ATTACHMENT 6

Clean Water Act Residual Designation Determination for Certain Stormwater Discharges in the Charles, Mystic, and Neponset River Watersheds, in Massachusetts

Charles River Watershed Stormwater Total Phosphorus Analysis

I. INTRODUCTION

On May 19, 2019, the Conservation Law Foundation (CLF) and the Charles River Watershed Association (CRWA) petitioned EPA to use its Clean Water Act residual designation authority to designate commercial, industrial, institutional, and multi-family residential properties greater than 1 acre in size in the Charles River Watershed (CRW) as needing National Pollutant Discharge Elimination System (NPDES) permits for stormwater discharges that significantly contribute pollutants to waters of the U.S., contribute to water quality standards violations, and/or that need to be controlled in order to meet Total Maximum Daily Load (TMDL) wasteload allocations (WLAs). EPA then undertook an analysis to quantify the total phosphorus (TP) loading from all private properties in the CRW. The goal of this analysis was to determine whether stormwater discharges from private properties were contributing to violations of water quality standards in the Charles River and required NPDES permit coverage. In addition, this analysis set out to identify which land use classes were contributing the most phosphorus to the Charles River through stormwater and to identify and evaluate options for maximizing phosphorus reductions efficiently (i.e., fewest stormwater controls installed). The results of the analysis can be used to better understand the potential magnitude of impact on TP loads from private properties, as well as understand the TP reductions in the CRW necessary to meet water quality standards that would result from designation and permitting actions. As described below, the analysis resulted in the following broad conclusions:

1. Private properties in the CRW generate approximately 50,738 pounds of TP per year from stormwater, which is 58% of the baseline TP load from stormwater sources identified in the Charles River TMDLs.
2. Without stormwater controls on some private properties in the CRW, the burden of phosphorus reduction falls completely on municipalities and this burden makes achieving the TMDL goals and water quality standards in the Charles River unlikely if not infeasible.
3. The greater the percent impervious cover (IC) on a property, the greater the mass load of phosphorus in stormwater from that property compared to other properties of similar size.
4. Of private properties in the CRW, commercial, industrial, and institutional classifications have the highest percentage of impervious cover per property.
5. Over 50% of the IC in the CRW is located on a subset of commercial, industrial, institutional, and multi-family residential properties, all of which contain greater than 1 acre of IC.
6. The most efficient way to reduce TP discharges from private properties is to target stormwater controls on properties based on the amount of IC on the properties (which is proportional to the amount of TP generated) and based on property types (which also affects amount of TP

generated), thereby maximizing TP reduction while minimizing the number of properties installing controls.

II. METHODS

To quantify TP loads in stormwater derived from private properties within the CRW, the first step was to identify the private properties within the watershed, identify the land use of each property, and calculate the area of IC on each property. To accomplish this, the following data files were used:

- Files obtained from MassGIS:
  - **Municipal Boundaries Shapefile** – provides town name and town boundary
  - **Tax Assessors Parcels Shapefile** – provides location, parcel ID (Loc_ID), and area of each parcel (property)
  - **Assessors Table L3** – provides use code, site address, owner information, and year built
  - **Land Cover Land Use Shapefile** - provides land cover name and generalized use name
  - **Land Use Table L3** - provides type code and a code description
  - **UC Land Use Table L3** - provides use code and use code description
  - **2005 Impervious Cover Raster File** – provides location and area of 2005 IC
  - **2016 Impervious Cover Shapefile** – provides location and area of 2016 IC

- Files obtained from EPA:
  - **MS4 Boundary** – provides location and area covered under the MS4
  - **CRW Boundary** – provides location and area of the CRW
  - **CSA Boundary** – provides location and area of communities with Combined Sewer Systems (CSSs)

A Geographic Information System (GIS) model was used to create a data file that calculated the property area, the associated land use, and the amount of IC on each property in the watershed (USEPA, 2022). Extensive quality assurance and quality control was completed on the resulting dataset to ensure proper classification of property information and to correct any errors in the underlying dataset (USEPA, 2022).

From this data file, EPA identified or quantified the following for each individual property: size (acres), land use classification, ownership information, location, and area (acres) and percent of impervious cover, pervious cover, forest, and wetlands.

The dataset was then used to calculate the TP generated from each property in pounds per year using the Phosphorus Load Export Rates (PLERs) documented in the MA MS4 Permit. This parcel loading analysis was accomplished by applying stormwater PLERs to land surface areas with differing land use and cover types such as commercial, industrial, high-density residential uses with impervious cover (IC) and pervious grassed and landscaped cover (i.e., developed land pervious). The PLERs provide estimates of the average annual phosphorus load export delivered by untreated stormwater from areas with distinct cover and use types for the same climatic conditions as used in the development of the Charles River phosphorus TMDLs. In general, the amount of impervious cover on a property increases the volume of stormwater derived from that property or land use class, which increases the loading of pollutants found in stormwater, including phosphorus. (Shaver, Horner, Skupien, May, & Ridley, 2007) (Center For Watershed Protection, 2003) (Schueler, 2011) (Chen, Theller, Gitau, Engel, & Harbor, 2017). Multiplying the area of interest by the distinct PLER provides an estimate of the average annual phosphorus loading rate. For example, one (1) acre of impervious cover in commercial use is estimated to deliver 1.78 lbs of phosphorus per year (e.g., 1.0 acre of commercial IC X 1/78 lbs/acre/yr = 1.78 lb/yr). Attachment 1 to Appendix F of the 2016 Massachusetts MS4 Permit includes a detailed description of assigning PLERs to different land use classes in the CRW (USEPA, 2016) and this is also summarized in the MEMORANDUM- Charles River Watershed Private Parcel Analysis GIS Methods (USEPA, 2022). These specific PLERs create a comprehensive methodology for calculating phosphorus load reductions and increases based on land use information for projects and properties in the CRW. Table 1 below displays the land use classifications used in this analysis and the associated PLERs for impervious cover and pervious cover for the given land use. As seen in Table 1, the amount of phosphorus generated by a land use type increases with the increased human utilization of that land use. For instance, the forest land use has a phosphorus loading rate of 1.52 lb/acre/year of TP for impervious areas within the forested area, while Commercial areas have a phosphorus loading rate of 1.78 lb/acre/year of TP for impervious areas. In addition, as seen in Table 1, impervious cover generates up to, and in excess of, 10 times the annual phosphorus load compared to pervious areas on that same land use class due to the increase in stormwater generated by impervious cover compared to previous cover (USEPA, 2016). For a detailed description of PLER and land use classes used for this analysis see MEMORANDUM- Charles River Watershed Private Parcel Analysis GIS Methods (USEPA, 2022).

PLER Aggregate Land Use Category	**PLER Impervious Cover (lbs/acre/year)**	**PLER – Developed Land Pervious Area (e.g., landscaped area) (lbs/acre/year)**
Commercial/Industrial	1.78	0.207
Multi Family/High Density Residential	2.32	0.207
Single Family/Medium Density Residential	1.96	0.207
Forest/Agriculture	1.52	0.207

Table 1 : PLERs used to calculate annual phosphorus load from properties in the CRW. PLERs for Developed Land Pervious Area do not include forested or wetland areas

a. Limitations

This analysis used the Massachusetts Tax Assessors Database to assign land uses to properties and calculate impervious cover contained on each property. The Massachusetts Tax Assessors Database and the 2016 Impervious Cover Shapefile does not contain information for public roads, highways, and right of ways, and therefore, the analysis did not capture all the impervious cover and phosphorus loading from all land area in the CRW. However, this analysis focuses on total phosphorus load in stormwater from private properties, not from public parcels already regulated under the 2016 MA MS4 permit, the Boston Individual MS4 Permit, or to parcels owned or operated by the Massachusetts Department of Transportation already subject to an NPDES permit.

For the purposes of this analysis, EPA excluded privately owned roads and properties on the border of the watershed where less than 50% of the property is in the watershed. Applying this exclusion to the analysis resulted in less than 1% of the total land area (2.5 square miles) of the private properties in the CRW being omitted from the analysis (USEPA, 2022). Given the low number of missing properties in the dataset, it is not expected that the overall watershed loading analysis and comparison of phosphorus loading from different sources is impacted.

The analysis does not attempt to estimate or calculate the connectedness (i.e., how much stormwater is delivered directly to nearby waterbodies) of any property identified in the analysis. The values in Table 1 represent the delivery of phosphorus from an area that is directly connected to a waterbody or municipal stormwater system. In addition, the pervious annual phosphorus loading rate was set at the weighted average of pervious area estimated loading rate based on soil type distribution in the CRW. Given the significantly lower contribution of phosphorus from pervious areas (approximately 25% of the stormwater phosphorus load in the CRW (USEPA, 2016)) this value is meant to approximate the impact of pervious cover stormwater without having site specific soil type data. Therefore, all phosphorus loading estimates in the property analysis should be considered conservative for the property or land use classification identified. This removes assumptions necessary for stormwater delivery and focuses on phosphorus generated at the source on each property, allowing for a more direct comparison of potential magnitude of impact.

This analysis does not contain calculations of phosphorus export from public lands. Given the limitations contained in the 2016 Land Cover Dataset and Impervious Cover Dataset from MassGIS, accurate calculation of phosphorus loading from public lands (primarily roadways and rights-of-way) is not feasible. However, given this analysis focuses on phosphorus export stormwater from private properties, the exclusion of public land does not affect the analysis.

b. Other Relevant Information for this Analysis

Massachusetts Department of Environmental Protection (MassDEP) established two Total Maximum Daily Loads (TMDLs) for the CRW. On October 17, 2007, EPA approved the Final TMDL for Nutrients in the Lower Charles River Basin (Lower Charles TMDL) (Massachusetts Department of Environmental Protection , 2007) and on June 10, 2011 EPA approved the Total Maximum Daily Load for Nutrients in the Upper/Middle Charles River (Upper/Middle Charles TMDL) (Massachusetts Department of Environmental Protection, 2011). The Lower Charles TMDL and the Upper/Middle Charles TMDL baseline phosphorus load from stormwater sources was calculated at 87,432 pounds of total phosphorus per year. Both TMDLs set Waste Load Allocations (WLAs) that specify reductions for discharges of phosphorus throughout the entire CRW from publicly owned treatment works, combined sewer overflows and stormwater discharges. To meet TMDL goals, the more developed lands (Commercial, Industrial, and High and Medium Density Residential) need to reduce total phosphorus loads by 65% annually while the less developed, low density residential lands need to reduce total phosphorus loads by 45% annually. While the TMDLs did not consider land classified as “institutional” as its own category, this analysis included a 65% reduction requirement for this classification, which is consistent with the other similarly developed land use categories. The TMDLs set a watershed-wide stormwater phosphorus load reduction requirement of 47,347 pounds per year, bringing the overall phosphorus load from stormwater from a baseline of 87,432 pounds per year to an allowable load of

40,085 pounds per year of phosphorus from stormwater sources. Overall, the stormwater TP load reduction will need to come from multiple stormwater sources; this analysis does not attempt to partition this overall stormwater TP required reduction between private and public properties. The 47,347 pounds per year TP reduction is referenced in this analysis as the stormwater required TP reduction from all stormwater sources in the CRW.

III. RESULTS AND DISCUSSION

a. Current Charles River Watershed Characterization

Based on the analysis described above, EPA identified 196,645 properties in the CRW. These properties comprise a total of 166,703 acres or 84% of the entire watershed. These properties are primarily single family residential (36%), institutional (20%), commercial (10.5%), open land (8.6%), multi-family residential (5.4%) Industrial (2.6%) and Agricultural (1.2%) (Figure 1). The remaining 16% of the watershed is comprised of waterbodies, public roads, and rights-of-way without tax codes in the Tax Assessors Parcels Shapefile (indicated as "other" in Figure 1). Figure 2 displays a map of the Charles River Watershed and 2016 land use classifications. In total, the CRW is approximately 40% public land (Institutional Federal, Institutional State, Institutional Local, Open Land and "Other" land use categories) and 60% private land (all other land use categories displayed in Figure 1).

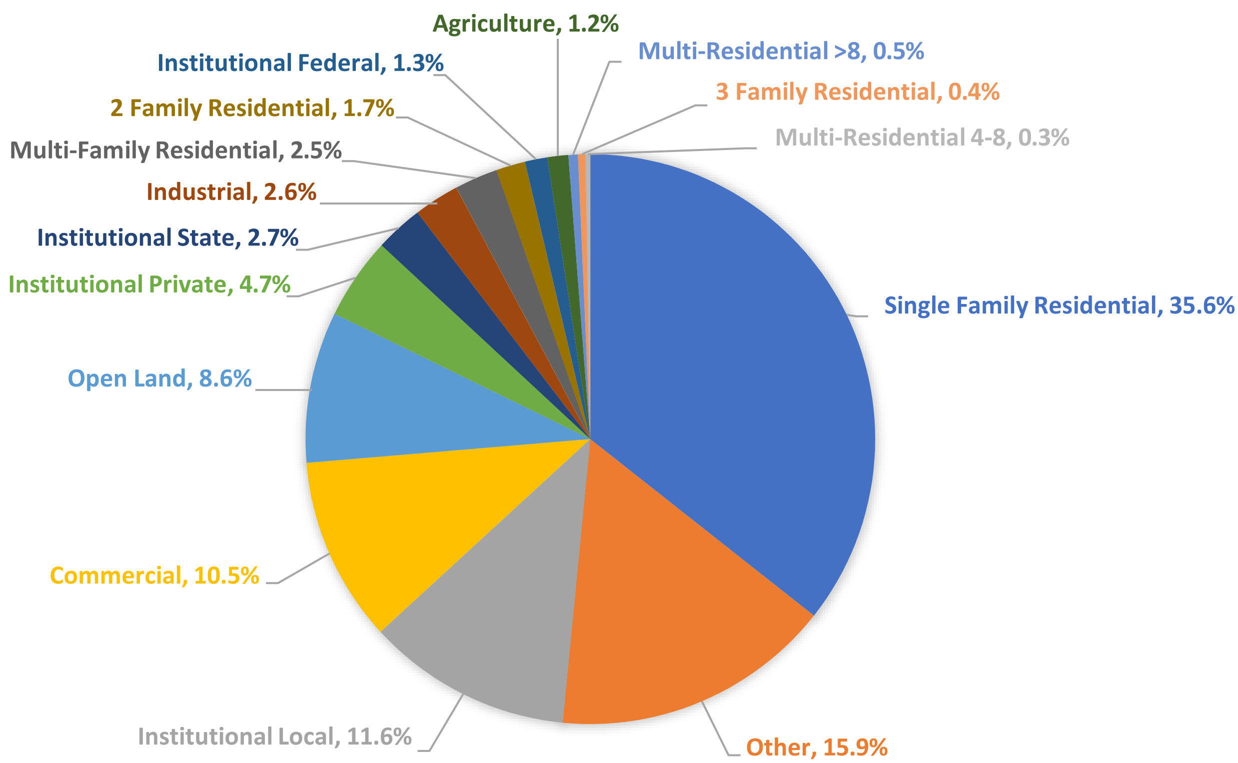

Figure 1: Acres of CRW Property by Classifications*

*The "Other" category accounts for land not in the property analysis, including waterbodies, public roads, and rights-of-way.

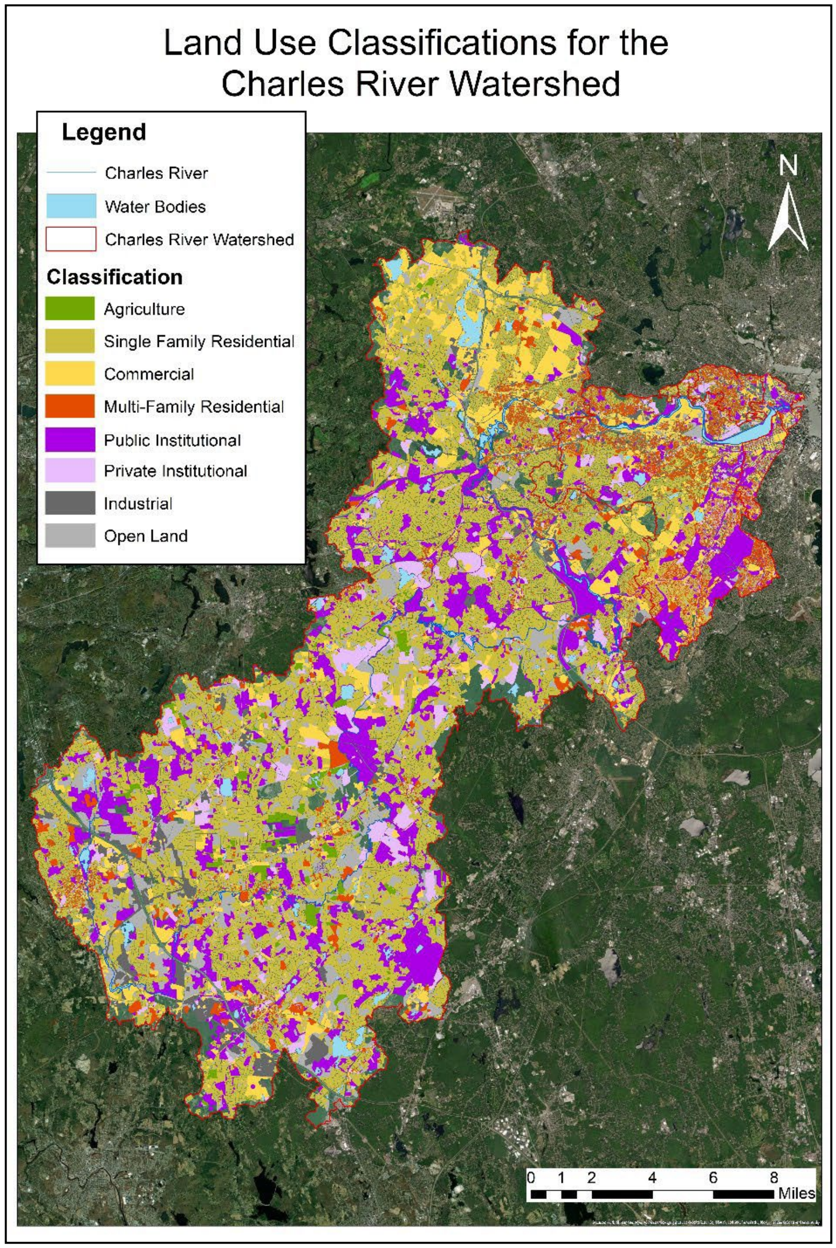

Figure 2: Land Use Classifications in the Charles River Watershed. Land Use data from MassGIS 2016 Land Cover Land Use Shapefile

b. Private Properties

Since stormwater discharges from most of the public land area (state and federal roads, public institutions, state and locally owned open space, etc.) in the CRW are currently regulated by the 2016 Massachusetts MS4 Permit, the Boston Individual MS4 Permit, or are on parcels owned or operated by the Massachusetts Department of Transportation already subject to an NPDES permit, this analysis focuses on phosphorus loads from private property including commercial, industrial, private institutional, single family residential, and multi-family residential properties.[1] In addition, there are 13,635 properties located in areas served by combined sewers; these properties were removed from this analysis as the stormwater is delivered to the Deer Island Wastewater Treatment Plant. Agricultural land was also excluded from the analysis due to the low number of properties (208) and relatively low phosphorus load compared to the other private property land uses (approximately 0.5% of the overall TP load). Therefore, this analysis focused on 166,489 private commercial, industrial, institutional, and residential properties in the CRW which comprise 114,298 acres (Table 2). As demonstrated in Table 1, the phosphorus loading rate of IC is approximately 10 times that of developed, pervious cover (e.g. for commercial/industrial the load is 1.78 lbs/acre/year for impervious vs 0.207 lbs/acre/year for pervious). Therefore, EPA's analysis of phosphorus load included a parcel-by-parcel calculation of the amount of IC land area and pervious land area. The appropriate PLERs (Impervious vs Pervious) were then applied on a parcel-by-parcel basis in accordance with its designated the land use (USEPA, 2022). From this parcel-by-parcel analysis, EPA determined that the stormwater runoff from private commercial, industrial, institutional, and residential properties identified in the analysis generate 50,738 pounds (43,787+6,951) of total phosphorus per year. In addition, EPA also determined that while impervious cover comprises about 20% of the total land area from these properties (22,424/114,298 acres), it actually contributes 86% of the total phosphorus load from these properties (43,787/50,738 lbs/year) (Table 2). While pervious areas, such as lawns and other various covers, generate stormwater runoff and contribute to the overall phosphorus loading, the load from these areas is much less than the load from impervious cover.

Classification	# Properties	Acres	IC Area (Acres)	% IC	IC TP Load (lbs/yr)	Pervious TP Load (lbs/yr)*	Average TP Load per Property (lbs/yr/property)
Commercial	9,548	20,120	5,657	28%	10,102	1,273	1.19
Industrial	1,000	5,016	1,468	29%	2,609	330	2.94
Institutional Private	4,255	8,986	1,412	16%	2,446	416	0.67
Multi-Family Residential	33,412	9,870	3,987	40%	9,223	428	0.29
Single Family Residential	118,274	70,307	9,900	14%	19,407	4,504	0.20
TOTAL	166,489	114,298	22,424		43,787	6,951	

Table 2: Private Properties
*Pervious load does not include TP loads from forest or wetland areas on private properties

[1] The GIS dataset contained several different designations for multi-family residential (see Figure 1). For this analysis, EPA combined all residential properties with two or more families into one category called "multi-family residential."

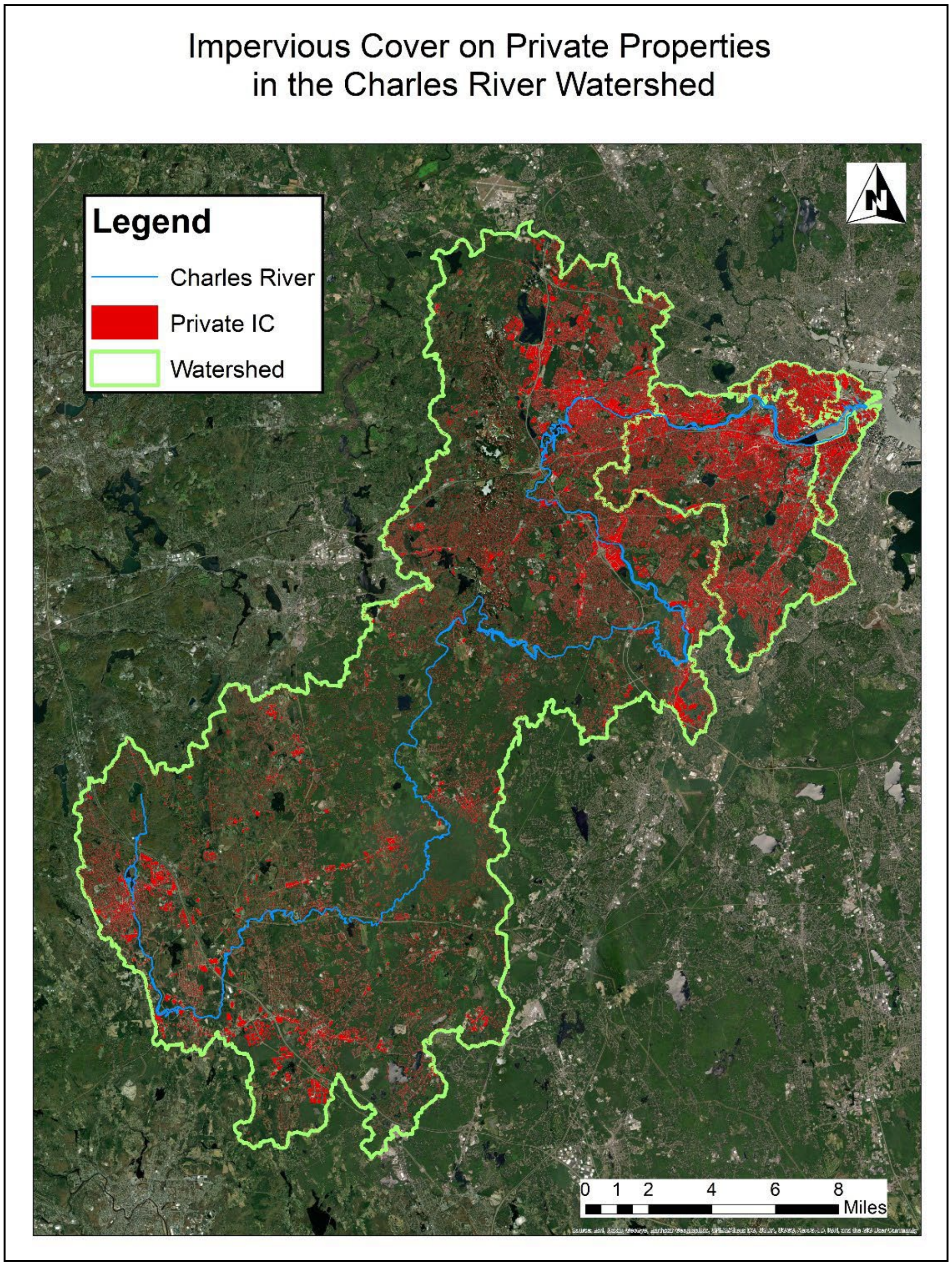

Figure 3: Impervious cover on private property in the Charles River Watershed. Data from MassGIS 2016 Impervious Cover Layer

Based on the analysis and as shown in Table 2, the estimated overall TP generated by private properties in the CRW is substantial and could be as much as 50,738 pounds per year (43,787+6,951), which is 58% (50,738/87,432) of the baseline stormwater load estimated by the TMDL analysis.

If all 166,489 private properties were to install stormwater controls on their properties to reduce TP in stormwater discharges by 65% on Commercial, Industrial, Institutional and Multi-family properties and by 45% from single family homes (as suggested by the Lower and Upper/Middle Charles TMDLs), the overall TP reduction from stormwater sources could be up to 28,197 pounds of phosphorus per year, or approximately 60% of the required watershed reduction in TP from the TMDLs (28,197/47,347). However, requiring all private properties to take action on their properties presents several challenges and may not be necessary to meet TMDL reduction goals. For instance, if we assume the public properties in the CRW contribute 36,694 pounds of phosphorus per year (baseline loading from the TMDL [87,432]– calculated load from private property [50,738]) and all public properties were able to reduce this load by 65%, the resulting reduction in TP load would be 23,851 pounds of phosphorus per year, or approximately 50% of the required reduction from the TMDL (23,851/47,347). These scenarios added together would equal a reduction of 52,048 (28,197+23,851) pounds of phosphorus per year removed, which would be greater than the TMDL target reduction of 47,347 pounds of phosphorus per year. While simplified, this indicates that there has to be a mix of actions on public and private land in order to meet TMDL goals and also highlights the fact that no one group can meet the TMDL goals alone (e.g. if no actions were taken on private property to reduce phosphorus in stormwater discharges the TMDL goals cannot be met).

c. Single Family Properties

There are approximately 118,274 single family residential properties in the watershed that consist of approximately 70,307 acres (Table 2 and Figure 5). Single family residential land use accounts for the highest number and acreage of properties; however, just 14% of its acreage (10,114 acres) is impervious. Therefore, the resulting phosphorus load for single family residential land use is distributed over many properties making the contribution from any one property relatively low (0.20 lbs/year/property) compared to other land use types (Figure 4).

From a phosphorus reduction perspective, this suggests that focusing efforts on other property types would lead to larger reductions while also requiring stormwater controls on fewer properties. For instance, if all single-family homes implemented structural controls to treat phosphorus on their properties and achieved a 45% reduction in TP generated per year in stormwater as required by the TMDL, the watershed would see an approximate reduction of 10,760 pounds of TP per year for the implementation of 118,274 individual structural practices, or 0.09 pounds of TP reduced per year per property. If, however, a 65% reduction as required by the TMDL was applied to commercial properties, the watershed would see an approximate reduction of 7,394 pounds per year of TP for the implementation of 9,548 structural practices, or 0.77 pounds of TP reduced per year per property. This example indicates an increase in efficiency of 8.6 times if controls were focused on commercial property instead of single-family residential properties. This efficiency is primarily driven by the amount of IC in the different land use classes. Looking at Table 2, it is evident that the phosphorus load from IC is larger than the phosphorus load from pervious cover on private properties. Single family residential properties have an average of 7.4 times less IC per property when compared to commercial properties in the CRW, indicating that structural controls would be needed on over seven single family properties to achieve the same amount of phosphorus reduction that could be achieved by placing controls on one commercial property.

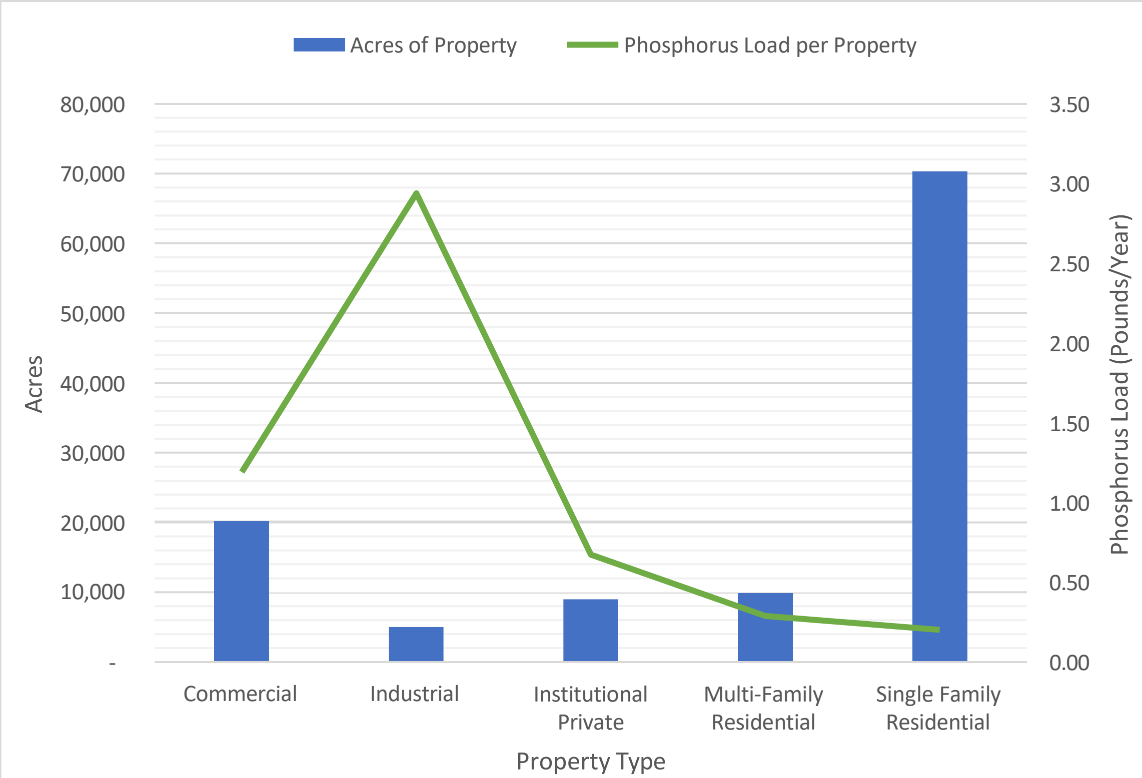

Figure 4: Acres of Commercial, Industrial, Private Institutional, Multi-Family Residential and Single Family Residential are in the CRW with associated phosphorus load generated by each land use

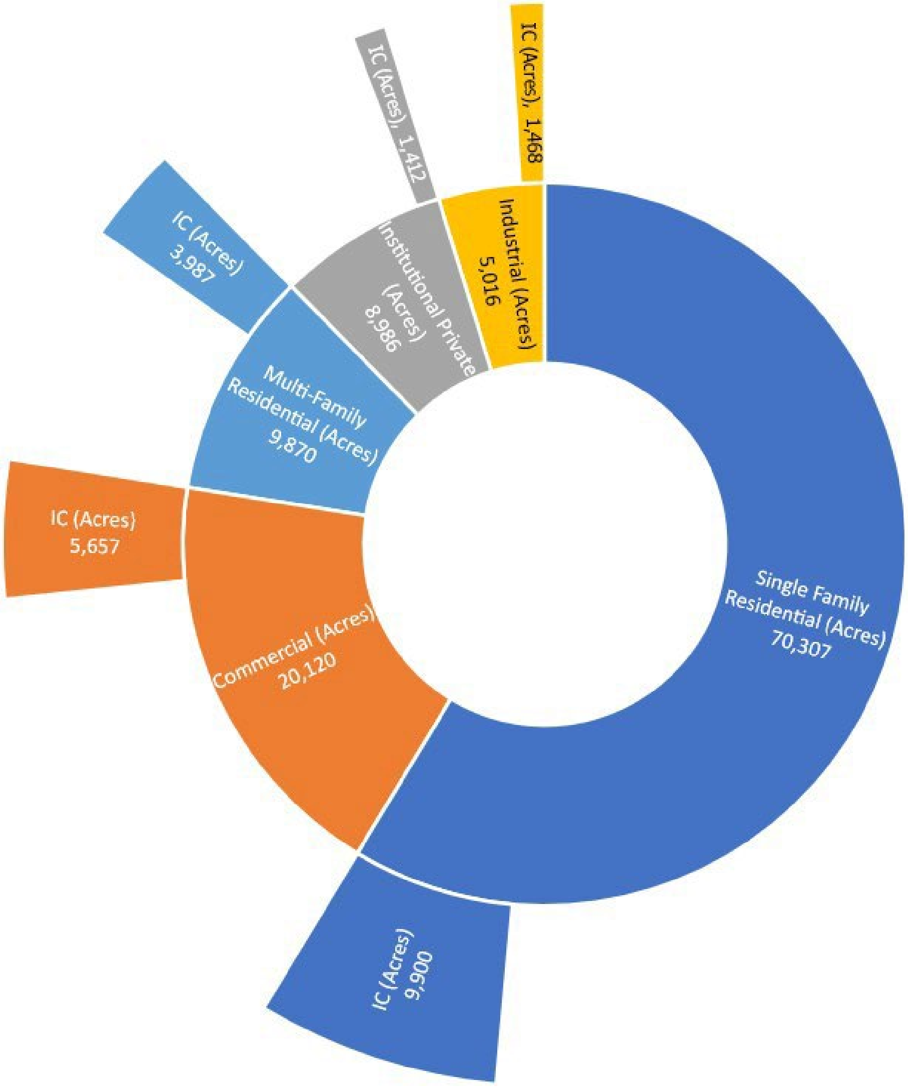

Figure 5: Acres of Private Properties by Classification and the Associated Impervious Cover (IC) (Acres) of Each Classification

d. Other Private Properties

When single family residential properties are removed from the dataset, the annual total phosphorus load from commercial, industrial, institutional, and multi-family residential (CIIM) properties is 26,827 pounds per year (Table 3 and Table 4), including 24,380 pounds per year (91%) generated from IC. A 65% reduction in the total load from CIIM properties as suggested by the TMDL would result in a potential reduction of 17,437 pounds per year. This reduction amounts to approximately 37% of the 47,347 pounds per year stormwater TP reduction required by the TMDL for the CRW. This reduction would require stormwater controls on 48,215 properties (i.e. the total number of CIIM properties in the CRW).

While it may be possible to achieve 37% of the overall TP reduction needed through practices on all 48,215 CIIM properties, it likely is not the most efficient way to reduce TP in stormwater from CIIM properties in the watershed. To identify a more efficient way to target properties for stormwater controls, EPA compared the impact of requiring controls on properties based on property size versus requiring controls based on the amount of impervious cover. As shown in Figure 6, there are 4,728 CIIM properties ≥1 acre in property size. These properties generate around 18,476 pounds of TP per year. There are 2,257 CIIM properties with ≥1 acre of IC, which generate around 15,048 pounds of TP per year. Comparatively, the properties ≥1 acre in size generate on average about 3.9 pounds of TP per property per year, while the properties with IC ≥1 acre generate approximately 6.7 pounds of TP per property per year. Overall, targeting phosphorus reduction actions on properties with larger IC instead of overall property size is more effective to reduce the phosphorus load. In this example it would require stormwater controls on approximately half the number of properties while achieving only a slight decline in TP reduction.

Property Size	Acres	IC Area (Acres)	# Properties	% of Total CRW CIIM IC	TP Load (lbs/yr)	Annual TP Load Reduction Assuming 65% Removal (lbs/yr)	% of Total Reduction Required in Watershed	# Properties per % of Total Reduction Required	Average IC Acres/Property
All Properties*	43,991	12,524	48,215	100%	26,827	17,437	36.8	1,309.2	0.26
≥0.1 Acre	43,091	11,851	35,193	95%	25,339	16,471	34.8	1,011.7	0.34
≥0.25 Acre	39,629	9,757	12,354	78%	20,635	13,412	28.3	436.1	0.79
≥0.5 Acre	37,793	8,792	7,016	70%	18,611	12,097	25.6	274.6	1.25
≥1 Acre	36,045	7,845	4,519	63%	16,737	10,879	23.0	196.7	1.74
≥2 Acres	33,640	6,619	2,797	53%	14,353	9,329	19.7	141.9	2.37
≥3 Acres	31,953	5,882	2,107	47%	12,910	8,391	17.7	118.9	2.79
≥4 Acres	30,711	5,405	1,749	43%	11,959	7,774	16.4	106.5	3.09
≥5 Acres	29,534	4,970	1,487	40%	11,090	7,209	15.2	97.7	3.34
≥6 Acres	28,451	4,567	1,288	36%	10,295	6,692	14.1	91.1	3.55
≥7 Acres	27,292	4,231	1,109	34%	9,606	6,244	13.2	84.1	3.81
≥8 Acres	26,425	3,961	994	32%	9,047	5,880	12.4	80.0	3.99
≥9 Acres	25,644	3,754	902	30%	8,619	5,602	11.8	76.2	4.16
≥10 Acres	24,870	3,558	820	28%	8,214	5,339	11.3	72.7	4.34
≥11 Acres	24,095	3,382	746	27%	7,845	5,099	10.8	69.3	4.53
≥12 Acres	23,141	3,073	663	25%	7,225	4,696	9.9	66.8	4.63
≥13 Acres	22,405	2,947	604	24%	6,946	4,515	9.5	63.3	4.88
≥14 Acres	21,944	2,865	570	23%	6,762	4,395	9.3	61.4	5.03
≥15 Acres	21,219	2,673	520	21%	6,361	4,135	8.7	59.5	5.14
≥16 Acres	20,773	2,530	491	20%	6,076	3,949	8.3	58.9	5.15
≥17 Acres	20,181	2,378	455	19%	5,749	3,737	7.9	57.6	5.23
≥18 Acres	19,726	2,272	429	18%	5,529	3,594	7.6	56.5	5.30
≥19 Acres	19,301	2,169	406	17%	5,310	3,452	7.3	55.7	5.34
≥20 Acres	18,634	2,039	372	16%	5,015	3,260	6.9	54.0	5.48

Table 3: Commercial, Industrial, Institutional, and Multi-Family Residential Properties Based on Property Size.

Impervious Cover Size	Acres	IC Area (Acres)	# Properties	% of Total CRW CIIM IC	TP Load (lbs/yr)	Annual TP Load Reduction Assuming 65% removal (lbs/yr)	% of Total Reduction Required in Watershed	# Properties per % of Total Reduction Required	Average IC Acres/Property
All Properties	43,991	12,524	48,215	100%	26,827	17,437	36.8	1,309.2	0.26
≥0.1 Acre	31,240	10,660	17,238	85%	21,908	14,240	30.1	573.2	0.62
≥0.25 Acre	26,955	9,119	6,320	73%	18,439	11,985	25.3	249.7	1.44
≥0.5 Acre	23,013	8,230	3,808	66%	16,477	10,710	22.6	168.3	2.16
≥1 Acre	19,721	7,041	2,120	56%	14,091	9,159	19.3	109.6	3.32
≥2 Acres	15,252	5,540	1,048	44%	11,033	7,171	15.1	69.2	5.29
≥3 Acres	12,206	4,592	658	37%	9,121	5,929	12.5	52.5	6.98
≥4 Acres	10,097	3,919	463	31%	7,782	5,059	10.7	43.3	8.46
≥5 Acres	8,274	3,358	337	27%	6,642	4,317	9.1	37.0	9.97
≥6 Acres	7,198	2,917	256	23%	5,747	3,736	7.9	32.4	11.39
≥7 Acres	6,195	2,545	199	20%	5,008	3,255	6.9	28.9	12.79
≥8 Acres	5,505	2,267	162	18%	4,461	2,900	6.1	26.5	14.00
≥9 Acres	4,984	2,020	133	16%	3,986	2,591	5.5	24.3	15.19
≥10 Acres	4,436	1,757	105	14%	3,474	2,258	4.8	22.0	16.74
≥11 Acres	4,042	1,570	87	13%	3,120	2,028	4.3	20.3	18.05
≥12 Acres	3,488	1,397	72	11%	2,761	1,795	3.8	19.0	19.40
≥13 Acres	3,002	1,248	60	10%	2,439	1,586	3.3	17.9	20.80
≥14 Acres	2,496	1,099	49	9%	2,132	1,386	2.9	16.7	22.42
≥15 Acres	2,391	1,041	45	8%	2,016	1,310	2.8	16.3	23.14
≥16 Acres	2,300	995	42	8%	1,930	1,254	2.6	15.9	23.69
≥17 Acres	2,066	880	35	7%	1,709	1,111	2.3	14.9	25.14
≥18 Acres	1,881	811	31	6%	1,563	1,016	2.1	14.4	26.15
≥19 Acres	1,777	755	28	6%	1,462	950	2.0	14.0	26.98
≥20 Acres	1,610	659	23	5%	1,273	828	1.7	13.2	28.64

Table 4: Commercial, Industrial, Institutional, and Multi-Family Residential Properties Based on Impervious Cover Size

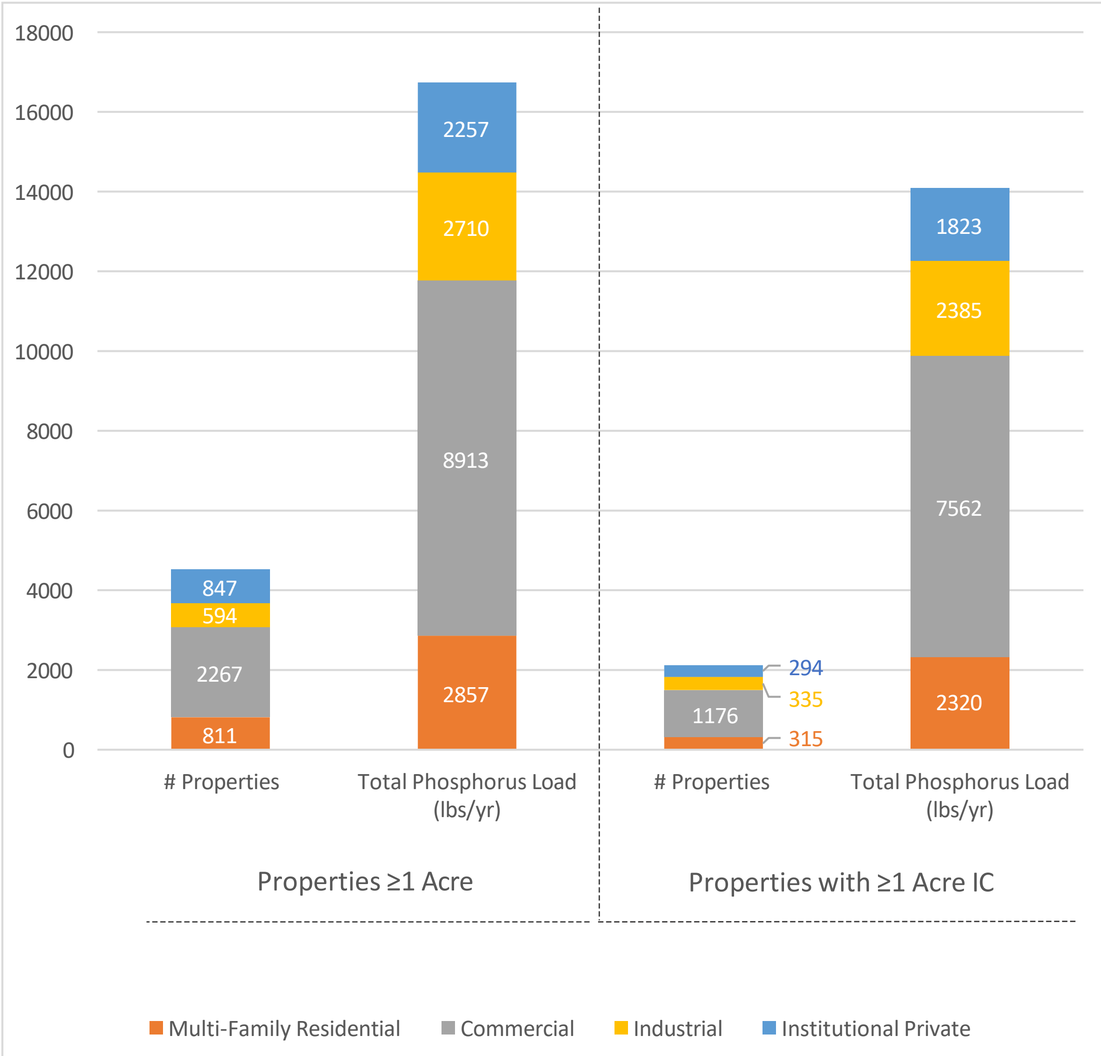

Figure 6: Number of Properties and Total Phosphorus Load by Property Classifications for Both Properties ≥1 Acre and Properties with IC ≥1 Acre

To further refine this evaluation, EPA evaluated the optimum size of IC that would most effectively capture the largest load reduction over the fewest number of properties. The private properties in the CRW were first broken up into groups based on the amount of IC contained on the property. Figure 7 displays the potential TP reduction (assuming a 65% reduction from the total load) from CIIM properties and the number of properties where the reduction would occur. The trendline in Figure 7 provides insight on the size of IC area that would result in optimizing the tradeoff between TP reduction and number of properties installing controls. Ultimately the optimal implementation scenario would lie where the trendline is "curving" or moving from high slope to low slope. In Figure 7, this optimal zone is highlighted in light orange and lies between properties with ≥0.25 acres and ≥5 acres of IC. [2]

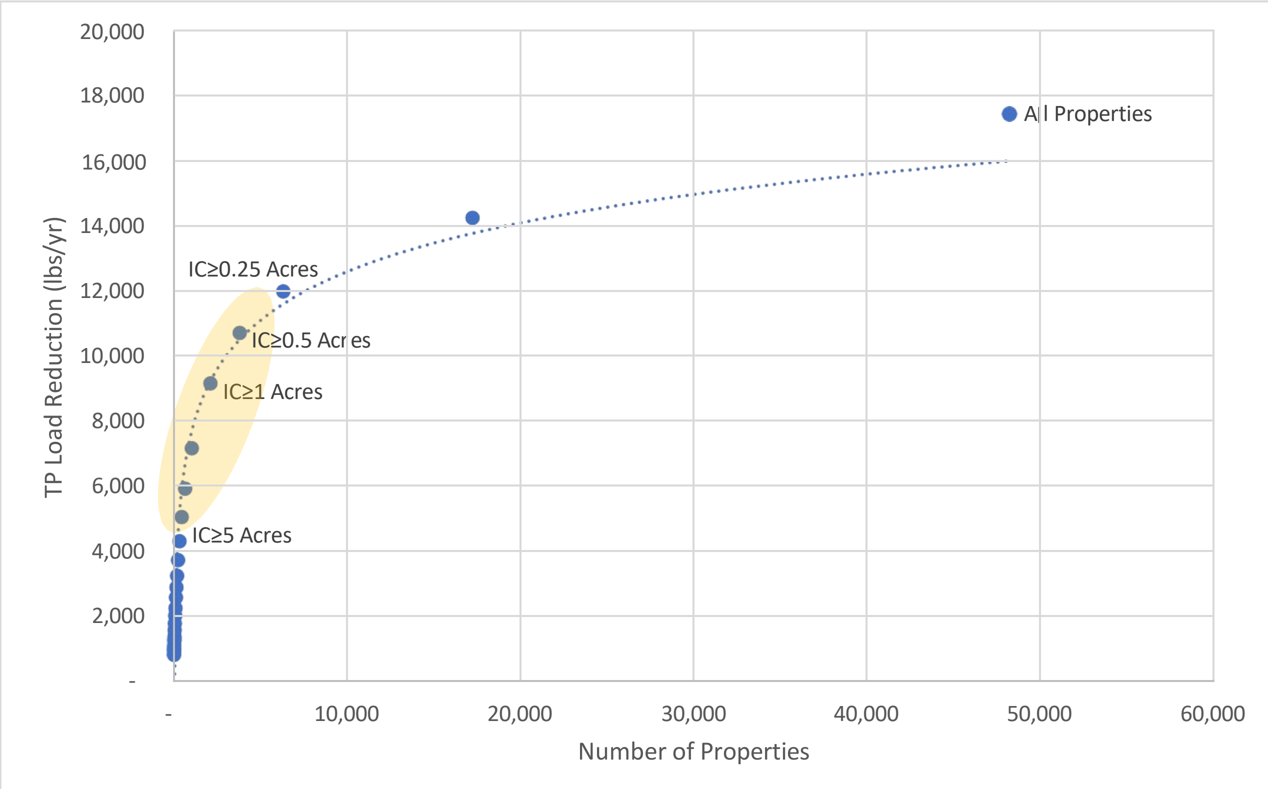

Figure 7: TP Load Reduction Assuming 65% Reduction vs. Number of Properties for CIIM Properties. The light orange represents a potential optimal IC size for stormwater control implementation

To understand the potential TP reductions from stormwater controls on properties at different IC thresholds, thresholds between 0.5 acres of IC and 5 acres of IC, were evaluated more closely. Specifically, thresholds of ≥0.5, 1.0, 2.0, and 5.0 acres of IC are discussed in further detail below.

An IC size of ≥ 0.5 acre includes 3,808 CIIM properties and contributes a TP load of approximately 16,477 pounds per year (Table 5). Approximately 93% of the TP load is generated from IC on these properties. Of the 3,808 properties, 2,151 are commercial, 632 are multi-family residential, 517 are industrial, and 508 are institutional. The average IC per property ranges from 1.85 acres to 2.69 acres with multi-family residential as the lowest and industrial as the highest. Reducing TP from these properties by 65% has the

[2] While Figure 7 provides a tool for visualizing one way to optimize implementation, it should not be interpreted without taking into account other factors for efficiency of stormwater control sighting within the watershed, namely targeting those properties with the greatest proportion of IC and targeting those land use classes contributing the largest amount of TP proportionally (Figure 4).

potential TP reduction of 10,710 pounds per year, which equates to 22.6% of the reduction needed in the CRW (Table 4).

Classification	# Properties	Acres	IC Area (Acres)	IC TP Load (lbs/yr)	Pervious TP Load (lbs/yr)*	TP Load (lbs/yr)	Average IC Area (Acres)/Property
Commercial	2151	12,234	4,592	8,199	669	8,868	2.13
Industrial	517	3,280	1,389	2,470	168	2,638	2.69
Institutional Private	508	3,789	1,083	1,902	204	2,107	2.13
Multi-Family Residential	632	3,711	1,167	2,688	177	2,864	1.85
TOTAL	3,808	23,013	8,230	15,259	1,218	16,477	

Table 5: Commercial, Industrial, Institutional, and Multi-Family Residential Properties with ≥0.5 Acre Impervious Cover

*Pervious load does not include TP loads from forest or wetland areas on private properties

An IC size of ≥ 1.0 acre includes 2,120 CIIM properties and contributes a TP load of approximately 14,091 pounds per year (Table 6). Around 92% of the phosphorus load is generated from IC. Of the 2,120 properties, 1,176 are commercial, 335 are industrial, 315 are multi-family residential and 294 are institutional properties, and the TP load from each property type follows the same order. They include 56% of the total impervious cover from all CIIM properties. The average IC area per property ranges from 3.01 to 3.74 acres with multi-family residential as the lowest and industrial as the highest (Table 6). Reducing the phosphorus load from these properties by 65% has the potential TP reduction of 9,159 pounds per year, which equates to 19% of the reduction needed in the CRW (Table 4).

Classification	# Properties	Acres	IC Area (Acres)	IC TP Load (lbs/yr)	Pervious TP Load (lbs/yr)	TP Load (lbs/yr)	Average IC Area (Acres)/Property
Commercial	1,176	10,500	3,903	6,969	593	7,562	3.32
Industrial	335	2,957	1,254	2,230	156	2,385	3.74
Institutional Private	294	3,330	937	1,648	175	1,823	3.19
Multi-Family Residential	315	2,934	947	2,181	139	2,320	3.01
TOTAL	2,120	19,721	7,041	13,028	1,063	14,091	

Table 6: Commercial, Industrial, Institutional, and Multi-Family Residential Properties with ≥1 Acre Impervious Cover

*Pervious load does not include TP loads from forest or wetland areas on private properties

An IC size ≥ 2.0 acres includes 1,048 CIIM properties and contributes a phosphorus load of approximately 10,242 pounds per year (Table 7). They include 44% of the total impervious cover from all CIIM properties. The average IC per property ranges from 4.74 acres for multi-family residential to 5.42 acres for commercial properties, which indicates that many properties have more than 2 acres IC (Table 7). Reducing the phosphorus load from these properties by 65% has the potential TP reduction of 7,171 pounds per year, which equates to 15% of the reduction needed CRW (Table 4).

Classification	# Properties	Acres	IC Area (Acres)	IC TP Load (lbs/yr)	Pervious TP Load (lbs/yr)*	TP Load (lbs/yr)	Average IC Area (Acres)/Property
Commercial	561	7,865	3,043	5,432	430	5,861	5.42
Industrial	199	2,471	1,064	1,892	127	2,019	5.35
Institutional Private	137	2,581	717	1,268	126	1,394	5.23
Multi-Family Residential	151	2,334	716	1,651	108	1,759	4.74
TOTAL	1,048	15,252	5,540	10,242	790	11,033	

Table 7: Commercial, Industrial, Institutional, and Multi-Family Residential Properties with ≥2 Acres Impervious Cover
*Pervious load does not include TP loads from forest or wetland areas on private properties

An IC size ≥ 5.0 acres includes 337 CIIM properties where 188 are commercial, 71 are industrial, 45 are multi-family residential and 33 are institutional and the phosphorus load from each property type follows the same order (Table 8). These properties include 27% of the impervious cover of all CIIM properties. The average IC area per property ranges from 8.65 to 12.14 acres with multi-family residential as the lowest and institutional as the highest (Table 8). These values are much higher than the 5-acre threshold, indicating that some properties likely have more than 5 acres IC. These properties generate 6,642 pounds of TP per year and reducing the load by 65% has the potential TP reduction of 4,317 pounds per year, which equates to 9% of the reduction needed in the CRW (Table 4).

Classification	# Properties	Acres	IC Area (Acres)	IC TP Load (lbs/yr)	Pervious TP Load (lbs/yr)*	TP Load (lbs/yr)	Average IC Area (Acres)/Property
Commercial	188	4,393	1,908	3,407	258	3,665	10.15
Industrial	71	1,393	661	1,173	72	1,246	9.31
Institutional Private	33	1,171	401	718	55	773	12.14
Multi-Family Residential	45	1,317	389	900	57	958	8.65
TOTAL	337	8,274	3,358	6,199	443	6,642	

Table 8: Commercial, Industrial, Institutional, and Multi-Family Residential Properties with ≥5 Acres Impervious Cover
*Pervious load does not include TP loads from forest or wetland areas on private properties

Figure 8 displays the potential TP reduction realized for each land use type assuming the CIIM properties in the scenarios described above were required to achieve a 65% reduction in TP in stormwater discharges called for in the TMDL WLAs. Commercial properties have the largest phosphorus reduction potential for all IC sizes. While multi-family residential properties have the second highest phosphorus reduction potential when looking at CIIM properties with any IC size (all properties), the proportion of total reduction from Multi-family residential properties in each scenario decreases as the IC threshold increases (Figure 6) due to the fact that Multi-family residential properties have the lowest amount of IC per property in each scenario (Table 5-Table 8).

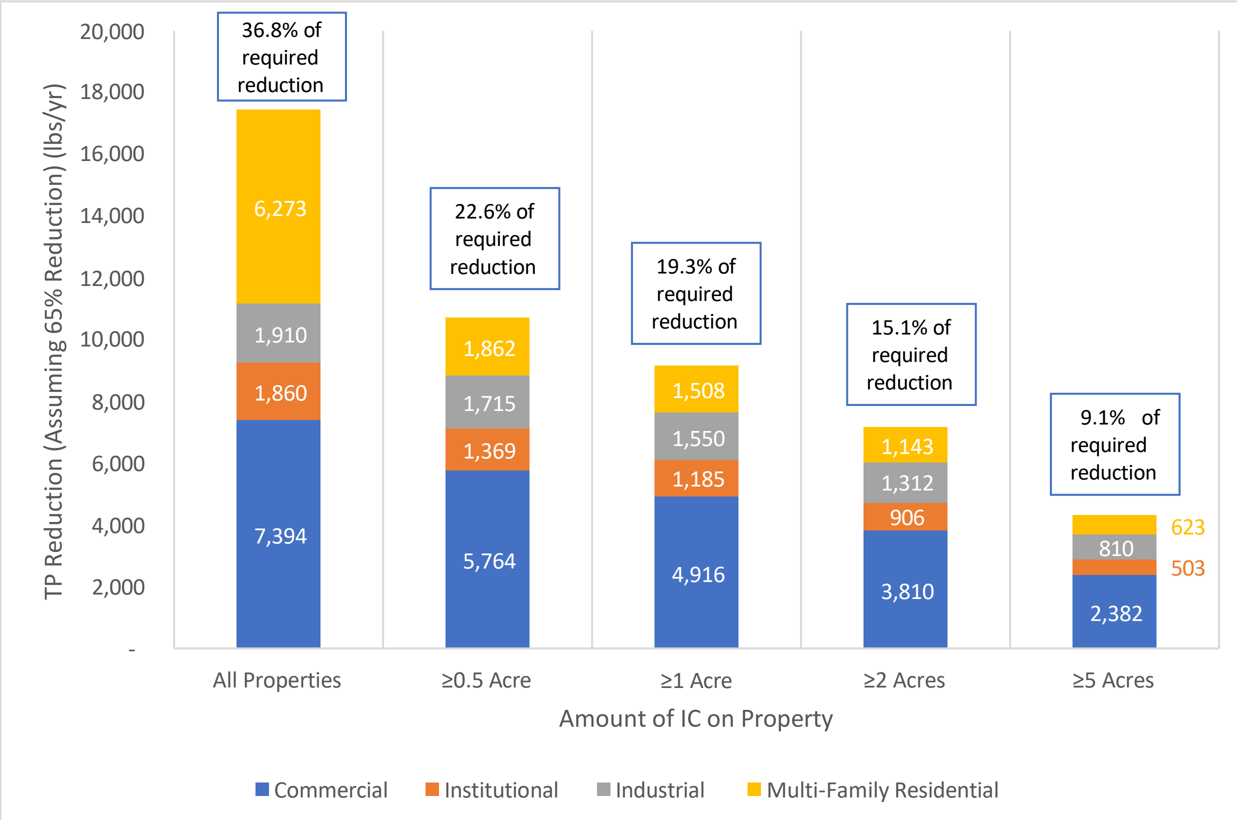

Figure 8: TP Reduction Assuming a 65% Reduction for CIIM Properties Based on Impervious Cover Size on Properties

IV. CONCLUSION

Stormwater systems in general, and in the highly-developed Charles River Watershed in particular, are complex, comprising different stormwater flow paths based on soils, slope, road design, piped network design, among other factors. This analysis does not attempt to reproduce stormwater flow paths from any property or land use group and focuses solely on the potential phosphorus in stormwater that could be discharged off any given property. It analyzes stormwater impacts and assesses the need for their reduction on a gross, aggregate scale, as EPA is entitled to do. *Natural Resources Defense Council, Inc. v. Costle*, 568 F.2d 1369, 1380 (D.C. Cir. 1977) (emphasis added). ("EPA may issue permits with conditions designed to reduce the level of effluent discharges to acceptable levels. This may well mean opting for a gross reduction in pollutant discharge rather than the fine-tuning suggested by numerical limitations. *But this ambitious statute is not hospitable to the concept that the appropriate response to a difficult pollution problem is not to try at all*."). The analysis demonstrated that private properties make up most of the phosphorus load in stormwater (over 60% of the baseline phosphorus load) in this watershed and that load is contributing to the Charles River not meeting water quality standards. Therefore, reducing the phosphorus in stormwater discharges from private properties is necessary to meet TMDL goals and water quality standards. While some action must be taken on private properties, it may be beneficial to target certain private properties for stormwater controls over others. It is likely that most of the discharges from private properties is discharged through the local community's municipal separate storm sewer system (MS4), making that municipality ultimately responsible for the phosphorus load coming off all private properties tied into their systems and regulated in the 2016 MA MS4 Permit. Municipalities will therefore likely be responsible for the majority of the phosphorus reductions in the CRW. However, placing the entire burden of phosphorus reductions on municipalities will likely not result in sufficient reduction to reach TMDL goals and WQS, indicating that designating stormwater discharges from certain classes of private properties for NPDES permits is required. In any scenario, municipalities will still need to engage the private property owners with smaller property size or IC size in order to eventually meet TMDL goals and WQS, but requiring action on private properties with larger amounts of IC now through NPDES permitting provides greater flexibility to the communities in deciding which private properties to target to meet their own MS4 permit obligations. Requiring actions through NPDES permitting on those properties with larger IC sizes reduces the burden on the community that holds an MS4 permit, targets those properties generating the largest amount of phosphorus in stormwater on a per-property scale, and makes meeting TMDL goals and water quality standards possible.

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