to Surface Waters	617,315	46,043	8,600	1,099,646	6,831	100.00	100.00	100.00	100.00	100.00

Table 9.6
Modeled Pollutant Loads in the Shepard Brook Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	207,854	27,245	4,785	264,022	3,943	74.30	98.96	99.13	54.96	99.77
Low Density Residential	36,467	10,886	1,846	80,693	1,581	17.54	39.96	38.58	30.56	40.11
Medium Density Residential	82,175	6,444	1,508	62,545	851	39.54	23.65	31.50	23.69	21.57
High Density Residential	34,557	2,157	724	40,041	262	16.63	7.92	15.12	15.17	6.63
Commercial	18,753	1,032	167	17,023	258	9.02	3.79	3.49	6.45	6.54
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	6,784	5,122	281	37,288	592	3.26	18.80	5.88	14.12	15.00
Institutional	29,118	1,603	260	26,432	400	14.01	5.88	5.42	10.01	10.15
Channel Erosion	-	3	3	104,941	-	-	0.01	0.07	21.85	-
Road Sanding	-	-	-	103,776	-	-	-	-	21.60	-
Forest	823	171	14	6,857	9	0.29	0.62	0.28	1.43	0.23
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	71,065	108	25	753	-	25.40	0.39	0.51	0.16	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	6	3	1	22	-	0.00	0.01	0.01	0.00	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	208,677	27,333	4,798	478,909	3,952	74.59	99.29	99.39	99.70	100.00
Total Non-Storm Load	71,076	197	29	1,460	-	25.41	0.71	0.61	0.30	-
Total Load to Surface Waters	279,753	27,530	4,827	480,370	3,952	100.00	100.00	100.00	100.00	100.00

Table 9.7
Modeled Pollutant Loads in the Upper Mill River Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	121,398	18,621	3,658	246,147	2,812	78.67	92.85	96.47	53.12	96.02
Low Density Residential	22,921	7,737	1,196	54,016	1,087	18.88	41.55	32.68	21.94	38.64
Medium Density Residential	66,039	5,856	1,249	53,533	747	54.40	31.45	34.13	21.75	26.57
High Density Residential	684	48	15	844	6	0.56	0.26	0.40	0.34	0.20
Commercial	15,252	949	140	14,746	229	12.56	5.10	3.83	5.99	8.15
Highway	2,274	3,145	929	109,252	530	1.87	16.89	25.38	44.38	18.84
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	14,228	886	131	13,756	214	11.72	4.76	3.57	5.59	7.60
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	3	3	110,353	-	-	0.02	0.09	23.81	-
Road Sanding	-	-	-	62,009	-	-	-	-	13.38	-
Forest	2,436	508	41	20,302	29	1.58	2.53	1.07	4.38	0.98
Rural Land	3,300	803	67	23,788	88	2.14	4.00	1.76	5.13	2.99
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	26,501	41	10	293	-	17.17	0.21	0.27	0.06	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	671	79	13	526	-	0.44	0.39	0.35	0.11	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	127,135	19,280	3,737	458,190	2,929	82.39	96.13	98.54	98.87	100.00
Total Non-Storm Load	27,172	776	55	5,228	-	17.61	3.87	1.46	1.13	-
Total Load to Surface Waters	154,307	20,055	3,792	463,418	2,929	100.00	100.00	100.00	100.00	100.00

Table 9.8
Modeled Pollutant Loads in the Willow Brook Subwatershed

Source	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
	Existing Loads to Surface Waters					Percent of total load				
Urban Land	303,955	36,635	7,033	486,740	5,482	81.96	91.32	95.76	49.87	96.44
Low Density Residential	34,932	10,718	1,588	78,870	1,552	11.49	29.26	22.58	16.20	28.32
Medium Density Residential	210,547	16,971	3,468	163,516	2,233	69.27	46.32	49.32	33.59	40.74
High Density Residential	5,469	351	103	6,465	42	1.80	0.96	1.46	1.33	0.77
Commercial	13,666	773	109	12,658	193	4.50	2.11	1.56	2.60	3.51
Highway	4,085	5,136	1,454	188,082	893	1.34	14.02	20.68	38.64	16.28
Industrial	959	745	36	5,381	86	0.32	2.03	0.51	1.11	1.56
Institutional	34,298	1,941	275	31,768	483	11.28	5.30	3.90	6.53	8.81
SSOs	-	-	-	-	-	-	-	-	-	-
CSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	7	7	226,657	-	-	0.02	0.09	23.22	-
Road Sanding	-	-	-	143,229	-	-	-	-	14.67	-
Forest	10,575	2,203	176	88,125	111	2.85	5.49	2.40	9.03	1.95
Rural Land	3,930	989	80	29,556	92	1.06	2.47	1.09	3.03	1.61
Livestock	6	23	3	-	-	0.00	0.06	0.04	-	-
Illicit Connections	51,060	72	14	487	-	13.77	0.18	0.19	0.05	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS	1,341	187	31	1,250	-	0.36	0.47	0.43	0.13	-
Open Water	3	3	0	14	-	0.00	0.01	0.00	0.00	-
Total Storm Load	318,469	38,264	7,222	962,554	5,684	85.87	95.38	98.34	98.62	100.00
Total Non-Storm Load	52,401	1,855	122	13,505	-	14.13	4.62	1.66	1.38	-
Total Load to Surface Waters	370,870	40,119	7,344	976,059	5,684	100.00	100.00	100.00	100.00	100.00

Table 9.9
Modeled Pollutant Loads in the Willow Brook Tributaries Subwatershe

	Existing Loads to Surface Waters					Percent of total load				
Source	**FC (billion/year)**	**TN (lb/yr)**	**TP (lb/yr)**	**TSS (lb/yr)**	**Runoff Volume (acre-feet/year)**	**FC (%)**	**TN (%)**	**TP (%)**	**TSS (%)**	**Runoff Volume (%)**
Urban Land	137,445	39,250	7,896	305,703	5,795	76.19	91.47	95.99	42.41	96.71
Low Density Residential	74,083	30,353	5,509	165,415	4,274	53.90	77.33	69.77	54.11	73.76
Medium Density Residential	30,816	3,317	831	23,668	424	22.42	8.45	10.52	7.74	7.32
High Density Residential	1,578	135	49	1,844	16	1.15	0.34	0.61	0.60	0.27
Commercial	21,832	1,650	286	19,998	399	15.88	4.20	3.62	6.54	6.89
Highway	1,937	3,252	1,128	88,185	549	1.41	8.28	14.28	28.85	9.48
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	7,198	544	94	6,593	132	5.24	1.39	1.19	2.16	2.27
SSOs	-	-	-	-	-	-	-	-	-	-
CSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	5	5	180,198	-	-	0.01	0.07	25.00	-
Road Sanding	-	-	-	102,254	-	-	-	-	14.18	-
Forest	14,646	3,051	244	122,048	159	8.12	7.11	2.97	16.93	2.65
Rural Land	1,672	318	32	8,758	38	0.93	0.74	0.39	1.21	0.64
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	21,797	29	5	195	-	12.08	0.07	0.06	0.03	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS	4,825	256	43	1,709	-	2.67	0.60	0.52	0.24	-
Open Water	2	2	0	9	-	0.00	0.00	0.00	0.00	-
Total Storm Load	153,765	40,941	8,095	705,890	5,992	85.24	95.41	98.41	97.92	100.00
Total Non-Storm Load	26,621	1,970	131	14,985	-	14.76	4.59	1.59	2.08	-
Total Load to Surface Waters	180,386	42,912	8,226	720,875	5,992	100.00	100.00	100.00	100.00	100.00

Appendix C

Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan

FUSS & O'NEILL

MEMORANDUM

TO: Nicole Davis and Gwen Macdonald, Save the Sound

FROM: Erik Mas, P.E, Julianne Busa, Ph.D., and Stefan Bengtson, MSc, Fuss & O'Neill, Inc.

DATE: June 28, 2018

RE: **Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment**
Mill River Watershed-Based Plan

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1. Introduction

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. Stormwater runoff collected by the combined sanitary and storm sewer system in the City of New Haven also contributes to three remaining Combined Sewer Overflow (CSO) discharges to the Mill River during periods of heavy rainfall, when the combined sewer system becomes overwhelmed. CSO discharges therefore contribute additional pollutant loads to the Mill River during wet weather.

Low Impact Development (LID) is a site design strategy that maintains, mimics, or replicates pre-development hydrology through the use of numerous site design principles and small-scale treatment practices distributed throughout a site to manage runoff volume and water quality at the source. Similarly, "green infrastructure" refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, LID and green infrastructure (referred to hereafter as simply "green infrastructure") include stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

In addition to reducing polluted runoff and improving water quality, green infrastructure has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change. For these reasons, many communities are exploring the use of and are adopting green infrastructure within their municipal infrastructure programs.

An important objective of the Mill River Watershed Management Plan is to reduce runoff volumes and pollutant loads through the use of green infrastructure by building on the previous and ongoing

LID and green infrastructure initiatives in the watershed and region and targeting areas of known water quality impairments.

2. Assessment Approach

An assessment was performed to identify opportunities and develop concepts for site-specific green infrastructure retrofits in the Mill River watershed. The assessment consisted of four primary tasks:

1. Identification of existing green infrastructure practices in the Mill River watershed,
2. Screening evaluation to quickly identify areas of the watershed with the greatest feasibility for and potential benefits from green infrastructure retrofits,
3. Field inventories of the most promising green infrastructure retrofit opportunities in the watershed identified from the screening step,
4. Green infrastructure concept designs for selected retrofit sites.

3. Existing Green Infrastructure Practices

There are a number of ongoing green infrastructure initiatives in the greater New Haven area. Implementation of green infrastructure is a key objective of the Greater New Haven Water Pollution Control Authority (GNHWPCA) strategic plan (GNHWPCA, 2017). GNHWPCA requires the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development and redevelopment projects within combined sewer areas (*Table 1*) in accordance with the GNHWPCA Permitting and Design Criteria Manual. GNHWPCA and the City of New Haven, working with CFE/Save the Sound and other groups, are also installing bioswales at numerous locations throughout the City within the public right-of-w ay to reduce runoff to the combined sewer system and reduce pollutant loads to surface waters. The City of New Haven has also adopted regulatory requirements to reduce stormwater runoff from development projects contributing to the City's combined sewer system.

The Town of Hamden has also been active in pursuing green infrastructure projects. The Town has applied for 319 funding for a project at Town Center Park which would involve installation of a stormwater treatment wetland to manage runoff from 88 acres of surrounding commercial and residential land. The Town has also adopted regulations and practices that directly support LID, including stormwater regulations that reference the DEEP stormwater manual, parking regulations that require any parking areas above and beyond the required minimum to be created with pervious materials and aim, more generally, at reducing paved surfaces, and landscape regulations that directly address stormwater quality issues. The Town has established impervious cover maximums and works closely with the RWA to coordinate stormwater efforts.

Area universities and other key facilities serve as visible demonstration sites for green infrastructure practices in and around the watershed. Over the past decade, Yale University has incorporated infiltration and water reuse at a number of buildings that are either within the Mill River watershed or contributing to the sewershed of CSO #011 (which outfalls to the Mill River). These include the Yale School of Forestry and Environmental Studies, Greenberg Conference Center, Yale School of Management, Yale Divinity School, and several science buildings (*Table 1*).

Table 1. GNHWPCA Green Redevelopment Projects

Permit Approval Year	Description	Address	Components
2007	Yale School of Forestry & Environmental Studies	Sachem & Prospect Streets*	Storage Tanks, Water Feature
2008	Albertus Magnus College Parking Lot	900 Prospect Street	Infiltrators
2008	St. Donato's Expansion	501 Lombard Street*	Infiltrators
2008	Yale Greenberg Conference Center	Prospect Street	Infiltrators
2008	Yale Ingalls Rink Expansion	73 Sachem Street	Bioswale, Tree wells, infiltrators
2008	Yale School of Manage ment	155 Whitney Avenue	Irrigation Storage Tank, Infiltrators
2008	Yale Divinity School	409 Prospect Street	Drywells
2009	Yale Biology Building	230 Whitney Avenue	Rainwater Reuse Tank, Bioswale, Infiltrators
2011	Murray Place Housing	191 Saltonstall Avenue	Infiltrators
2012	Lovell House Apartments	45 Nash Street	Infiltrators
2012	Albertus Magnus College Drainage	700 Prospect Street	Drywells and curtain drain
2013	Yale Kline Chemistry Laboratory	285 Prospect Street*	Rainwater Reuse Tank, Infiltrators
2014	Community Building	72 James Street	Infiltrators
2014	315 Whitney Avenue	315 Whitney Avenue	Pervious Pavers, Infiltrators
2014	1040 State Street	1040 State Street	Infiltrators
2016	Yale Science Building	260 Whitney Avenue*	Infiltrators
2015	Esplanade Apartments	396 Prospect Street*	Perforated pipe, water quality chamber
2017	District NHV, LLC	470 James Street	Retention Basins
2017	Wright Lab Renovation	266 Whitney Avenue*	Rip Rap Swales
2017	Bender Showroom	335 East Street	Infiltrators
2018	New Haven Housing	703 Whitney Avenue	Infiltrators
2017	Apartments	245 Whitney Avenue*	Pavers, Rain Gardens, Infiltrators
Under Review	Unicast Development	620 Grand Avenue	Infiltrators
field visit 6/2018	St Joseph Church (St Mary's)	129 Edwards St	Infiltrators
field visit 6/2018	United Church of the Redeemer	185 Cold Spring Street	Infiltrators

* An asterisk after the address indicates sites which are outside the watershed, but inside the sewershed of CSO#11

Similarly, Quinnipiac University has incorporated permeable pavement into some of its parking areas, including an overflow lot on Sherman Avenue, and is actively exploring additional sustainability improvements. Throughout the South Central Basin, the UConn CT NEMO program is working on a pilot project focused on incorporating green infrastructure into local projects. The Regional Water Authority has been another advocate for water quality improvements in the watershed; the Whitney Water Treatment Facility features a 30,000 square foot extensive green roof that captures stormwater and reduces runoff.

During site visits, the field team also noted that Elim Park Retirement Community, one of the sites identified as a priority site during the green infrastructure screening process (described below), already managed stormwater using an existing treatment wetland and pond. There are likely other, scattered green infrastructure practices in use on private properties throughout the watershed.

4. Assessment Methods and Findings

The remainder of this technical memorandum documents the methods and findings of the green infrastructure screening evaluation, field inventories, and concept designs.

Screening Evaluation

A GIS-based screening evaluation was conducted to quickly identify specific parcel-based locations within the watershed where green infrastructure retrofits can be implemented that would provide water quality (i.e., pollutant reduction) and quantity (i.e., runoff reduction) benefits in the watershed. The types of green infrastructure retrofits with potential applicability in the Mill River watershed include:

- Permeable pavement
- Bioretention/bioswales
- Infiltration/filtration including tree box filters
- Green/blue roofs
- Tree planting
- Water harvesting/reuse

Green infrastructure retrofit opportunities exist on sites or parcels and within street rights-of-way, as evidenced by the ongoing "green streets" or "complete streets" retrofits by the City of New Haven and the GNHWPCA. Right-of-way projects were included in the screening process; however, the primary focus of the analysis was on parcel-based green infrastructure opportunities on publicly-owned land and privately-owned institutional properties.

The following screening criteria and data sources were used to create an initial list of the most feasible sites for green infrastructure retrofits in the target subwatersheds:

- **Target Subwatersheds** – Subwatersheds with impaired water bodies, as defined in the 2016 Integrated Water Quality Report were prioritized, since green infrastructure retrofits in these areas would have the greatest water quality benefits. The following subwatersheds were identified as target areas for further consideration:

    - Upper Mill River
    - Middle Mill River
    - Lower Mill River
    - Willow Brook
    - Shepard Brook

    The Lower Mill River subwatershed also encompasses those areas of the Mill River watershed with combined sewers, thereby providing additional benefits related to CSO discharges by reducing the amount of runoff entering the combined sewer system (*Figure 1*).

- **Land Ownership** – Publicly-owned (e.g., municipal) parcels are most favorable because they avoid the cost of land acquisition and provide direct control over green infrastructure construction, maintenance, and monitoring by the municipality. Other publicly-owned parcels such as schools, universities, state facilities, and federal facilities are also potential green infrastructure candidates. Certain types of private parcels (e.g., private universities, churches) may be suitable and were also included in the analysis. In the screening process, land ownership attribution was based on land use classifications from both the South Central Regional Council of Governments (SCRCOG) and the Naugatuck Valley Council of Governments (NVCOG). Approximately 489 parcels in the Mill River watershed were identified as possible sites given land use classifications of community facility, institutional, recreational, open space, or utilities. Of those parcels, 231 occur in targeted subwatersheds.[1]

- **Subsurface Conditions** – Subsurface conditions are key considerations for green infrastructure retrofits that rely on infiltration of stormwater runoff and where runoff reduction is desired. Soil infiltration capacity, depth to groundwater, depth to restrictive layers (bedrock, dense till), soil bulk density, and inundation of soils due to flooding are important soil-based characteristics that can affect the feasibility of infiltration-based green infrastructure retrofits.[2] For the purposes of this desktop screening evaluation, we used hydrologic soil groups (HSGs), as mapped by the Natural Resources Conservation Service (NRCS), to identify candidate sites for green infrastructure retrofits. HSGs provide an initial estimate of infiltration rate and storage capacity of soils on a site. Sites where mapped HSGs have high infiltration rates (A and B soils) are most suitable for infiltration stormwater practices. While soil maps provide initial estimates of infiltration potential, field investigations will be necessary to verify soil conditions for final feasibility determinations and design purposes. Note also that while the analysis generally focused on sites with A and B soils, input from the steering committee led us to include a number of sites in New Haven that are mapped as D soils, but where experience has shown that the soils in fact exhibit good infiltration characteristics.

Screening Results

The most feasible sites for green infrastructure retrofits were initially defined as those where all three screening criteria coincided, based on GIS analysis. Specifically, candidate sites for green infrastructure retrofits were identified as:

- Within impaired subwatersheds; and
- On publicly-owned land or higher-priority private institutional land (e.g., churches and private schools); and
- Having HSG A or B soils (or sites in New Haven, as described above).

[1] Note that, although given a lower priority here, private properties also offer considerable opportunities for GI/LID. Individual landowners should be encouraged to pursue green infrastructure, and municipalities can further encourage adoption of GI practices through review and revision of land use regulations.

[2] Other site-specific factors such as land area, impervious area, drainage area, subsurface utilities, subsurface contamination, and storm drainage system capacity are also important considerations for green infrastructure retrofits.

Candidate sites were then further screened for degree of impervious cover, such that open space areas that are essentially wooded conservation land with no existing buildings, roads, or parking areas (and therefore little expectation of generating pollutants) were considered lower priority and excluded from the list.

All sites meeting the above criteria were included on a list of potential sites (*Attachment A*). These sites were further divided into higher priority and lower priority sites, with public sites given priority due to the advantage conveyed by public ownership when actually trying to fund and implement retrofit projects. The list was further refined with input from Save the Sound staff and projects suggested by the Steering Committee. The final list of priority sites (*Attachment A*) included a total of 78 sites, 38 of which were identified as higher priority, and 40 of which were identified as lower priority.

Field Inventories

Site visits were conducted at 30 of the higher priority sites, as well as 6 of the lower priority sites, with visits attended by staff from Fuss & O'Neill, Connecticut Fund for the Environment/Save the Sound (CFE/STS), or a team consisting of representatives from both organizations. Most site visits were conducted on June 12 and 13, 2018, with some follow-up visits conducted by CFE/STS the following week. The sites and adjacent street areas were walked and visually inspected for potential green infrastructure retrofit opportunities (i.e., impervious surfaces connected to the on-site drainage system, available green space to accommodate new green infrastructure practices, existing drainage features that could be enhanced or improved) and physical site characteristics such as site configuration, drainage patterns, current use, slope, landscaping, subsurface utilities, design complexity, and maintenance access considerations. Notes were recorded and photographs taken at each site.

Sites Selected for Concept Designs

Based on the findings of the field inventories, green infrastructure retrofit opportunities were identified at the majority of the sites visited. The following 10 sites were selected for development of concept designs, as these sites are believed to (1) have the greatest feasibility for green infrastructure retrofits and the greatest potential pollution reduction impact, (2) represent a cross-section of common retrofit types and serve to demonstrate a variety of green infrastructure approaches, and (3) are distributed geographically throughout the targeted areas of the Mill River watershed (*Figure 2*):

1. Elm City College Preparatory Elementary School, New Haven
2. James Street, New Haven
3. John S. Martinez School and Exchange Street, New Haven
4. Wilbur Cross High School, New Haven
5. Livingston Street at East Rock Road, New Haven
6. Bartlem Recreation Area, Cheshire
7. Strathmore Drive, Cheshire
8. YNHH Outpatient Services, Hamden
9. Whitney High School North/West, Hamden
10. Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road, Hamden

5. Site-Specific Project Concepts

The site-specific green infrastructure retrofit concepts presented in this section are intended to serve as potential on-the-ground projects for future implementation. They also provide examples of the types of projects that could be implemented at similar sites throughout the watershed. It is important to note that the concepts presented in this section are examples of potential opportunities, yet do not reflect site-specific project designs. Individual project proponents (e.g., municipalities, private property owners, developers) are responsible for evaluating the ultimate feasibility of, as well as design and permitting for, these and similar site-specific concepts.

Preliminary, planning-level costs were estimated for the site-specific concepts presented in this section. These estimates are based upon unit costs derived from published sources, engineering experience, and the proposed concept designs. Capital (construction, design, permitting, and contingency) and operation and maintenance costs are included in the estimates, and total annualized costs are presented based on the anticipated design life of each green infrastructure practice. A range of likely costs is presented for each concept, reflecting the inherent uncertainty in these planning-level cost estimates. A detailed breakdown of these estimated costs is included in *Attachment C.*

In some cases, costs are presented for multiple alternative project approaches, for example, both a subsurface infiltration option and a pervious pavement option[3]. Subsurface infiltration chambers are a far more expensive option, but have the benefit of increased potential infiltration capacity in certain soils and the ability to accept stormwater that is already in an underground drainage system, whereas pervious pavement is limited to infiltrating surface flows. Pervious pavement also poses increased maintenance concerns over subsurface infiltration options, as the pavement can be damaged by snow removal operations and must be kept clean of silt and other fine materials that would clog the pavement and reduce its ability to infiltrate.

Where bioretention/rain gardens are recommended, pricing assumes the 'bioretention' rate (see Appendix C), which utilizes contracted labor for design and implementation. Simple raingardens can also be constructed using volunteer labor for hand-digging and planting at reduced costs that would be more in line with the 'raingarden' pricing rate (see Appendix C).

Preliminary sizing calculations are also provided for each practice and are based on the goal of capturing and treating/infiltrating the water quality volume (WQV), generally defined as the first one-inch of runoff from the contributing drainage area. Approximate drainage areas are provided for each practice within the designs, along with the expected WQV to be generated from that drainage area.

The table in *Attachment D* contains information on site characteristics and potential green infrastructure opportunities for the other sites visited during the field inventories that were deemed to have good potential for green infrastructure retrofits.

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[3] Note that pervious pavement costs presented in the memo and in Appendix C are based upon a porous asphalt design. More decorative alternatives, such as pervious pavers, will have increased costs (see Appendix C).

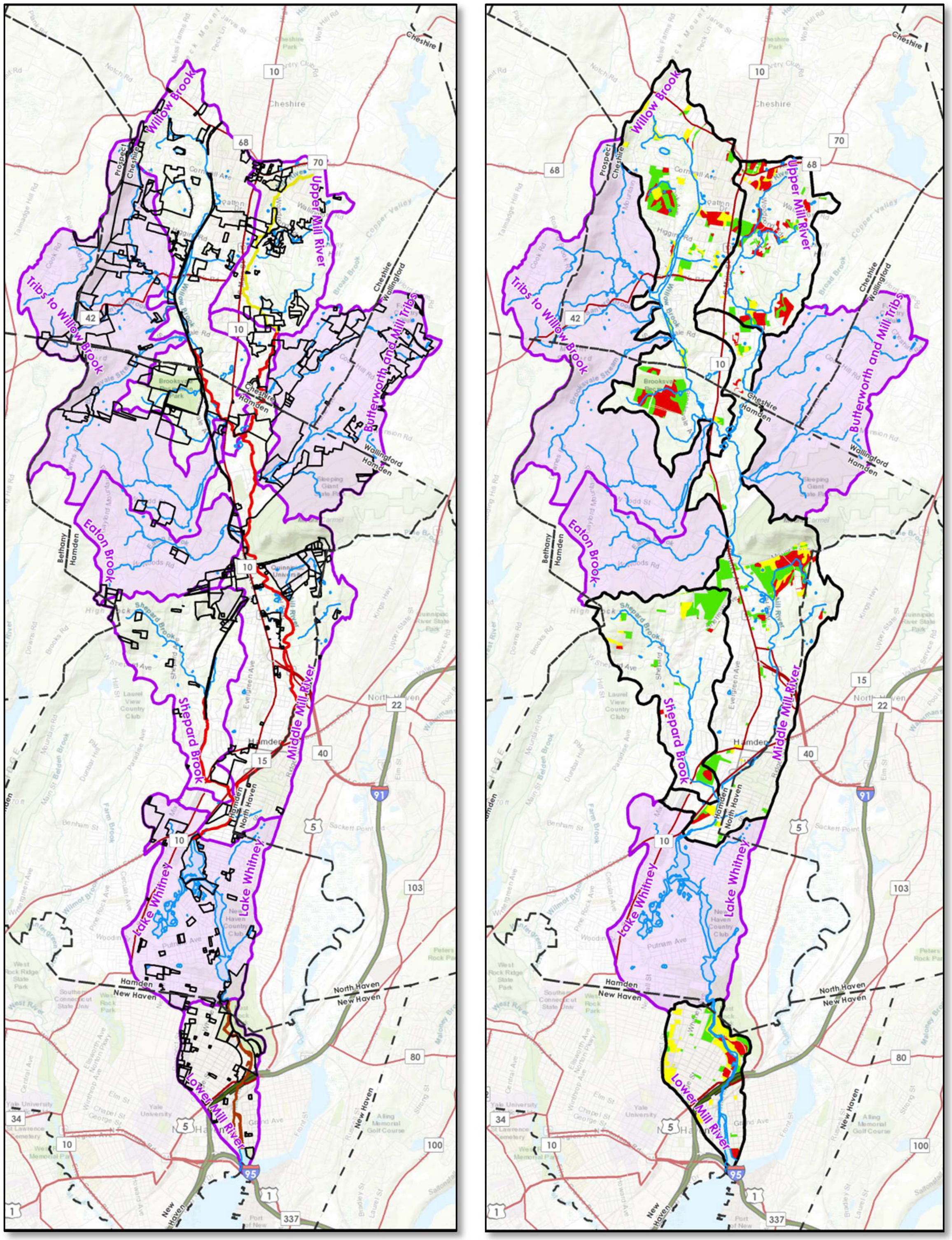

Figure 1. Maps of screening criteria. Impaired subwatersheds are outlined, while non-impaired subwatersheds are masked in purple. On the left, parcels meeting the land ownership are outlined in black. On the right, only the subset of parcels within impaired watersheds is depicted; parcel color reflects the subsurface conditions: green indicates A or B soils, yellow areas are labeled as D soils, but includes areas of urban soils known to have good infiltration, and red indicates areas of C soils or limited infiltration potential.

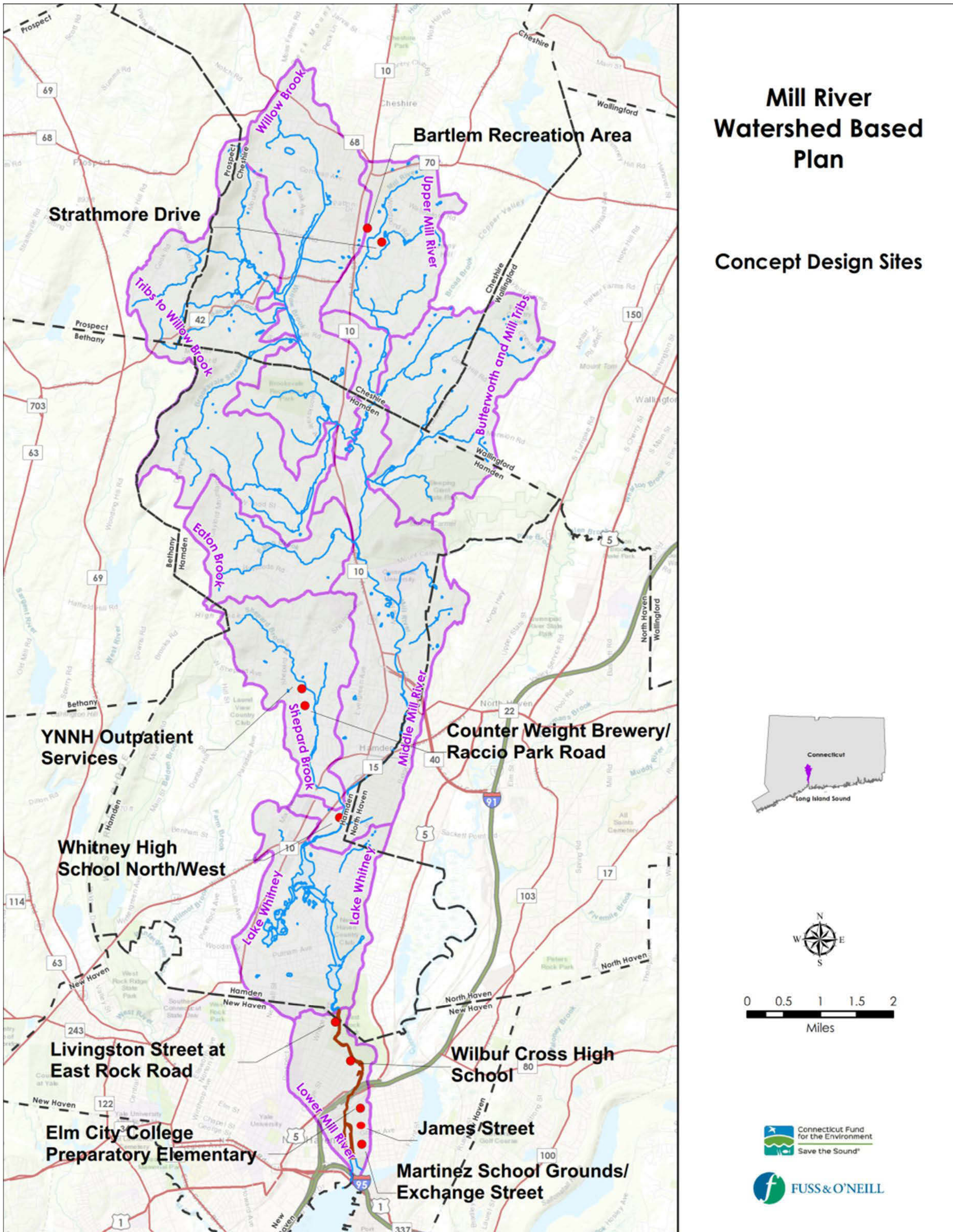

Figure 2. Locations of sites selected for concept designs.

Elm City College Preparatory Elementary School

Located at 407 James Street, New Haven, Elm City Preparatory Elementary occupies an approximately 1.5-acre site at the corner of James Street and Lombard Street, in a CSO area (CSO #009). With the exception of a 0.25-acre artificial turf field, the site is entirely impervious. Existing catch basins capture parking lot runoff along the western edge of the lot. Downspouts from the building appear to be internal and to tie in to the drainage system at the downgradient catch basin before connecting to the City's stormwater infrastructure running along James Street. A broken curb at the west edge of the parking lot is currently allowing runoff to bypass the catch basins and travel down a short embankment to the sidewalk.

The sidewalk in front of the school along James Street is approximately 11 feet wide in most places. Planters with trees are incorporated into the sidewalk at 50 foot intervals; however, there is a tree missing directly in front of the school parking area (*Figure 3*).

Space is the most significant constraint at this site, as parking is tight and there is little impervious area. Existing street trees, a fire hydrant/water lines, and other utilities pose additional constraints. A variety of BMPs are recommended for this site in order to best achieve the following goals: maximize enhancement of curricular value in a limited space, maximize infiltration/treatment potential, and keep implementation costs manageable. These elements could be implemented all at once, or installed gradually as funding permits (total project costs will vary widely depending on which components are chosen).

- **Tree Box Filter and Bioretention/Infiltration.** A tree box filter and replacement tree are proposed for the location where a tree is currently missing (*Figure 3*). A tree box filter design with additional subsurface infiltration capacity is recommended (*Figure 5*). A curb cut from James Street would channel runoff from the street into the filter and infiltration system. It is also proposed to convert five feet of sidewalk directly adjacent to the street to bioretention areas or rain gardens with native grasses and other plantings. Additional curb cuts would direct water into these bioretention areas, which would also serve to enhance the landscape around the school. These bioretention areas could be integrated into the curriculum as demonstration sites to supplement lessons on science and the environment, and, of the BMPs proposed, would likely offer the greatest opportunity for interactive lessons (planting, maintenance, etc.). For ease of implementation and consistency with the proposed James Street design concept, the City could choose to implement their standard 5 foot by 15 foot bioswale design along the sidewalk at this location (*Figure 6*). *Estimated Cost for Tree Box Filter: $9,000; Estimated Cost per Bioswale: $20,000*

- **Parking Lot Retrofits.** Subsurface infiltration and/or pervious pavement is proposed for the parking area (*Figure* 4, *Figure 6*) to manage stormwater falling on the parking area as well as roof runoff captured by the school's gutters and downspouts.

    - Based on available field data, using subsurface infiltration in the area adjacent to the turf play area would make it possible to intercept existing lines carrying downspout runoff and turf drainage without significantly reconfiguring these drainage systems (approximately 40,000sf of drainage area, and 3,200cf WQV). An 1,100sf practice underneath the six parking spaces adjacent to the turf field would potentially allow for treatment of up to 4,150cf WQV. The existing downgradient catch basin located in the school's driveway would serve as overflow to allow any excess water to be conveyed to the storm sewer in James Street, as is currently occurring. Note that site-specific soil drainage characteristics may allow for effective use of pervious pavement without additional subsurface infrastructure, for a significantly reduced project cost (although this would make it more difficult and costly to accept stormwater from roof and turf drains and would therefore likely result in treatment of a significantly lower percentage of total site runoff). *Estimated Cost: $108,000 (Subsurface infiltration); Estimated Cost: $5,000 (Pervious Pavement)*

- o To minimize costs, and to increase the variety of BMPs demonstrated on site, pervious pavement is proposed as the preferred option for the parking spaces parallel to James Street. Converting these spaces to pervious pavement would remove 2,500sf of pervious surface from the lot, and depending on the infiltration capacity of the soils and precise slope of the site, may be sufficient area to effectively infiltrate the roughly 800cf WQV of stormwater runoff expected from the entire 10,000sf main parking area, as the remainder of the surface slopes slightly to the west. *Estimated Cost: $10,000*

- **Management of Dumpster Area.** The school's dumpsters are located in the southeast corner of the parking lot, at the top of a slope which drains to James Street. Dumpsters should always be kept closed to minimize exposure to stormwater. For additional protection, a containment system consisting of spill containment grooves could be incorporated into the pavement to further prevent pollutants from being carried into the storm drainage system (*Figure 6*). *Estimated Cost: $0-$1,000*

Total Estimated Cost: Variable, depending on components installed.

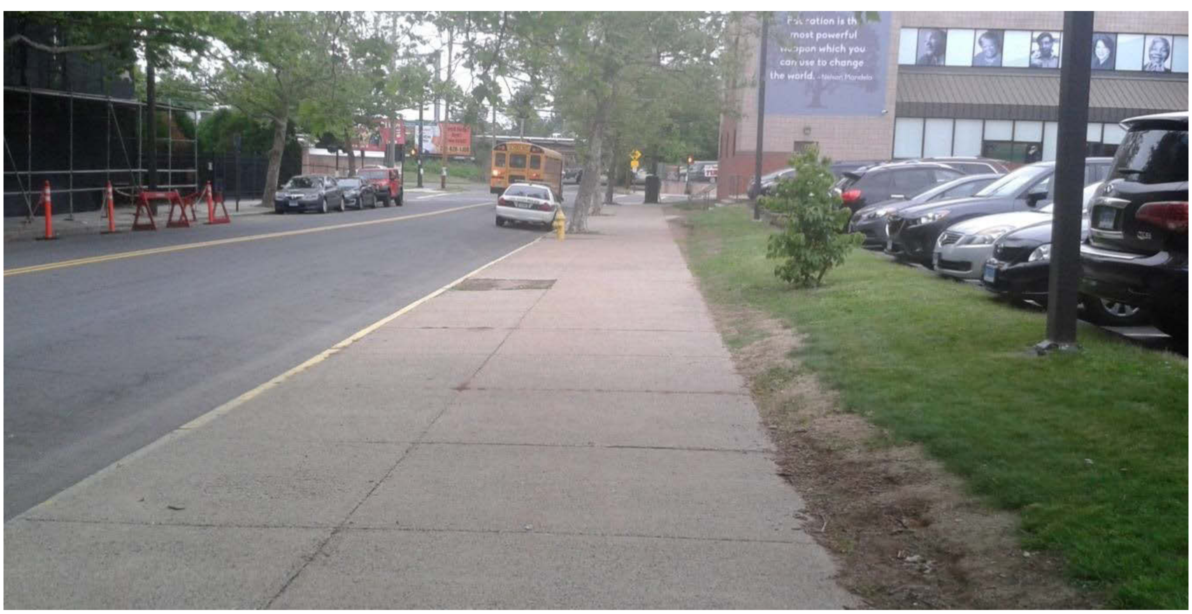

Figure 3 Sidewalk in front of Elm City College Preparatory Elementary School, with missing tree.

Figure 4. Parking lot at Elm City College Preparatory Elementary School.

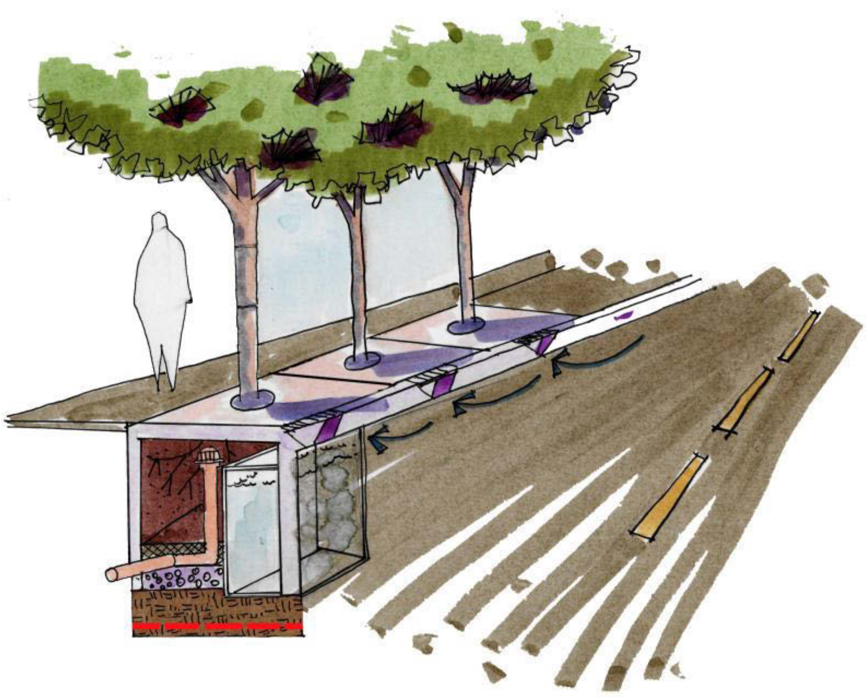

Figure 5. Schematic of a typical tree box filter with underground storage capacity.

Figure 6. Proposed green infrastructure retrofits for Elm City College Preparatory Elementary School. CB indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

James Street

James Street was identified as a potential demonstration site for a "green streets" approach to stormwater retrofits in the road right-of-way. The site is proposed to begin at Elm City College Preparatory Elementary School (at Lombard Street), and continue south to Chapel Street. This portion of James Street represents a typical residential street in the Fair Haven neighborhood (*Figure 7*), an underserved area of New Haven. The street is also within the area served by CSO #009. In addition to providing stormwater runoff reduction and pollution control benefits, the proposed retrofits for James Street would also provide green space in the neighborhood and yield aesthetic benefits for residents. Specific siting considerations along James Street include the feasibility of working around existing utilities while simultaneously selecting sites with sufficient catchment area to justify installation costs. Bioswales or bump-outs must also be sited appropriately relative to existing catch basin infrastructure (i.e., bioswales should be located 'downstream', ideally right before a catch basin) in order to maximize capture of stormwater and facilitate returning overflows to the existing drainage system.

- **Tree Box Filters.** Additional tree box filters of the type proposed for Elm City Preparatory School are proposed for various locations along James Street. Obvious sites are locations where street trees are missing; one such site exists on the east side of James Street, immediately south of the Elm City Preparatory School. *Estimated Cost: $9,000 per tree box filter*

- **Bump-Outs or Curbside Bioswales.** Two possible types of green infrastructure are proposed to provide bioretention along the length of James Street: bump-outs and curbside bioswales (*Figure 8*). Both are types of linear bioretention retrofit used alongside or within a public street, designed to collect and infiltrate/treat runoff from the adjacent roadway. These practices consist of a stone storage layer, a soil layer designed to filter runoff, plantings, and curb cuts to allow runoff to enter and exit the system. Both bioswales and bump-outs are sized to capture and treat/infiltrate the water quality volume.

    - Bioswales utilize space in the right of way, converting impervious area between the sidewalk and the street into bioretention. The City of New Haven is already installing bioswales throughout the downtown area and West River watershed, using a modified version of a bioswale design developed by New York City, which has a 5-foot by 15-foot footprint. At 75sf, this design can capture and treat approximately 276cf WQV. This is sufficient to capture the drainage from one side of an approximately 200ft stretch of road. *Figure 9* shows a typical bioswale that was installed in New Haven. As with bump-outs, bioswales would be designed to accept stormwater from the street, using curb-cuts as an inlet, with existing downgradient catch basins serving to receive excess water from the BMPs' overflows.

    - Bump-outs (*Figure 10*) would replace a portion of the existing road shoulder with bioretention areas, utilizing "No Standing" zones near intersections to intercept stormwater runoff from the road. Bump-outs serve a dual purpose as traffic calming features, which can make residential streets more friendly to pedestrians and bicycles.

Bump-outs and bioswales could be used in combination along the length of James Street, or a single practice type could be repeated for a more uniform design (*Figure 8*). Pervious pavement may again be a less expensive alternative option, but would offer far fewer aesthetic benefits to the neighborhood. Several specific locations along James Street were identified as potential sites for BMP implementation in the road right of way. In some instances, multiple potential addresses were noted in close proximity to one another (i.e., where drainage areas would overlap based on the 200 foot drainage area assumption). In these cases, the options should be evaluated during detailed site design to select the option with the least constraints or conflicts. Based on a preliminary assessment, locations shown in *Figure* 8 represent locations suitable for bioswales in the public right of way.

Two additional opportunities were identified along James Street for more extensive BMP installations:

- At the southeast corner of James Street and Market Street, there is a large green parcel adjacent to the Market and James Street Farms which is operated under the umbrella of New Haven Farms. The standardized BMPs described above could be implemented in the road right of way at this location; this site could also be proposed for a more extensive raingarden demonstration and education site.
- Raingardens could be implemented at the condominium complex at the northeast corner of James Street and Grand Avenue, particularly at the southwest and northwest corners of the complex, although existing trees may impose siting constraints. The catch basins in the approximately 8,500sf parking lot could also be converted to infiltrating catch basins, with overflows being returned to the stormdrain system via the existing infrastructure.

Estimated Cost: $20,000 per Bioswale or Bump-out (lower unit pricing may be available when multiple practices are installed together; see notes in Appendix C)

Total Estimated Cost Assuming 1 Tree Box Filter and 13 Bump-Out/Bioswale Practices: $263,000

Figure 7. Existing conditions along James Street, New Haven highlighting possible locations for bioretention practices in the right of way along James Street.

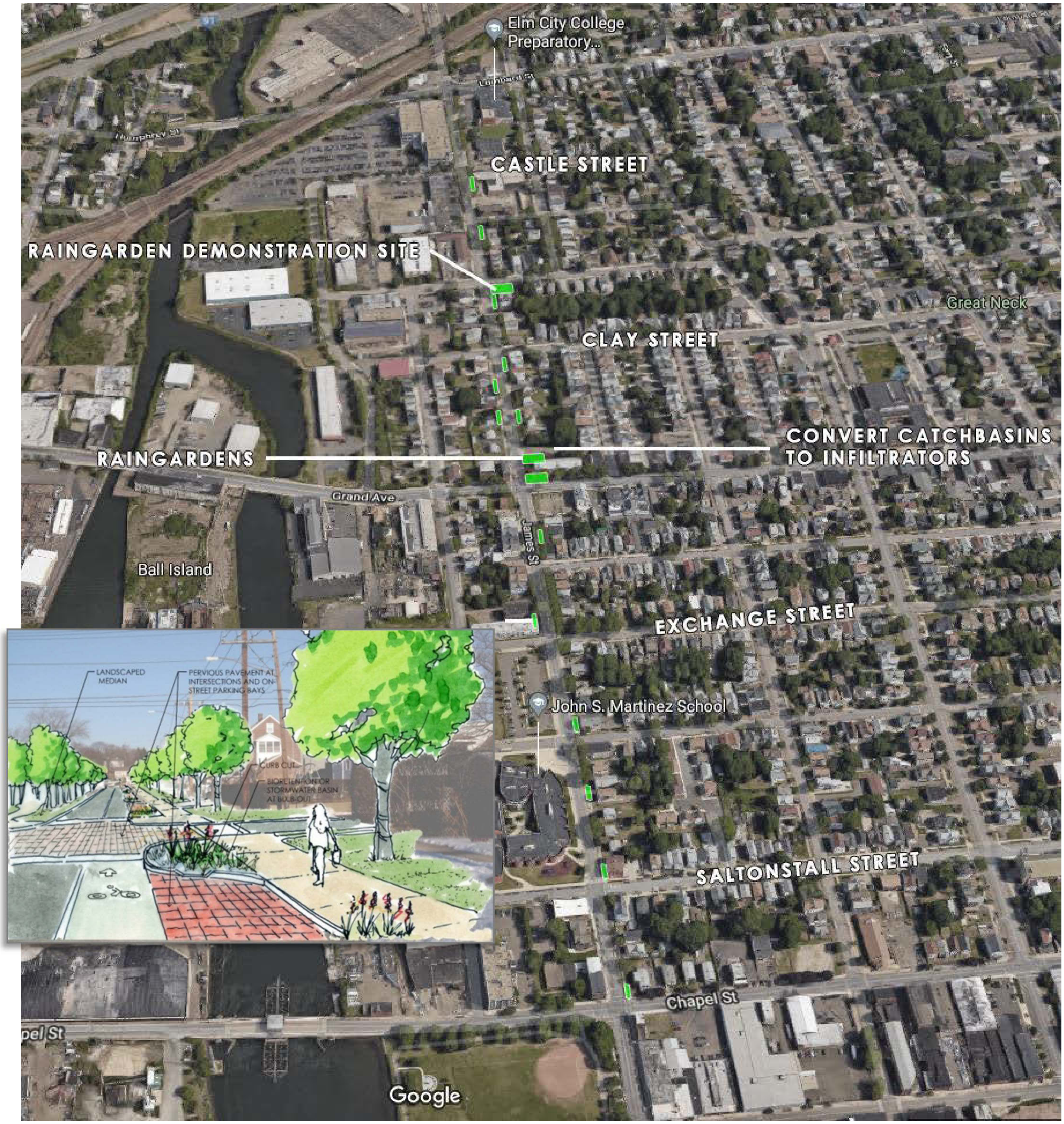

Figure 8. Proposed green infrastructure retrofits for the public right of way, community garden, and condos along James Street. Figure depicts the general concept design of repeating bioswales and/or bump-outs. Locations as marked represent the conceptual pattern, and are matched to suggested locations as much as possible given the scale, but do not necessarily match precisely to specific recommended sites . The inset image demonstrates a street-view rendering of the concept.

Figure 9. (above) Bioswale installed in the City of New Haven. Credit: Dawn Henning, City of New Haven Engineering

Figure 10. (left) Example Bump-Out bioretention planter installed by the City of New Haven on Clinton Avenue. Credit: Dawn Henning, City of New Haven Engineering.

John S. Martinez School Grounds and Exchange Street

The Martinez School building is located on James Street, in the block south of Wolcott Street, while the parking lot and athletic fields for the school are located in the block immediately north of the school, between Wolcott Street and Exchange Street. Like the previous two sites, the Martinez School and surroundings are in the area served by CSO #009. Stormwater designs for the school and parking area median have previously been developed[4], but the design proposed here focuses on the north end of the property, where the school grounds abut a proposed, future section of Mill River Trail and a mix of residential and industrial land uses to the north.

West of Haven Street, Exchange Street has been blocked off with several large boulders to prevent vehicle traffic from entering (*Figure 11*); this section of the roadway is proposed to become part of the Mill River Trail. At present, the pavement in this section is in disrepair and there is no drainage infrastructure located along this stretch of Exchange Street. Trash and water currently collect at the far west end of Exchange Street where the road terminates into a chain link fence with concrete barriers/wall beyond.

- **Trash Clean-up.** The first step to any improvement at this site should be the engagement of community volunteers in removal of trash and debris located at the west edge of the site. This opportunity could also be used to grow interest in the site and discuss further improvement options with local residents and potential project partners.

- **Pavement Removal.** Removal of pavement from the portion of Exchange Street west of Haven Street and permanent closure of the road would result in a nearly 9,000 square foot reduction of impervious surface, thereby reducing surface runoff and creating space for natural infiltration. Assuming pavement is not contaminated beyond typical road surface pollutants (e.g., petroleum products), this project could be conducted in partnership with the City of New Haven as a stand-alone action at relatively minimal expense.

- **Integrated Stormwater Treatment and Trail Improvements.** Once pavement is removed, bioretention areas and trail improvements are proposed to create an aesthetically pleasing entrance point for a future segment of the Mill River trail. A series of bioretention areas/rain gardens (*Figure 12*) with native plantings would be braided together with the trail, creating an urban oasis at the edge of the Martinez school athletic fields (*Figure 13*). Existing storm drainage from the northern edge of the school parking lot and the catch basin at the northeast corner of Exchange Street and Haven Street could be redirected to the bioretention cells. Overland sheet flow from the athletic fields would also be captured and treated. While water would be accepted along the east-west length of the system, water entering the up-gradient bioretention cells to the east would overflow into down-gradient cells further west in step-wise fashion. Preliminary information suggests that the system can be sized to accommodate typical precipitation events. Excess stormwater during extreme events could be allowed to flow overland, as is currently the case at the

[4] Save the Sound, Connecticut Fund for the Environment (2012). Green Infrastructure Feasibility Scan for Bridgeport and New Haven, CT.

site, or could potentially bedirected back into the existing storm drain system. *Estimated Cost: $90,000*

Figure 9. Existing conditions at the intersection of Exchange Street and Haven Street, New Haven.

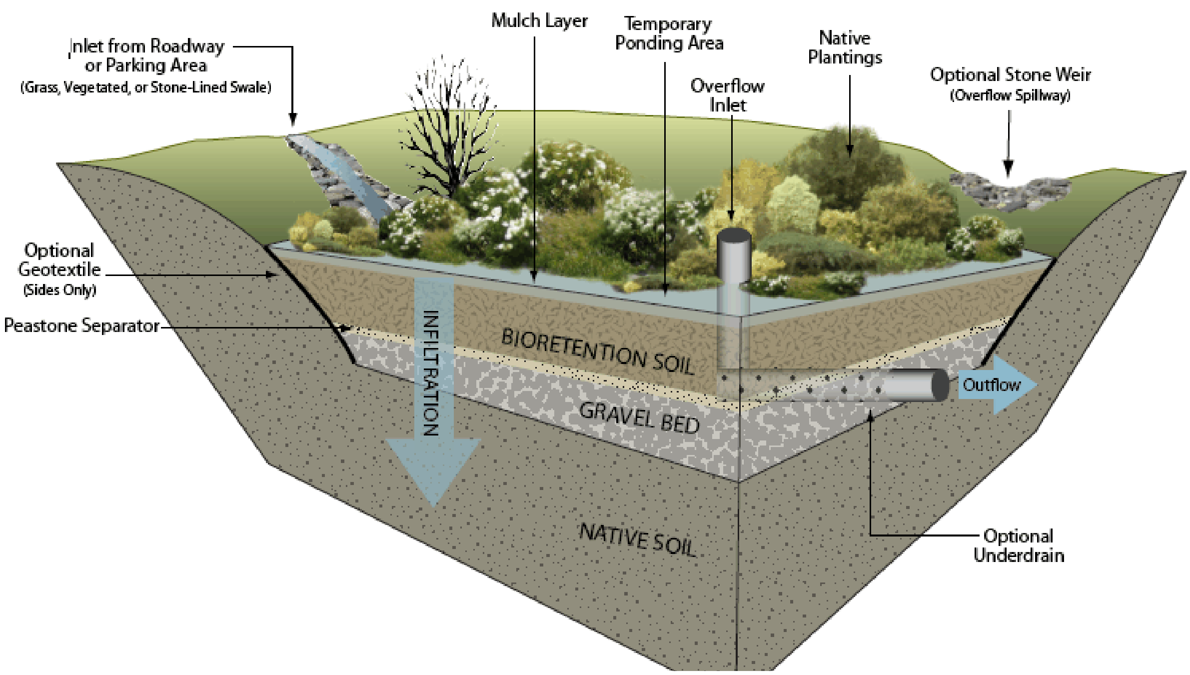

Figure 10. Bioretention schematic.

Figure 11. Proposed green infrastructure retrofits for the John S. Martinez School Grounds, Exchange Street, and Mill River Trail Site.

Wilbur Cross High School

Wilbur Cross High School is located in the East Rock neighborhood of New Haven, immediately west of the Mill River. Not including athletic facilities, the school and parking cover nearly 10 acres in the Lower Mill River subwatershed. The school lies immediately northwest of CSO #012, but the school building and parking areas addressed here are outside of the CSO area. The proposed concept design focuses on the approximately 2-acre parking lot on the southeast side of the site, along with drainage from the main portion of the high school building. It is likely that the proposed design would also intercept surface flow from the adjacent tennis courts further to the east.

The existing parking lot features extra-long, numbered bus parking spaces along the northeast and east perimeters of the lot. The parking layout maximizes available locations for bus parking, but in doing so, the layout creates two large dead spaces where parking is prohibited (*Figure 14*), both of which are located in the northeast corner of the lot. Each of these locations coincides with the location of existing catch basins. A double catch basin in the corner of the lot is the most downgradient collection point and outfalls directly to the Mill River approximately 10 feet below the parking lot grade. Roof drainage from the east side of the building appears to be connected into the drainage system at the catch basin located in the middle of the eastern edge of the parking lot.

- **Parking Lot Bioretention**. Proposed retrofits include the removal of pavement from the two 'dead spaces' (approximately 830sf and 870sf) in the northeast corner of the lot and conversion to bioretention to accept surface flows across the parking lot. Of the 6,900cf WQV anticipated from the approximately 87,000sf parking lot, the two bioretention areas would treat up to up to 6,200cf (90%) of WQV (*Figure 15*).
  Estimated Cost: $79,000

- **Subsurface Infiltration.** An additional 900sf of subsurface infiltration along the eastern edge of the lot would utilize the existing mid-lot catch basin as an inlet to intercept roof drainage from the approximately 44,000sf of building footprint, infiltrating up to 3,400cf WQV out of the approximately 3,500cf WQV expected . The next catch basin downgradient would serve as an outlet to channel excess water back into the drainage system, and the existing double catch basin would serve as an overflow outlet to the Mill River for the entire retrofit system.
  Estimated Cost: $89,000

Total Estimated Cost: $168,000

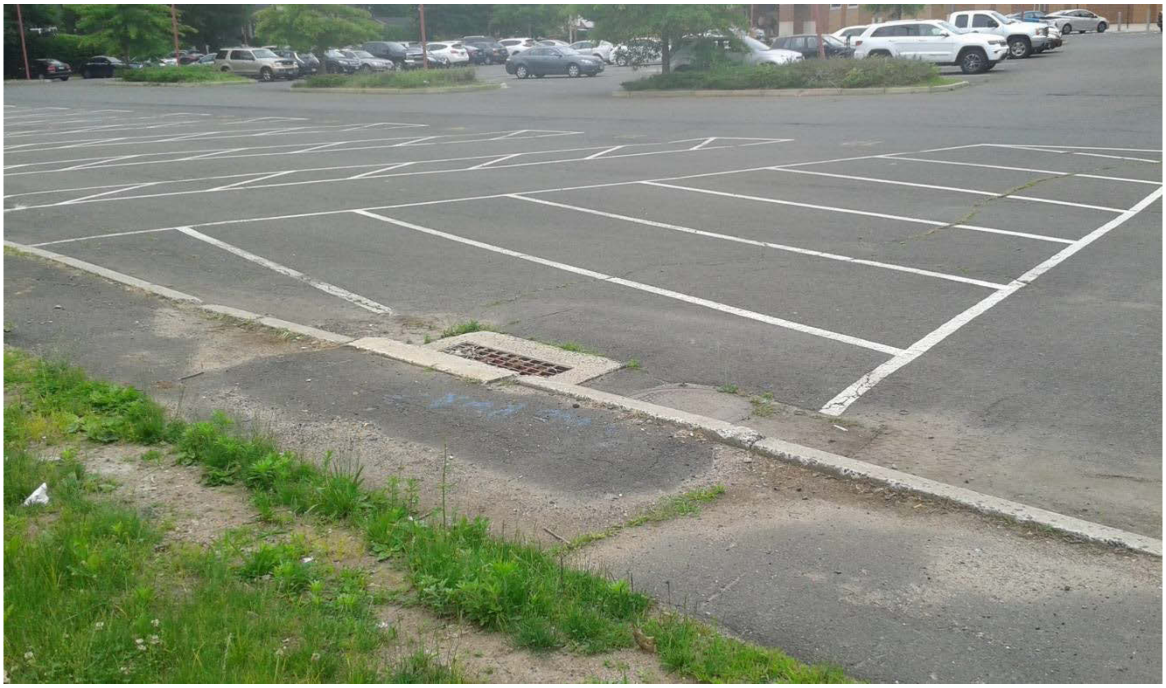

Figure 12. One of the two 'dead spaces' where parking is prohibited amidst bus parking spaces at the Wilbur Cross High School parking lot.

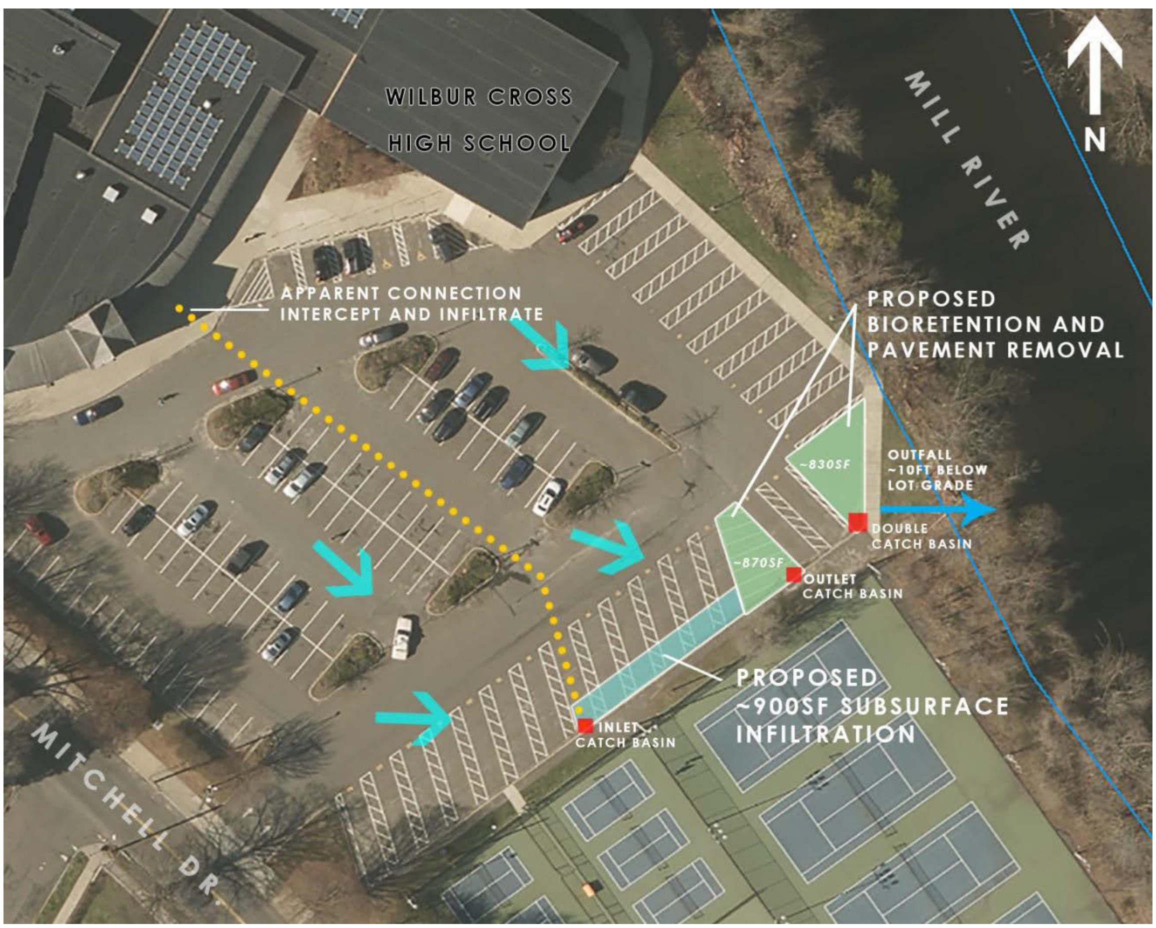

Figure 13. Proposed green infrastructure retrofits for Wilbur Cross High School. Red squares indicate existing catch basins. Blue arrows indicate existing surface flow patterns.

Livingston Street at East Rock Road

East Rock Park begins just south of Lake Whitney and follows the Mill River for over 1.5 miles. On the east side of the river, the park provides a buffer for the river that is generally wooded and at least 0.2 miles wide. On the west side of the river, the park is much narrower and less heavily wooded; the proposed concept design focuses on this side of the park, particularly the borders of the park that follow Livingston Street and East Rock Road.

An existing walking trail follows the park edge along Livingston Street (*Figure 16*). Scattered catch basins along Livingston Street intercept flow from the street and carry it north toward East Rock Road. At East Rock Road, storm drains from Livingston Street join with the storm drain under East Rock Road and carry runoff east to the Mill River. The outfall for this system is located north of the East Rock Road bridge.

While the park occupies the land east of Livingston Street, the west side of the street is residential. Many downspouts appear to be connected to the drainage system, though others were disconnected.

- **Vegetated Infiltration Swale.** A short wooden fence runs along the east side of Livingston Street beginning at the intersection with Cold Spring Street and following the road northward for approximately 850 feet. A vegetated swale is proposed to promote infiltration along this stretch of Livingston, using curb cuts spaced along the swale to accept approximately 1,200cf WQV of stormwater from approximately 15,000sf of drainage area consisting of the northbound lane of Livingston Street. *Estimated Cost: $61,000*

- **Bioretention Landscaping and Trail Enhancement.** A storm drain in the center of the intersection of Livingston Street and East Rock Road currently accepts stormwater flows from all four corners of the intersection, as well as flows from further west on East Rock Road. Two raingardens/bioretention areas are proposed to accept stormwater from Livingston Street, East Rock Road, and East Rock Park Road via curbcuts located just upgradient of the existing catch basins.
    - One raingarden/bioretention area would be located on the northwest corner of the intersection (with approximate area of 250sf and capacity to capture and treat approximately 900cf WQV). The northwest raingarden/ bioretention area would serve a drainage area of approximately 10,000sf (800cf WQV), consisting of the north side of East Rock Road between Livingston Street and Everit Street, as well as a portion of the south side of East Rock Park Road. The BMP is proposed with an overflow structure that would carry excess stormwater back to one of the existing catch basins.
    - A second raingraden/ bioretention area on the southeast corner of the intersection (with approximate area of 300sf and capacity to capture and treat approximately 1,100cf WQV) would be located in existing open green space among trees to minimize root and tree impacts (*Figure 18*). Stormwater would enter the BMP from a curbcut located just south of the existing fire hydrant and upgradient of the existing catch basin

on the east side of Livingston Road. The BMP would capture stormwater from the east side of Livingston Street from the mid-block catch basin to the curb cut, an area of approximately 14,000sf (1,100cf WQV). In order to preserve the existing trail, an ADA compliant boardwalk feature would allow pedestrians to connect from the corner sidewalk to the existing walking trail in the park, crossing over the raingarden/bioretention area (*Figure 17*). Additional interpretive signage would be added to the existing park sign already in place at the southeast corner of Livingston Street and East Rock Road to enable the stormwater features to serve as an education and outreach site. The raingarden/bioretention area is proposed to contain an overflow structure that allows excess stormwater to sheetflow across vegetated land to the south and east.

- *Estimated Cost: $31,000 (consisting of $26,000 for bioretention areas and* $5,000 for trail enhancement)

Figure 14. Existing conditions at Livingston Street (foreground) and East Rock Road, showing open space where bioretention is proposed and the existing walking trail.

Figure 17. Proposed bioretention area and trail improvements in East Rock Park.


N
BIORETENTION/ RAINGARDENS
CURB CUTS
OUTLET TO EXISTING CATCH BASINS
PROPOSED ACCESSIBLE BOARDWALK
FIRE HYDRANT
LIVINGSTON STREET
EVERIT STREET
EXISTING TRAIL
MILL RIVER
CB
VEGETATED SWALE
CURB CUT
CURB CUT
CB
COLD SPRING STREET
ORANGE STREET

Figure 18. Proposed green infrastructure retrofits for Livingston Street at East Rock Road. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

YNHH Outpatient Services

The Yale New Haven Health System (YNHH) Outpatient Services facility is located on Sherman Avenue in Hamden, CT, on an approximately 2-acre site. Shepard Brook runs along the northeast edge of the property, and drainage from the site enters the brook approximately 2 miles upstream of its confluence with the Mill River.

The site is largely covered by impervious surfaces, including approximately 28,000sf of parking lot space spread between two lots, an approximately 8,000sf building footprint , and an additional 7,500sf of paved driveway. Most of the remaining space within the parcel is occupied by maintained lawn. Trees border the north and south edges of the site, forming a buffer with adjacent parcels. A few large trees line the west edge of the parcel, along Sherman Avenue. A parking lot island in the rear lot features mature trees and shrubs as well and provides some shade on the site. This island could potentially be converted to bioretention, however existing trees, sidewalks, and underground electrical located in the island would pose conflicts for such a conversion.

A series of catch basins are connected in the parking lot and carry stormwater away from Sherman Avenue and toward Shepard Brook. Downspouts from the YNHH Outpatient facility are also connected to this storm drain system. The most downgradient catch basin was clogged with silt and debris during the field visit, indicating high sediment loads. Pooling in the vegetated area east of the site suggests a possible high water table, which may be contributing to pooling in the vicinity of the downgradient catch basin. Because of this, proposed BMPs are focused higher in the landscape, to ensure successful infiltration of stormwater.

- **Parking Lot Retrofits.** Approximately 5,000sf of pervious pavement is proposed for the 23,000sf rear parking area, focusing on the spaces in the center of the parking lot, where stormwater runoff could be infiltrated before reaching the most downgradient catch basin in the northeast corner of the site (*Figure 19*). In addition to reducing impervious area on this portion of the site by approximately 20%, the pervious pavement will also accept stormwater flows from more westerly sections of the parking lot, as water flows to the northeast across the site. *Estimated Cost: $20,000*

- **Front Lawn Retrofits.** The approximately 5,000sf front parking lot slopes toward the front lawn area, between Sherman Avenue and the front parking lot. This lawn area also appears to receive stormwater flows from an approximately 3,000sf area consisting of the northbound travel lane of Sherman Avenue as it approaches the driveway from the south, and the front portion of the YNHH driveway. This yields a total WQV for this portion of the site of approximately 630cf. An approximately 200sf bioretention area (with approximate treatment capacity of 735cf WQV) is proposed for the bumpout portion of the front lawn, with curb cuts allowing stormwater to enter from both the parking area and the driveway. *Estimated Cost: $10,000*

- **Main Lawn Retrofits.** Approximately 600 sf of distributed bioretention/rain garden area is proposed for the main lawn. Approximately 400sf of linear bioretention (approximately 5 feet wide by 80 feet long) is proposed along the north edge of the lawn to capture stormwater from the approximately 4,500sf of driveway area between the two parking lots. An additional triangular raingarden/bioretention feature of approximately 200 sf is proposed for the area adjacent to the sidewalk leading from the rear parking lot to the building. Downspouts from the north side of the 8,000sf building would be disconnected from the storm drain system and redirected to this area. Developing the bioretention area as a rain garden would provide a landscape feature on the site, and could be supplemented with interpretative signage for public education and outreach. This area could potentially be utilized as an outdoor gathering space, either for patients waiting for appointments or for staff on break. Lower maintenance bioretention designs are equally feasible on the site, and would require only periodic cleaning in addition to mowing, which is already occurring at the proposed location (*Figure 19*). *Estimated Cost: $28,000*

Total Estimated Cost: $58,000

Figure 15. Proposed green infrastructure retrofits for YNHH Outpatient Services Facility. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Whitney High School North/West

Area Cooperative Educational Services (ACES) operates two special education programs out of its Whitney High School North and West campuses, located immediately west of the Mill River on Skiff Street in New Haven. The Whitney North/West campus is an approximately 5-acre site, which is nearly 100% impervious. Three buildings are located on the site, which slopes from Skiff Street down toward the south end of the site and also east toward the Mill River. Parking is terraced, creating three separate tiers along the north/south gradient (*Figure 20*).

Existing east-west oriented parking islands separate the tiers; these islands are narrow and steeply sloped, making them unlikely candidates for green infrastructure practices. Existing curb cuts at the ends of these islands carry water from one tier down to the next, with stormwater eventually flowing to catch basins along the southern edges of the parking areas. Downgradient catch basins are assumed to outfall directly to the Mill River, on the far side of a chain-link fence which follows the eastern edge of the parcel.

The southeast corner of the site, adjacent to the Staff Development Building, currently contains a raised bed garden area, picnic table, and composter. A gravel swale appears to carry excess stormwater from a low point in that area to the south edge of the site and toward the Mill River.

- **Parking Lot Retrofits and Bioretention.** A combination of subsurface infiltration, pervious pavement, and bioretention is proposed to reduce stormwater runoff from the extensive parking areas on the site and provide a variety of green infrastructure demonstration sites for curricular value.

    - Approximately 14,500sf of pervious pavement is proposed in the front parking lot and upper and middle tier parking areas of the main lot to reduce impervious cover on the site and infiltrate runoff from the upper two tiers of parking. *Estimated Cost: $58,000*

    - Approximately 500sf of subsurface infiltration is proposed to be located behind the Staff Development Building, intercepting flow from the existing catch basins at the low end of the parking lot, infiltrating approximately 1,800cf WQV, and returning excess stormwater to the existing drainage system at the east end of the practice (*Figure 21*). This practice would be designed to capture drainage from an approximately 20,000sf area including the parking area surrounding the Staff Development Building and redirected drainage from the building (approximately 1,600cf of WQV). *Estimated Cost: $47,000*

    - Approximately 800sf of bioretention is proposed in the southeast-most corner of the parking lot, requiring the removal of two parking spaces (*Figure 22*). Existing catch basins in this location would be raised to serve as overflow structures. A sediment forebay is proposed for the first bioretention cell (to be located in the existing parking area) in order to minimize required maintenance of the downgradient bioretention area. From the sediment forebay, water would flow to a landscape feature that winds through the existing picnic/garden area, avoiding existing trees, and connecting to the existing gravel swale (*Figure 23*). The bioretention area would accept water flowing down the campus driveway, as well as flow from the lower tier parking area, including any overflow from the upper tiers (approximately 1 acre of drainage area or 3,500cf of WQV). The bioretention system would be designed to capture approximately 3,000cf WQV. Building on existing uses in this area which appear to emphasize environmentally-friendly practices (e.g., composting, raised bed gardening), the bioretention system could provide educational opportunities for students and staff in the form of signage and/or curricular connections. *Estimated Cost: $38,000*

Total Estimated Cost: $143,000

Figure 16. Tiered parking, with existing conveyances that transport stormwater from the upper tiers to lower tiers.

Figure 17. Proposed location for subsurface infiltration behind the Staff Development Building. The downgradient catch basin (near the dumpster) would serve as an overflow for the system and outfalls to the Mill River.

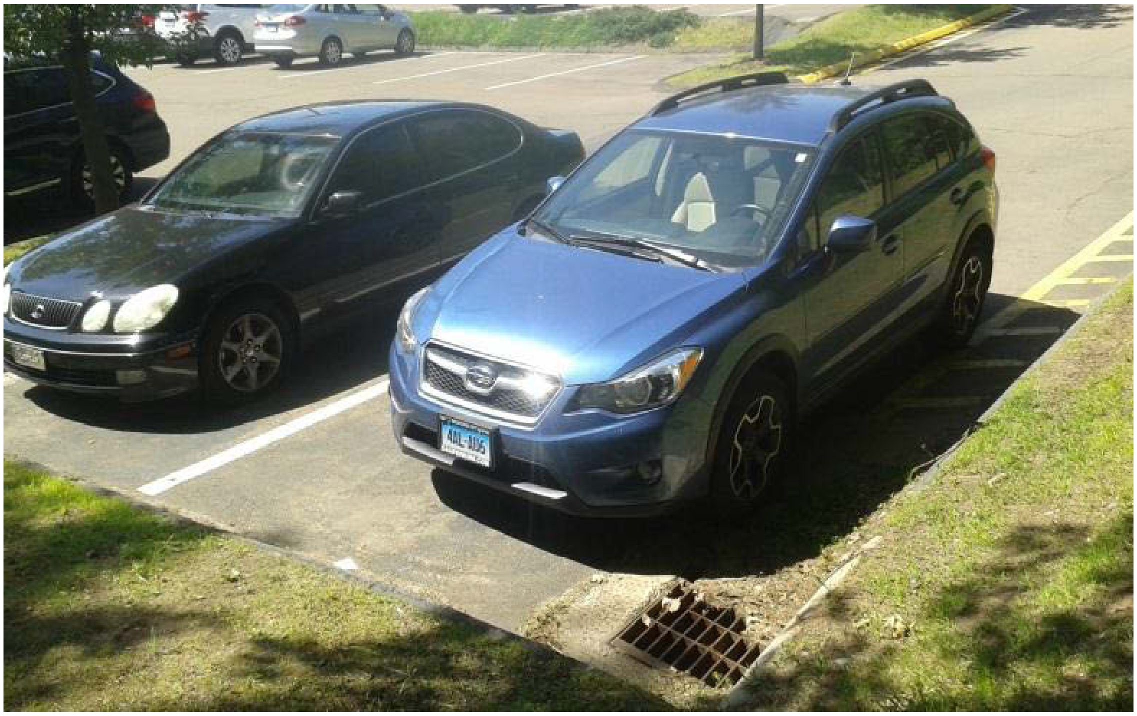

Figure 18. Proposed location of sediment forebay (top) and bioretention areas (bottom).

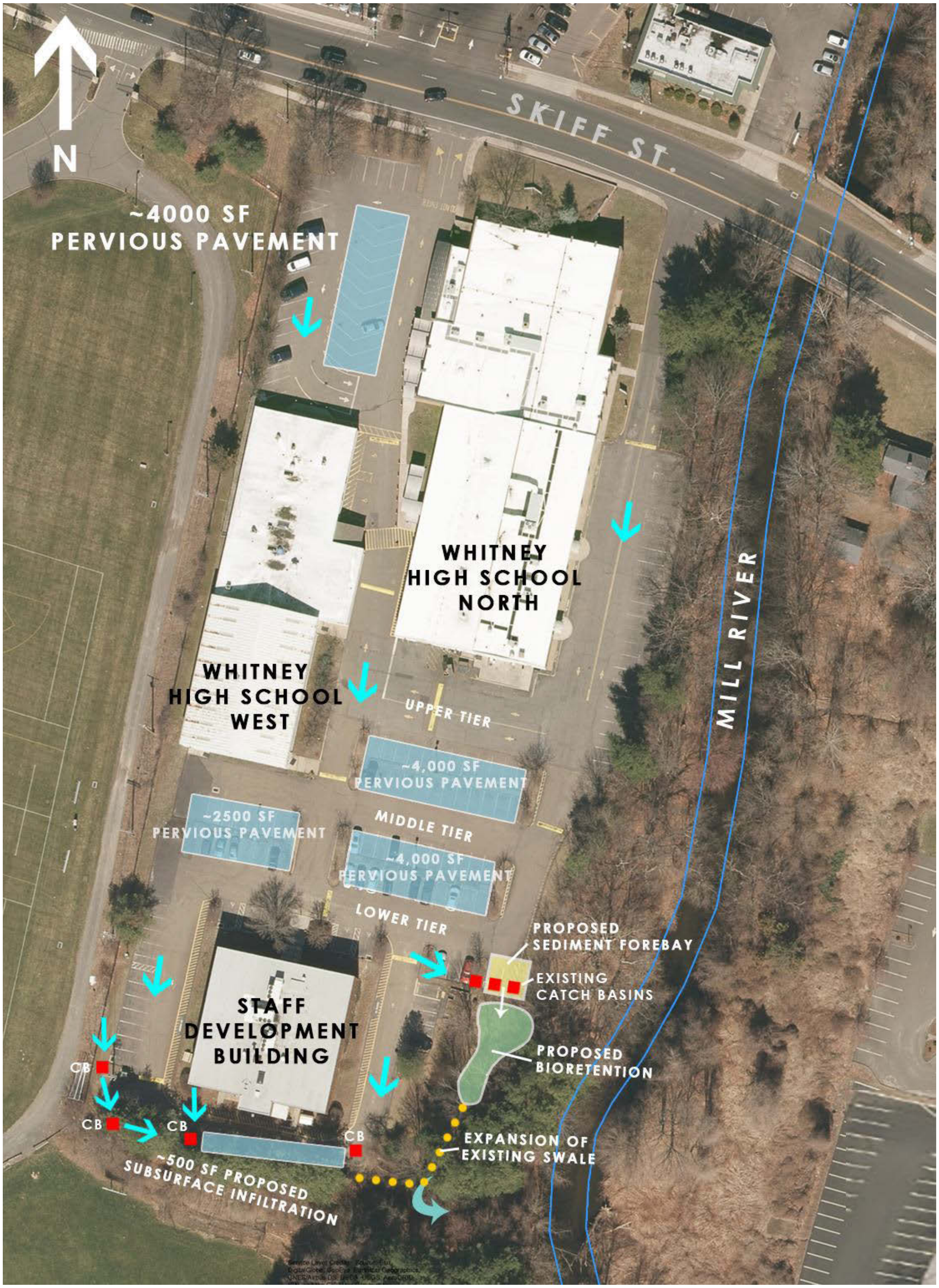

Figure 19. Proposed green infrastructure retrofits for Whitney High School North/West. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road

Counter Weight Brewery is located along the south side of Raccio Park Road, within approximately 500 feet of Shepard Brook. The building and lot occupy approximately 1-acre (*Figure 24, Figure 25*), with the adjacent portion of Raccio Park Road and circular turnaround adding 0.25-acres of additional drainage area. The parcel between the brewery and Shepard Brook is occupied by Spring Glen Nursery.

The roof drains on the brewery building are currently connected to the storm drainage system. A series of five catch basins in the circle and along the eastern and southern edges of the property transport stormwater away from the site, presumably to an outfall on Shepard Brook. Note that while most of this site is mapped as B soils (good infiltration), the southern edge of the site is indicated to be D soils, so additional soil testing will be especially necessary at this site in order to more precisely determine the infiltration capacity of the soils.

Existing parking lots are in poor condition, and catch basins on site were clogged with silt and debris. Existing vegetated areas and parking islands on the brewery property do not appear to receive regular maintenance, whereas planting areas on the nursery property were obviously receiving regular care.

- **Bioretention Area/Rain Gardens.** A series of bioretention areas/rain gardens are proposed for the site:
  - A series of three distributed bioretention areas/raingardens are proposed within Counter Weight Brewery's parking area. A 150sf bioretention area/rain garden is proposed in the existing island bumpout at the northeast edge of the front parking lot; this practice would accommodate capture of approximately 550cf of WQV and would accept stormwater flows from a portion of the 7,500sf front parking lot (with associated 600cf of WQV). A second 100sf bioretention area is proposed in the existing island bump-out at the southeast edge of the front parking lot; this practice would accommodate approximately 370cf of WQV. In addition to accepting surface runoff from the front parking lot, this practice could potentially receive flow from redirected roof leaders. A third 75sf bioretention area/rain garden is proposed for the existing vegetated bumpout at the southeast corner of the building. This practice could accommodate approximately 275cf of WQV and would be designed to accept flow from redirected roof leaders, with a potential roof catchment area of approximately 4,500sf (354cf of WQV). Overflow from this bioretention area would be directed overland toward the existing catch basin and proposed pervious pavement (see below). *Estimated Cost: $16,000 (assuming all three areas); costs for individual practices range from $4,000 to $7,000*
  - A 200sf linear bioretention area along the southern edge of Raccio Park Road would accept stormwater runoff from the road via a curb cut on the western end of the feature (*Figure 26*), with the potential to capture and treat approximately 735cf of WQV. To increase the drainage area, the upgradient catch basin west of the practice should be closed off; this would direct approximately 5,500sf of drainage area to the practice (with corresponding 435cf of WQV). While the green space between the brewery and nursery driveways and the bumpout areas mentioned

above are maintained with plantings (*Figure 24*), the existing green space between the road and the main brewery parking lot is unmaintained, so this feature could be designed either with landscape enhancement or minimal maintenance as the primary goal. The bioretention area would overflow to the existing downgradient catch basin adjacent to the Counter Weight Brewery driveway. *Estimated Cost: $10,000*

Figure 20. Existing conditions at Counter Weight Brewery, looking toward the brewery building from the circle on Raccio Park Road.

- **Parking Lot Retrofits.** Approximately 2,000sf of pervious pavement is proposed along the eastern edge of the parking lot to reduce impervious cover and intercept additional surface flows to the two existing catch basins at the edge of the lot. Approximately 28,000sf of impervious area drains toward this section of the parking lot, with corresponding 2,217cf WQV. The 7,500sf front parking area could also be converted to pervious pavement in the future if the lot is repaved. *Estimated Cost: $8,000 (assuming 2,000sf); an additional $30,000 would be required to convert the entire front lot to pervious pavement*

- **Maintain Existing Catch basins.** Some of the catch basins at the site were observed to be clogged with silt and other debris. Periodic clearing of this debris will maintain proper functioning of the existing system, decrease pollutant loads to the storm drain system, and reduce ponding in adjacent impervious areas. *Estimated Cost: minimal; use existing brewery staff labor or volunteers*

Total Estimated Cost: $34,000 ($64,000 including conversion of front lot to pervious pavement)

Figure 21. Existing conditions at Counter Weight Brewery, showing clogged catch basin (left) and degraded asphalt parking lot (right).

Figure 22. Proposed green infrastructure retrofits for Counter Weight Brewery and Raccio Park Road. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Bartlem Recreation Area

This large municipal park is located on CT 10 (South Main Street) in Cheshire, directly across from Cheshire High School. The site is owned by the Town of Cheshire and includes lacrosse, baseball, and soccer fields, as well as a covered swimming facility and multiple parking areas. Most of the stormwater from the site drains to an approximately 36-inch outfall at the southern end of the property. These parking areas and structures comprise approximately 5-acres of directly connected impervious cover on the site. An additional 1.75-acres of maintained athletic field area likely contributes surface flows to the storm sewer system during heavy rains.

Existing catch basins are located behind the swimming pool and appear to capture overflows from the pool decks as well as stormwater runoff. Additional catch basins are located in the northern parking lot, on either side of the driveway, and in the lawn between the baseball field and swimming pool parking lot *(Figure 27*). The catch basin located at the southwest corner of the swimming pool parking lot appears to be the most downgradient catch basin before stormwater outfalls into the Mill River. An existing gravel swale carries additional overland runoff from the baseball diamond, along the south edge of the ball field, into a catch basin located in the grass adjacent to the parking lot, and ultimately through the parking lot catch basin to the outfall.

- **Linear Bioretention**. An existing short fence runs along the north edge of the baseball field, creating a lawn area approximately 15 feet wide between the fence and the curbed driveway of the recreation area (*Figure 28*). This space is currently utilized for event parking. Approximately 300sf of linear bioretention is proposed toward the east end of this space to treat stormwater runoff from the driveway while preserving as much parking as possible (*Figure 29*). A curb cut will allow stormwater to flow from the road (approximately 14,000sf of drainage area, with 1,100cf WQV) into the proposed bioretention before reaching the existing catch basin. As the landscape slopes slightly to the east, check dams are proposed as part of the design to slow the movement of water through the bioretention feature. The bioretention area can be designed to overflow either to the existing catch basin or the proposed water quality swale (below). *Estimated Cost: $14,000*

- **Vegetated Water Quality Swale.** A second linear feature (2,500sf) is proposed between the baseball field and the swimming pool parking lot, on top of the existing storm drainage pipes. Existing catch basins would be raised to serve as overflow structures during heavy rains, and a vegetated swale is proposed along the length of the parking lot to infiltrate surface runoff from the 44,000sf of uncurbed parking lot (with accompanying 3,500cf of WQV) and adjacent ball field (expected to generate, at minimum, an additional 350cf or more of WQV) (*Figure 29*). Effectiveness of the swale could be further enhanced by re-grading the parking lot whenever it is next repaved to encourage stormwater to flow toward the swale. Drainage from the pool roof could potentially be directed toward the swale as well, although it was not clear from the site visit how pool roof drainage is currently handled. *Estimated cost: $36,000*

- **Pervious Pavement.** 15,000sf of pervious pavement is proposed for the middle two rows of parking in the north parking lot. This conversion to pervious pavement would reduce the impervious surface of the 50,000sf lot by nearly 30% and decrease the volume of stormwater inputs to the existing drainage system. *Estimated Cost: $60,000*

Figure 23. Existing catch basins at the edge of the swimming pool parking lot at Bartlem Recreation Area. The space between the parking lot and ball field is proposed for conversion to a vegetated swale.

Figure 24. Roadside area proposed for linear bioretention.

- **Bioretention/Rain Garden.** A bioretention area/rain garden and native planting area of up to 1,500sf is proposed for the lawn area between the circular drive in front of the swimming pool and the swimming pool parking lot. A curb cut in the circle would allow stormwater to flow into the rain garden, with the existing catch basin serving as an overflow to direct excess stormwater back into the drainage system. A 300sf bioretention area is proposed to capture and treat runoff from the approximately

12,000sf of impervious drainage area (approximately 950cf of WQV) that would connect to the BMP via the proposed curb cut in the circle. Remaining area in this planting island should be converted to native plantings. Due to its location near the pool entrance, this would likely be the most visible location at which to include educational information about the full suite of proposed green infrastructure components suggested for the site. *Estimated Cost: $14,000 (assuming 300sf of bioretention; additional funds (or plant donations) may be required for native plantings to fill the entire island)*

Total Estimated Cost: $124,000

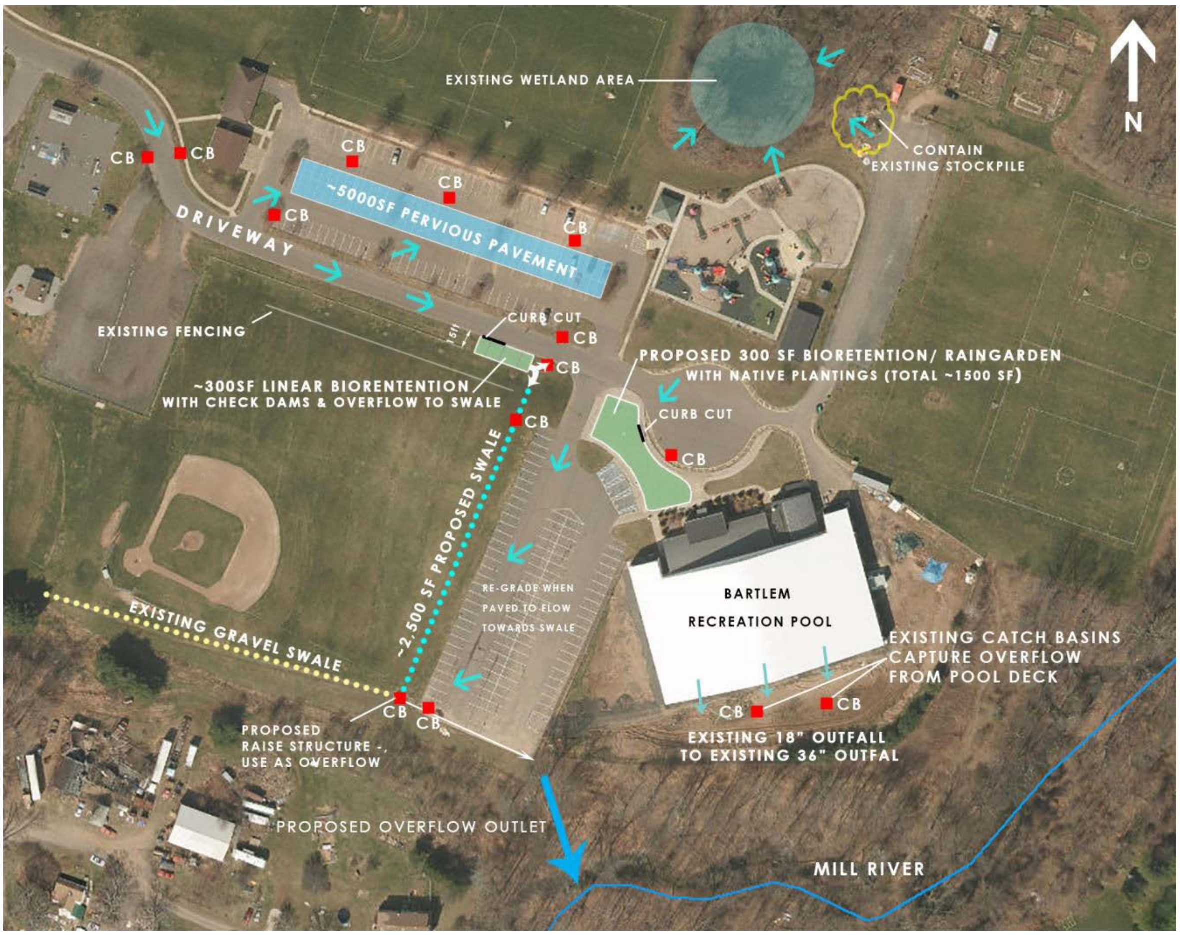

Figure 25. Proposed green infrastructure retrofits for Bartlem Recreation Area. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Strathmore Drive

Strathmore Drive is located in a residential subdivision in Cheshire that lies just east of the Mill River, across the river from the Bartlem Recreation Area and south of Wallingford Road. An unnamed tributary of the Mill River winds through the neighborhood.

Green spaces were required to be created during the development of the subdivision. Two such sites are located on Strathmore Drive, between the two ends of Buttonwood Circle. A playground occupies the green space to the west side of Strathmore Drive; on the east side of the street, the existing green space consists of a semi-circular lawn area bordered by bermed planting areas that include mature evergreen trees and shrubs (*Figure 30*). Beyond the berms is another area of lawn that backs up to residential lawns from homes on Buttonwood Circle. To the southeast, this area meets up with a wooded buffer through which the unnamed tributary stream passes through the neighborhood. The area, including the lawn and bermed planting areas, is currently maintained by the Homeowner's Association via a landscaping contractor.

- **Public Green Space Retrofit.** Although located adjacent to a high point on Strathmore Drive, the semi-circular lawn forms a natural bowl in the landscape, and could be converted to an approximately 500sf bioretention area to collect and infiltrate runoff from approximately 11,000sf of catchment area on Strathmore Drive and portions of Buttonwood Circle (with corresponding 900cf of WQV) (*Figure 31*). Water could be redirected from catch basins on Strathmore Drive that are located at each end of the green space and directed into the bioretention area to either infiltrate or ultimately be released back into the tributary stream via an overflow swale. More detailed site survey is necessary to confirm feasibility, but available contour/elevation data indicates between a 5% and 8% slope from the catch basin locations to the depression/proposed bioretention area. It may also be possible to direct roof leaders from houses that back up to the green space into the bioretention area. If desired, the bioretention area could be designed as a rain garden to enhance the existing landscape features of this space. *Estimated Cost: $24,000*

Total Estimated Cost: $24,000

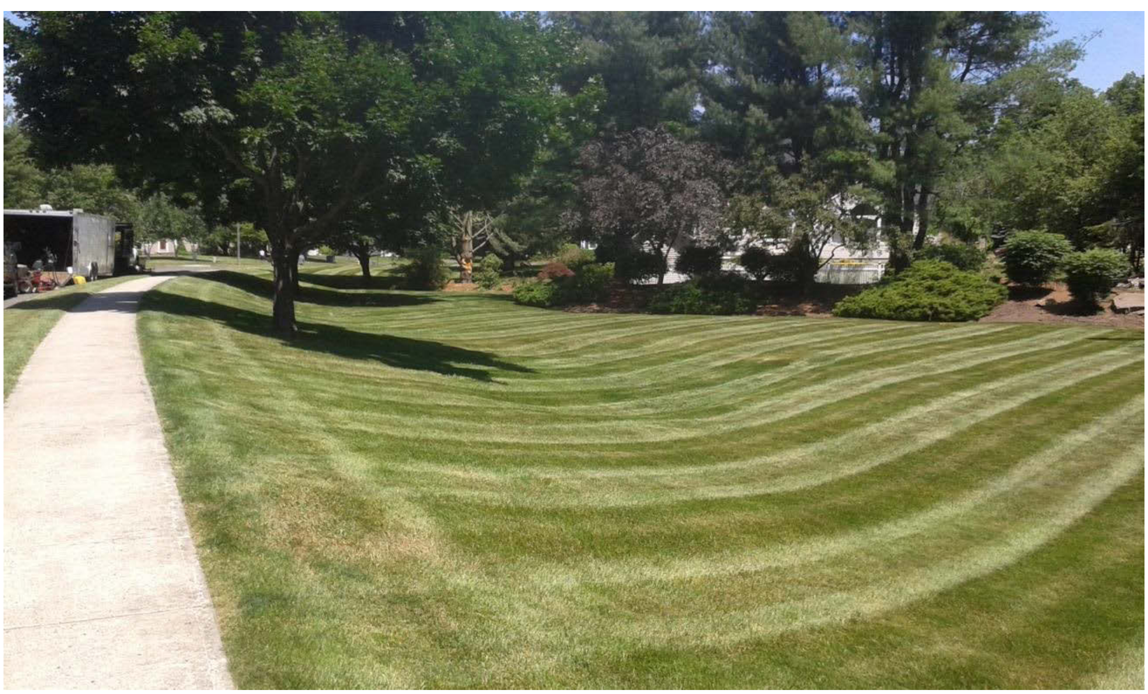

Figure 26. Sidewalk along Strathmore Drive and public lawn area, with bermed plantings in background.

Figure 27. Proposed green infrastructure retrofits at Strathmore Drive. "CB" indicates existing catch basin.
Blue arrows indicate existing surface flow patterns.

Attachment A

Green Infrastructure Retrofit Screening Results
Potential Retrofit Sites

List of Potential Sties for Green Infrastructure Retrofits: Mill River Watershed

Site Name	Municipality	Impaired Segment	Ownership	Hydrologic Soil Group	Priority Level	Sewer Type
1st Presbyterian	New Haven	Y	Private	A	Lower	Separate
350 Chapel St, Suzio York Hill	New Haven	Y	Private	B	Lower	Separate
Ball & Socket Arts	Cheshire	Y	Private	B	Lower	Separate
Bartlem Rec Area	Cheshire	Y	Public	B	Higher	Separate
Bates Dr	Cheshire	Y	ROW	B	Higher	Separate
Behind China Buffet, Route 10	Hamden	Y	Private	B	Lower	Separate
Bromley Ct	Hamden	Y	ROW	B	Higher	Separate
Celentano/Yale Divinity	New Haven	Y	Private	D	Lower	Separate
Cheshire Academy	Cheshire	Y	Private	B	Lower	Separate
Cheshire HS/Municipal	Cheshire	Y	Public	D	Higher	Separate
Cheshire Lutheran	Cheshire	Y	Private	A	Lower	Separate
Cheshire Public Safety	Cheshire	Y	Public	B	Higher	Separate
Cheshire Public Works	Cheshire	Y	Public	D	Lower	Separate
Cheshire Schools HQ/St Peters	Cheshire	Y	Public/Private	B	Higher	Separate
Cheshire United Methodist	Cheshire	Y	Private	B	Lower	Separate
Corporate Park, Raccio Park Road	Hamden	Y	ROW	B	Higher	Separate
Covenant Evangelical	New Haven	Y	Private	A	Lower	Combined
Criscuolo Park	New Haven	Y	Public	C	Lower	Combined
CT Bus Depot	New Haven	Y	Private	D	Lower	Separate
CT10 in Cheshire/Big Y	Cheshire	Y	ROW/Private	D	Lower	Separate
Dixwell Ave	Hamden	Y	ROW	B/D	Higher	Separate
Dixwell/Shepard/Skiff	Hamden	Y	ROW	D	Higher	Separate
East Rock Neighborhood	New Haven	Y	ROW	A	Higher	Separate
Eli Whitney Museum	Hamden	N	Public	C	Lower	Separate
Elim Park Retirement Community	Cheshire	Y	Private	B	Lower	Separate
Farnam Court	New Haven	Y	Public	D	Higher	Separate
Foote School	New Haven	Y	Public	D	Lower	Separate
Foster Day School	North Haven	Y	Private	B	Lower	Separate
Hamden Hall	Hamden	N	Private	D	Lower	Separate
Hamden Municipal Campus (including Middle School)	Hamden	Y	ROW/Public	A	Higher	Separate
Hamden Public Works garages	Hamden	Y	Public	B	Higher	Separate
Hooker Elementary	New Haven	Y	Public	A	Higher	Separate
Industrial park	Cheshire	Y	ROW	B/D	Higher	Separate
James Street	New Haven	Y	ROW	B/D	Higher	Combined
Jinny Hill, King, Mansion	Cheshire	Y	ROW/Private	B	Lower	Separate
Jocelyn Sq	New Haven	Y	Public	D	Higher	Separate
John S Martinez Magnet School	New Haven	Y	Public	B	Higher	Combined
Legion Field	Hamden	Y	Public	B	Higher	Separate
Livingston St @ Cold Spring	New Haven	Y	ROW	A	Higher	Separate
Livingston St @ East Rock	New Haven	Y	ROW	A	Higher	Separate
Mill River Daycare/Elm City College Preparatory Elementary School	New Haven	Y	Public	D	Higher	Combined

List of Potential Sties for Green Infrastructure Retrofits: Mill River Watershed

Site Name	Municipality	Impaired Segment	Ownership	Hydrologic Soil Group	Priority Level	Sewer Type
New Haven CC	Hamden	N	Private	B	Lower	Separate
Norton School	Cheshire	Y	Public	B	Higher	Separate
Oak Ave, Rustic Ln	Cheshire	Y	Land Trust	B	Lower	Separate
Olin Powder Farm	Hamden	N	Land Trust	A	Lower	Separate
Orange/Humphrey	New Haven	Y	ROW	D	Higher	Combined
Our Lady of Mt Carmel campus	Hamden	Y	Private	B	Lower	Separate
Quinnipiac Parking Lot	Hamden	Y	Private	B	Lower	Separate
Quinnipiac University	Hamden	Y	Private	B	Lower	Separate
Radiall America	New Haven	Y	Private	C	Lower	Separate
Ridge Road Elementary	North Haven	Y	Public	B/D	Higher	Separate
Southwick Condominimum Complex/Thompson Gardens West	Cheshire	Y	Private	A	Lower	Separate
Spring Glen School	Hamden	Y	Public	D	Higher	Separate
St Bridget's	Cheshire	Y	Private	B	Lower	Separate
St Joseph Catholic	New Haven	Y	Private	A	Lower	Separate
St Stanislaus	New Haven	Y	Private	A	Lower	Combined
St Thomas	New Haven	N	Private	A	Lower	Separate
St Thomas Becket Church	Cheshire	Y	Private	B	Lower	Separate
Strathmore Dr	Cheshire	Y	ROW	B	Higher	Separate
First Unitarian Universal Church	New Haven	Y	Private	A	Lower	Separate
United Church	New Haven	Y	Private	A	Lower	Combined
United Church/Temple Beth Sholom	Hamden	Y	Private	B	Lower	Separate
United Way	New Haven	Y	Private	D	Lower	Combined
USPS	Hamden	Y	ROW	B	Higher	Separate
Walnut St Mill River St	New Haven	Y	Private	D	Lower	Combined
Washington Ave	Hamden	Y	ROW	D	Higher	Separate
Wentworth's	Hamden	Y	Private	A	Lower	Separate
West Woods Bible Chapel	Hamden	N	Private	B	Lower	Separate
Whitney / Washington ROW	Hamden	Y	ROW	B	Higher	Separate
Whitney HS East	Hamden	Y	Public	D	Higher	Separate
Whitney HS North/West	Hamden	Y	Public	D	Higher	Separate
Wilbur Cross HS/Athletic Complex	New Haven	Y	Public	D	Higher	Separate
Willow St and Mitchell Dr	New Haven	Y	Private	D	Lower	Combined
Wooster Square Neighborhood	New Haven	Y	ROW	D	Higher	Separate
Worthington Hooker School	New Haven	Y	Public	A	Higher	Separate
YNHH Outpatient	Hamden	Y	Private	B	Higher	Separate
Zentek Farms	Cheshire	Y	Private	A	Higher	Separate

**** Blue shading indicates sites where field visits were conducted**