WATERSHED ANALYSIS OF THE MYSTIC RIVER AND NEPONSET RIVER WATERSHEDS

TASK 4C TECHNICAL REPORT
NEPONSET RIVER WATERSHED PROPERTY PARCEL ANALYSES

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1 INTRODUCTION

The Neponset River Watershed is highly residential, drains into Boston Harbor, and faces multiple water quality impairments including pathogens and nutrients (phosphorus and nitrogen) from human activity and urban development. These impairments are evidenced by high fecal bacteria levels. Twenty-four waterbody segments have TMDLs for fecal bacteria, with illicit sewer connections, failing septic systems, and stormwater carrying fecal matter from domestic and wild animals identified as the primary sources (MassDEP, 2012, 2002) with an additional eighteen segments listed as requiring a TMDL (MassDEP, 2023). Stormwater runoff also carries excess nutrients into waterbodies which can cause algal blooms and macrophyte growth that contribute to anoxic bottom waters that do not support aquatic life, reduce water clarity, degrade waterbodies' aesthetic quality, and impair designated uses such as fishing, swimming, and boating, as evidenced in the nearby Charles River and Mystic River Watersheds where stormwater is the primary source of these pollutants (U.S. EPA, 2022a; USEPA, 2020). Within the Neponset River Watershed, there are twenty-three segments on the 303(d) list with evidence of nutrient pollution and eutrophication based on impairments for either nutrients, dissolved oxygen, turbidity, aquatic plants (macrophytes), or algae (MassDEP, 2023). On August 24, 2020, the U.S. Environmental Protection Agency (EPA) received a residual designation petition from the Conservation Law Foundation for the Neponset River Watershed. The petition requests that EPA permit stormwater from commercial, industrial, institutional, and multi-family residential (CIIM) properties of one acre or greater under the National Pollutant Discharge Elimination System (NPDES) program to meet water quality standards (WQS) in the Neponset River.

This report presents a methodology to develop, and analyses of, parcel-level stormwater TP and total nitrogen (TN) loading within the Neponset River Watershed that may be used by EPA Region 1 to support decision making regarding the residual designation petition. Long-term stormwater runoff and pollutant loading developed for the Neponset River Watershed (Paradigm Environmental, 2023a) forms the basis against which parcel-level stormwater management strategies can be evaluated. Key information presented in this report includes an analysis of CIIM parcels, their characteristics such as the amount of impervious cover (IC), and their estimated stormwater nutrient loads. IC is the largest source of stormwater runoff within the watershed and findings from an analysis of the relationship between the number of CIIM parcels, IC area, and TP load are presented to demonstrate potential strategies designating the fewest number of parcels while achieving the largest possible pollutant reduction benefits. The results of this report can be further refined using other considerations, such as where and how communities facing environmental justice (EJ) concerns may be impacted, and apportioned into each municipality within the watershed where, ultimately, progress can be made towards improving water quality.

2 METHODOLOGY

The general methodology presented here follows the process used in the Charles River Watershed (CRW) Total Phosphorous analysis (U.S. EPA, 2022a Appendix 4, 2022b). Key steps, refinements, and quality assurance checks are detailed in the following subsections.

2.1 Data Inventory

Readily available data necessary for parcel analysis were collected, reviewed, and assessed. Data were obtained from online repositories as well as from EPA staff. Table 2-1 provides an inventory of the GIS data collected and indicates the use of that dataset.

Table 2-1. Data used in the parcel analysis

Name	Use	Source	Source Link	Source Date
2016 Land use and land cover	IC calculation	MassGIS	https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use	May 2019
Hydrologic Response Units (HRUs)	Loading rate and load calculations	Task 4A and 4B (Paradigm Environmental, 2023a)		
Parcel boundaries	For summary results	MassGIS	https://www.mass.gov/info-details/massgis-data-property-tax-parcels	Feb 2023
L3 Tax Assessor Table	Parcel details	MassGIS		Feb 2023
Municipal boundaries	For summary results	MassGIS	https://www.mass.gov/info-details/massgis-data-municipalities	April 2022
Neponset River Watershed	For summary results	MassGIS	https://www.mass.gov/info-details/massgis-data-major-watersheds	June 2000
Subwatershed boundaries	For summary results	MassGIS	https://www.mass.gov/info-details/massgis-data-drainage-sub-basins	December 2007
Municipal separate storm sewer system (MS4) boundaries	For summary results	EPA	Admin Record	

2.2 Parcel Analysis

Parcel analysis includes two main components: 1) GIS-based spatial analysis and 2) summary analysis using a python-based tool. These steps are described below and were formulated to be as accurate, transparent, and reproducible as feasible. The parcel analysis workflow, required inputs, and outputs is shown in Figure 2-1. Results of the parcel analysis are summary attributes for each parcel, as shown in Table 2-2, and additional summaries aggregating the parcel data with other conditions and spatial scales as detailed in Section 3.

Table 2-2. Parcel-level summary attributes calculated

Attribute	Description
Loc_ID	Unique parcel ID
Parcel Type	Tax classification (e.g., TAX, FEE, ROW, WATER)
Municipality Name	City or Town name
Owner	Property owner's name
Owner Address	Property owner's address
Owner City	Property owner's city
Owner Country	Property owner's country
Owner State	Property owner's state
Owner Zip Code	Property owner's zip code
Lot Size (ac)	Deed area (converted to acres in this analysis)
Site Address	Site address
Site Zip Code	Site address zip code
Units	Number of units on the property
Year Built	Year building was built
Public/Private	Owner type (public or private) based on filtering described in Section 2.3.1
FY	Year of data
MS4 (boolean, 1 = within MS4)	Inside or outside of the MS4 area
CSA (boolean, 1 = within CSA)	Inside or outside of the Combined Sewer Area (CSA)
Subbasin	Subbasin name(s) and percentages if multiple
Area in Major Basin (%)	Percentage of parcel area with the watershed
Use Code	Use code from Tax Assessor
L3 Use Description	Use description from Tax Assessor
Dept. Revenue Description	Use description from MA Dept. of Revenue (from Use Code)
Parcel Use Group	Land use classification in the current analysis (from Use Code)
MassGIS Land Use	Land use from MassGIS 2016 LULC
Total Area (ac)	Parcel area calculated in the current analysis
IC Area (ac)	The impervious cover area from the 2016 data
IC Percent	Percent impervious cover calculated from MassGIS 2016 LULC
Wetland Area (ac)	Wetland area on the parcel
Wetland Percent	Wetland percent on the parcel
Water Area (ac)	Water area on the parcel
Water Percent	Water percent on the parcel
Forest Area (ac)	Forest area on the parcel
Forest Percent	Forest percentage on the parcel
Pervious Area (ac)	Pervious area
Pervious Percent	Percent pervious

Attribute	Description
Total Pervious Load (lb/yr)	TP and TN load from the parcel's pervious cover
IC Load (lb/yr)	TP and TN load from the parcel's impervious cover
Total parcel load (lb/yr)	Total TP and TN load from parcel

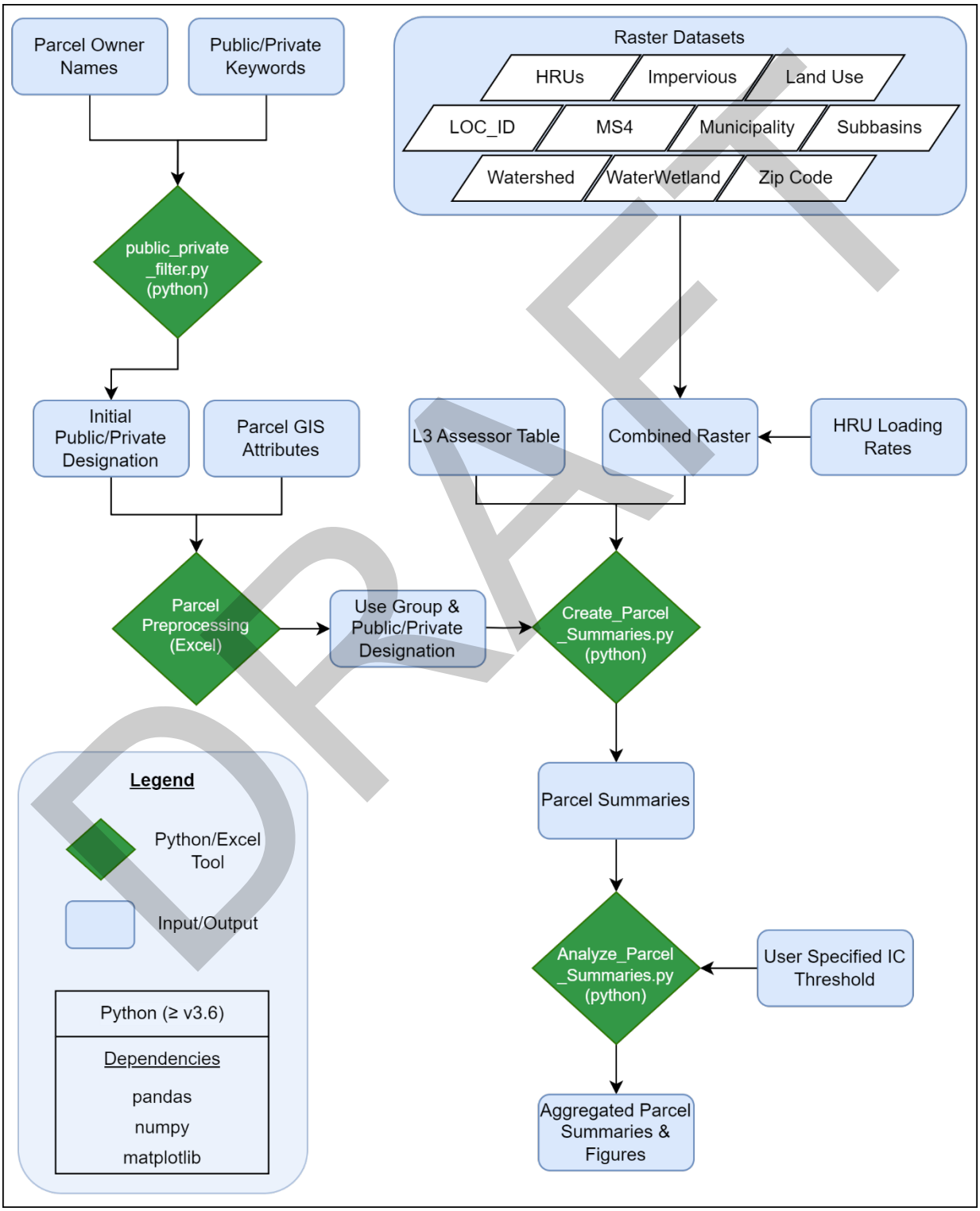

Figure 2-1. Parcel analysis workflow, including relevant requirements, inputs, and outputs.

2.2.1 *GIS-based Spatial Analysis*

The GIS-based processing is raster-based and assembles the required data for parcel-level analysis and summaries at other spatial scales. The output of this step is a combined raster layer and attribute table listing the unique combinations of all input rasters. The major GIS processing steps are:

1. Ensure all layers use the same projection (EPSG: 26986, Massachusetts State Plane Coordinate System, Mainland Zone).
2. Clip all layers to the area of interest (Neponset River Watershed boundary).
3. Convert all polygon layers to rasters with 1-square meter cells (e.g., parcel layer). The raster cell values will be a unique identifier (e.g., *LOC_ID* for parcels) to allow the joining of attributes in later steps.
4. Overlay all rasters using the ESRI Combine tool. The output is a combined raster and an attribute table with a unique identifier for each unique combination of input raster values.

The combined raster attribute table is converted into an Excel spreadsheet and the pollutant load calculated based on the HRU by multiplying the area of each unique combination by the appropriate loading rate. The development of loading rates is described in the Task 4A-B memo (Paradigm Environmental, 2023a).

Parcel Preprocessing

One additional processing step was performed on the tax parcel polygon layer to create a second input to the python-based processing described below. Namely, once all the parcels were clipped to the watershed, all the unique "Use_Codes" were mapped to a single use group similar to those used in the CRW TP analysis (Table 2-3). This allows users to easily update parcel classifications as additional parcel details or corrections become available, without having to modify the python code. The Use Codes are generally, but not always, standardized codes set by the MA Department of Revenue and provide a greater number of categories than the 2016 LULC dataset (MA Dept. of Revenue Division of Local Services, 2016). For example, the CRW TP analysis grouped several Code 9 Use Code values into institutional groups; these categories do not exist in the MassGIS 2016 LULC dataset but are important for evaluating loading from CIIM parcels. As well as using the CRW Use Code groups, a right-of-way group and water group were added as the current analysis considers all parcels within the Neponset River Watershed. A public or private designation was assigned to each parcel during this preprocessing step (detailed in Section 2.3.1).

Table 2-3. Use Groups assigned in the CRW and Neponset analyses

CRW Use Group	Neponset Use Groups	Public/Private
Agriculture	Agriculture	Private
Commercial	Commercial	Public or Private
Industrial	Industrial	Public or Private
Open Land	Open Land	Public or Private
Local Institutional	Local Institutional	Public
Private Institutional	Private Institutional	Private
State Institutional	State Institutional	Public
MultiFamily Residential	MultiFamily Residential	Public or Private
Single Family Residential	Single Family Residential	Public or Private
Federal Institutional	Federal Institutional	Public
Two Family Residential	MultiFamily Residential	Public or Private
Three Family Residential	MultiFamily Residential	Public or Private
MultiFamily Residential (4-8)	MultiFamily Residential	Public or Private

CRW Use Group	Neponset Use Groups	Public/Private
MultiFamily Residential (>8)	MultiFamily Residential	Public or Private
	Right-of-Way	Public or Private
	Water	Public or Private

The main steps in parcel Use Group classification are listed below. In general, each step reclassifies unknowns from the preceding steps.

1. Assign from Use Code based on existing CRW classification
2. Assign institutional categories from Use Code 9 parcels unique to the Neponset River Watershed
3. Assign "Unknown" if no Use Code and no Owner
4. Assign Multi-Use (Table 2-4)
5. Assign from major Use Code category (first digit, Table 2-5)
6. Assign from PolyType (only Right-of-Way and Water)
7. Remaining Unknowns classified from the dominant MassGIS 2016 LULC category.
8. Manually reclassify select parcels.

Table 2-4. Reclassification table for Multi-Use parcels

2 Digit Use Code	Use Group
01	MultiFamily Residential
03	Commercial
04	Industrial
06	Open Land
07	Open Land
08	Open Land
09	Private Institutional

Table 2-5. Reclassification table for major Use Code category

1 Digit Use Code	Use Group
1	MultiFamily Residential
2	Open Land
3	Commercial
4	Industrial
5	Unknown
6	Open Land
7	Open Land
8	Open Land
9	Private Institutional

Results of the parcel preprocessing, in terms of total distribution within the Neponset River Watershed, are shown in Figure 2-2 and mapped in Figure 2-3. This analysis shows that a third (33%) of the watershed area is made up of single-family residences; combined multi-family residences make up 6%. Public institutional groups (local, state, and federal) make up 6.4% of the watershed area with private institutional totaling 3.6%. In total, commercial, industrial, and private institutional constitute 13.5% of the watershed area. The distribution of public/private parcels, grouped by Use Code group, is shown in Table 2-6. In total, the current classification has 33.9% public parcels (largely open land) and 66.1% private by area. By parcel count, however, the watershed is dominated by private parcels (95.8%).

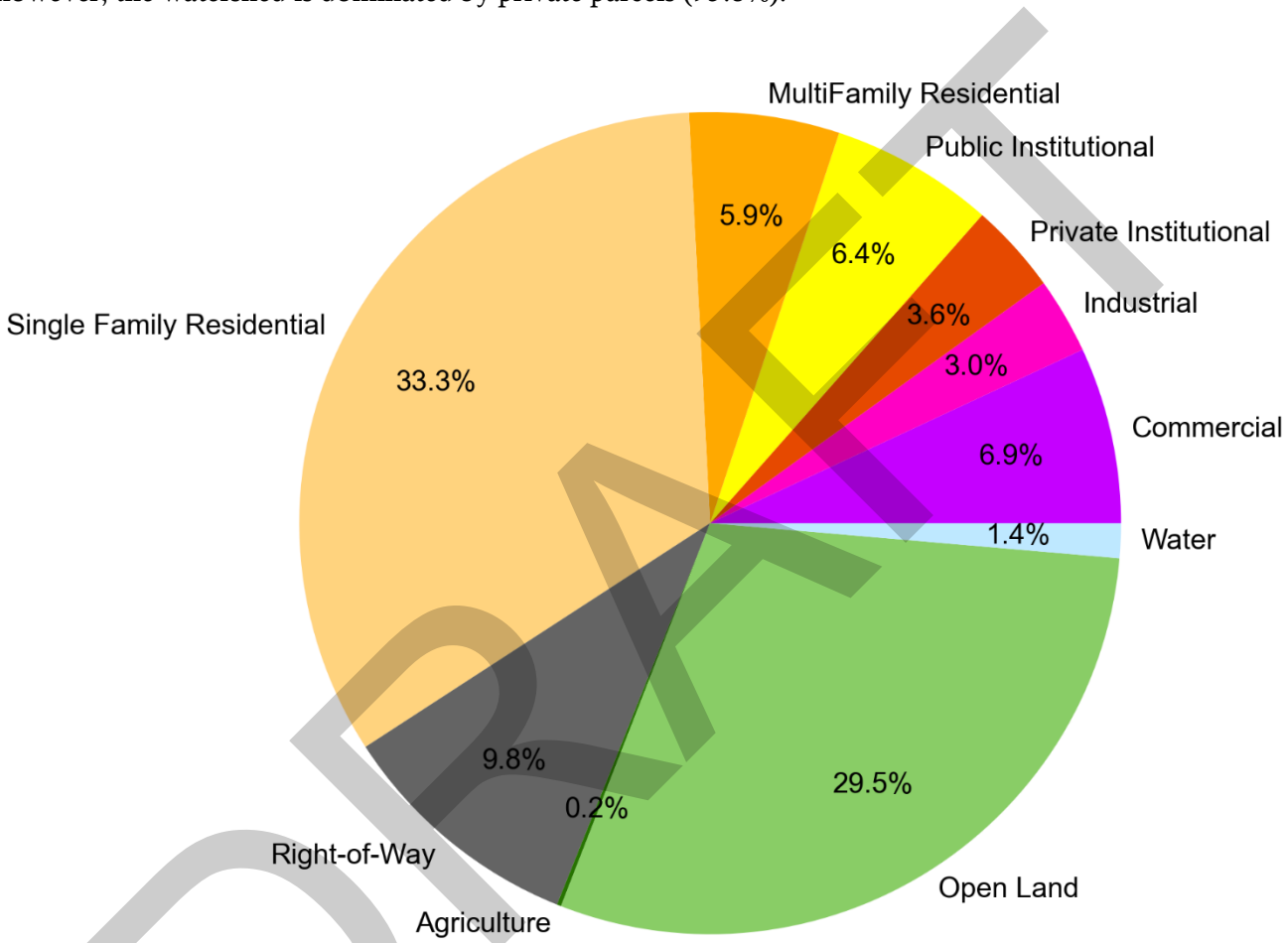

Figure 2-2. Distribution of parcel area by Use Group within the Neponset River Watershed.

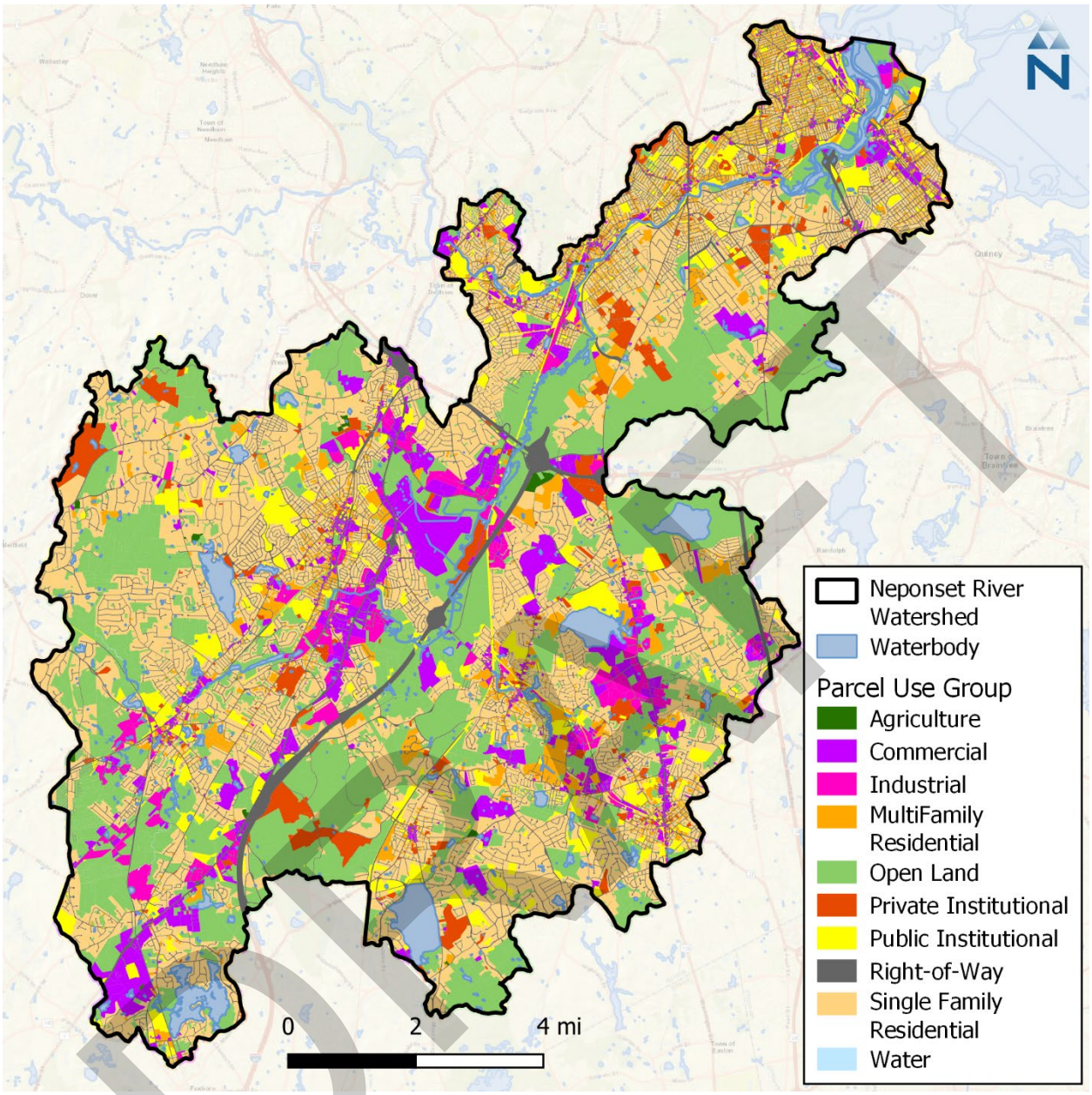

Figure 2-3. Map of parcel Use Groups within the Neponset River Watershed. Note that the resolution of this map is parcel-scale; waterbodies exist within non-Water class parcels and have been added to aid visualization.

Table 2-6. Distribution of public and private parcel areas by Use Group

Public/Private	Use Group	Count	Count (%)	Total Area (ac)	Total Area (%)
Private	Agriculture	66	0.08	126.77	0.17
	Commercial	2,585	3.25	5,189.70	6.92
	Industrial	507	0.64	2,241.27	2.99
	MultiFamily Residential	13,315	16.74	6,214.75	8.29
	Open Land	4,883	6.14	9,844.63	13.14
	Private Institutional	813	1.02	2,667.03	3.56
	Public Institutional	0	0.00	0.00	0.00
	Right-of-Way	121	0.15	54.93	0.07
	Single Family Residential	53,929	67.81	24,987.16	33.34
	Water	0	0.00	0.00	0.00
	Subtotal	**76,219**	**95.8**	**51,326.24**	**68.5**
Public	Agriculture	0	0.00	0.00	0.00
	Commercial	4	0.01	10.46	0.01
	Industrial	0	0.00	0.00	0.00
	MultiFamily Residential	0	0.00	0.00	0.00
	Open Land	810	1.02	12,303.27	16.42
	Private Institutional	0	0.00	0.00	0.00
	Public Institutional	2,288	2.88	4,820.08	6.43
	Right-of-Way	164	0.21	5,462.53	7.29
	Single Family Residential	0	0.00	0.00	0.00
	Water	42	0.05	1,021.75	1.36
	Subtotal	**3,308**	**4.2**	**23,618.10**	**31.5**
	Total	**79,527**	**100**	**74,944.34**	**100**

Public/ Private	Use Group	Count	Count (%)	Total Area (ac)	Total Area (%)
Private	Agriculture	65	0.08	126.74	0.17
	Commercial	2,564	3.22	5,186.25	6.92
	Industrial	507	0.64	2,241.27	2.99
	MultiFamily Residential	13,233	16.64	4,425.76	5.91
	Open Land	4,967	6.25	9,841.80	13.13
	Private Institutional	813	1.02	2,667.03	3.56
	Right-of-Way	113	0.14	54.43	0.07
	Single Family Residential	53,929	67.81	24,987.16	33.34
	Water	0	0.00	0.00	0.00
	Subtotal	**76,191**	**95.8**	**49,530.46**	**66.1**
Public	Agriculture	0	0.00	0.00	0.00

	Commercial	4	0.01	10.46	0.01
	Industrial	0	0.00	0.00	0.00
	MultiFamily Residential	0	0.00	0.00	0.00
	Open Land	810	1.02	12,303.27	16.42
	Public Institutional	2,288	2.88	4,820.08	6.43
	Right-of-Way	191	0.24	7,258.29	9.68
	Single Family Residential	0	0.00	0.00	0.00
	Water	43	0.05	1,021.78	1.36
	Subtotal	**3,336**	**4.2**	**25,413.88**	**33.9**
Total		**79,527**	**100**	**74,944.34**	**100**

2.2.2 *Python-Based Summary Analysis*

The raster attribute table output from GIS processing was further processed using a tool developed in python (Figure 2-1). Python is a commonly used programming language for data management and analysis due to its ease of use and readability; all python software and packages used in this analysis are freely available and open source. The output of this processing is an Excel compatible spreadsheet file including every parcel and additional summaries based on aggregating the data with different conditions and spatial scales. The major python processing steps include:

1. Read the combined raster attribute table into a data frame using the pandas python package.
    - This is a powerful data structure that allows for a wide variety of data manipulation and evaluation.
    - Efficient for large-size datasets.
2. Join relevant attribute tables.
    - The parcel *LOC_ID* is used to join parcels with the preprocessed parcel data and the L3 Assessors Table, which provides parcel details such as site address, owner information, and year built.
    - Performing this step outside of a GIS environment should reduce processing time and potential data overlap errors.
3. Calculate parcel-level information.
    - The information shown in Table 2-2 is calculated for each parcel.
4. Generate parcel-level summary tables.
    - A summary spreadsheet file is generated and saved. The file includes all necessary information as shown in Table 2-2 for each property parcel.
    - The code can also optionally generate a summary table for multiple attributes (e.g., the unique intersection of parcel, municipality, and subbasin). This is useful for additional QA of area and loads.
5. Generate additional summaries.
    - Additional summaries of the calculated parcel data are created by aggregating with other conditions and spatial scales.
    - For example, TP loading from IC areas can be summarized for parcels of varying IC areas and Use Groups.

Outputs of the python-based processing are presented and evaluated in the Results and Discussion section. All input data, processing codes, and outputs will be made available to EPA; outputs can be visualized by joining with the *LOC_ID* in the parcel polygon layer.

2.3 Refinements from CRW Analysis

Parcel analysis for the Neponset River Watershed is based on the general methodology used in the Charles River Watershed. Several refinements were made to improve transparency and consistency including:

1. High-resolution (i.e., 1 squared meter cell size) raster-based GIS data processing
2. A consistent source of land use classification (MassGIS 2016 LULC)
3. Binary public or private designation at parcel-scale
4. The long-term annual average loading rates from the Opti-Tool HRU time series (for a period of 2007-2016)
5. The pollutant loading from the pervious areas is based on the HSG classification, providing additional resolution for load calculation.

The GIS processing performed in the CRW TP analysis was based primarily on polygon datasets, which can lead to errors or require additional processing with polygons being duplicated and/or overlapped. For the Neponset River analysis, the raster-based approach (Section 2.2.1) spatially aligns all datasets to eliminate errors such as polygon slivers or overlap of multi-part polygons.

The impervious cover is based on a rasterized version of the MassGIS 2016 LULC dataset, which contains the most recent and detailed IC data currently available. The land cover information in this layer is consistent with the Coastal Change Analysis Program (C-CAP)'s high-resolution land cover classification scheme and the entire LULC layer has been thoroughly vetted and documented by MassGIS (MassGIS, 2016). The CRW analysis used both a MassGIS 2005 IC raster and the 2016 LULC polygon dataset and stated that the 2005 IC raster was overly simplified. However, the 2016 land cover classifications are based on 1-meter aerial imagery and can be converted back to a 1-meter raster with essentially no loss in accuracy. This was evaluated for the Mystic River Watershed and shown in the Task 3C memo (Paradigm Environmental, 2023b). Additionally, loading rates were calculated from the Opti-Tool Hydrologic Response Units (HRUs) that are primarily based on the MassGIS 2016 LULC dataset and average annual SW HRU pollutant load export rates that were developed in subtasks 4A and 4B (Paradigm Environmental, 2023a).

2.3.1 *Public/Private Classification*

For the Neponset River Watershed, a binary public/private classification based on similar Use Codes as those used in the CRW analysis was developed. The public/private designation uses keyword filters on the "OWNER1" attribute as an initial designation which is then further refined by looking at the assigned Use Group (Table 2-3). For example, any local, state, or federal institutional groups that were not classified as public in the keyword filtering were changed to public. These keywords are listed in Table 2-7 and were selected by visual inspection of unique code 9 owner names remaining after filtering out CRW use codes for local, state, and federal institutional groups. Binary classification is important to help distinguish between parcels already subject to regulation.

The main steps in creating the public/private designation are:

1. Owner keyword filtering (performed in python script)
2. Update RoW based on parcel PolyType
3. Classify parcels with a "Water" Use Group as public
    a. These parcels are predominately water and account for only 0.1% of the total TP and TN loads (Table 3-2)
4. Classify unknowns based on Use Group
5. Update Residential
    a. If residential and not Use code 9XX: private
6. Manual reclassification of selected parcels

Table 2-7. OWNER1 keywords for initial public/private parcel filtering

Public Keywords		
CITY OF	MASS BAY TRANS AUTHORITY	MASSACHUSETTS COMM OF METRO DIST COMM
COMM OF MASS	MASS BAY TRANS, AUTHORITY	MASSACHUSETTS COMMON OF
COMMNWLTH OF MASS	MASS BAY TRANS. AUTH	MASSACHUSETTS COMMONWEALTH
COMMONWEALTH OF	MASS BAY TRANS. AUTHORITY	MASSACHUSETTS COMMONWEALTH OF
COMMWLTH OF MASS	MASS BAY TRANSP AUTH	MASSACHUSETTS DEPARTMENT
COMWLTH OF MASS	MASS BAY TRANSPORT AUTH	MASSACHUSETTS GOVT LAND BANK
COUNTY OF	MASS BAY TRANSPORTATION	MASSACHUSETTS PORT AUTH
DCR	MASS BAY TRANSPORTATION AUTH	MASSACHUSETTS PORT AUTHORITY
DEPARTMENT OF	MASS BAY TRANSPTN AUTHOR	MASSACHUSETTS TURNPIKE AUTHORITY
DEPT OF	MASS DOT	MBTA
DEPT. OF	MASS ELECTRIC CO	POST OFFICE
FIRE + POLICE BUILDING	MASS PORT AUTHORITY	REDEVELOPMENT ASSOC
FIRE DEPARTMENT	MASS TURNPIKE AUTHORITY	REDEVELOPMENT AUTH
HOUSING AUTH	MASS WATER RESOURCE AUTH	TOWN OF
LIBRARY	MASSACHUSETT PORT AUTHORITY	TOWN OFFICE BUILDING
M B T A	MASSACHUSETTS BAY TRANS AUTH	U S POST OFFICE
MASS BAY AUTHORITY	MASSACHUSETTS BAY TRANSIT AUTHORITY	UNITED STATES OF AMERICA
MASS BAY TRAN AUTHORITY	MASSACHUSETTS BAY TRANSIT AUTHORITY	UNITED STATES POSTAL SERVICE
MASS BAY TRANS AUTH	MASSACHUSETTS COMM OF	UNITED STATES PROPERTY
Private Keywords		
COMPANY	CONDO	LLC
TRUST	TRS	CREDIT UNION
REALTY	RLTY	INC
INCORPORATED		

2.4 Quality Assurance / Quality Control (QA/QC)

Several QA/QC steps have been performed to ensure the highest level of accuracy feasible. The greatest source of uncertainty in this analysis is the parcel attributes from the L3 Tax Assessor table. As seen in Table 2-7, owner names and other details are not standardized and may have typos or other inconsistencies that make automated processing difficult. To address this, parcels that remain unclassified as public/private after the processing described in Section 2.3.1 were manually examined and updated.

Additional checks include:

- Ensuring parcels have a single MassGIS 2016 land use category by intersecting parcel boundaries and reclassified land use categories.
- Evaluating the fraction of public and private ownership for feasibility
- Checking the sum of all parcel areas within a municipality equals the sum of municipality area and similar checks for other boundaries such as sub-watersheds.

2.5 Limitations

One limitation of this analysis is that parcels crossing the boundary of the Neponset River Watershed will only be evaluated for the portion of their area within the watershed. This is not expected to impact the calculation of load within the watershed but will impact the calculation of area for different land uses at the parcel scale. For example, a parcel may have IC outside of the watershed boundary, but only the IC area and load within the watershed will be accounted for. The percentage of IC area will be calculated as the IC area within the watershed divided by the total parcel area within the watershed. The impact of splitting parcels on the watershed boundary should be negligible given that this is a small portion of the total number of parcels.

3 RESULTS AND DISCUSSION

This section describes the calculated TP and TN loads from private and public properties based on the parcel Use Group. Analyses include the proportional impact of different private property classes, the proportional impact of different property sizes based on the amount of impervious cover on each property, and a range of the optimal IC size thresholds to reduce the greatest amount of TN and TP while potentially designating the fewest number of properties. The analyses presented here do not distinguish between parcels inside or outside of MS4 areas. Only 5% of the area within the Neponset River Watershed is outside MS4 boundaries and this area is predominately undeveloped and pervious (see Figure 2-9 and Table 2-9 in Paradigm Environmental [2023a]).

Total baseline nutrient loads used in this parcel analysis are from the 1992-2022 time period and represent unattenuated stormwater TP and TN loads of 34,367 lb/yr and 253,686 lb/yr, respectively (Table 3-1). Note that there is 1,254 ac of parcel area outside of any municipality (denoted as "No Data" in Table 3-1). TP load from these areas is 0.05% of the watershed total but was not assigned to any municipality; this corresponds to the approach for calculating municipality loading used in the loading analysis (Paradigm Environmental, 2023a).

Table 3-1. Stormwater annual average TP and TN loads (1992-2022) for municipalities within the Neponset River Watershed

Municipality	Unattenuated Annual Average (1992 2022) Load (lb/yr)			
	Public (%)	Private (%)	TP	TN
BOSTON	30%	70%	5,190.56	37,058.56
CANTON	29%	71%	4,660.38	35,662.07
DEDHAM	34%	66%	1,240.24	9,340.38
DOVER	18%	82%	415.84	2,815.36
FOXBOROUGH	21%	79%	1,112.64	8,562.31
MEDFIELD	27%	73%	447.38	3,088.03
MILTON	34%	66%	3,289.64	23,747.69
NORWOOD	26%	74%	4,439.66	34,070.60
QUINCY	31%	69%	1,813.70	13,204.50
RANDOLPH	49%	51%	320.40	2,315.00
SHARON	36%	64%	2,649.47	18,981.10
STOUGHTON	30%	70%	2,253.34	16,534.24
WALPOLE	31%	69%	4,350.17	31,983.97
WESTWOOD	29%	71%	2,165.69	16,148.12
No Data[1]	61%	39%	18.19	173.57
		Total	**34,367.30**	**253,685.50**

[1]Note that there are 274 ac of parcel area within the Neponset River Watershed that are not covered by a municipal boundary. These areas represent 0.05% and 0.07% of the total TP and TN loads, respectively.

3.1 All Parcels

A total of 79,527 parcels were analyzed within the Neponset River Watershed. More than two thirds of the parcels are single family residential (68%) and multi-family residential parcels make up another 17%. By land area these two categories make up 42%. Open land makes up 30% of the parcel area and is approximately evenly split between public and private.

Figure 3-1 illustrates the distribution of summary attributes by Public/Private designation for all parcels in the Neponset River Watershed. Private parcels account for 96% of parcels and 66% of total parcel area. Twenty-one percent of total parcel area is impervious cover, with private parcels having 1.8 times as much total IC area as public parcels (64% of total IC area). In terms of nutrient loading, private parcels contribute 70% of the total TP and 69% of the total TN. Loading from IC within private parcels amounts to 81% of the total TP and 82% of the total TN load from private parcels. Private IC load represents 57% of total TP and total TN from all parcels. These results indicate that private parcels contribute nearly three quarters of the nutrient load and may require further stormwater controls for the watershed to meet its water quality goals. Table 3-2 and Table 3-3 provide additional details summarizing the IC area and load for parcels by Use Group and Private/Public designation for TP and TN, respectively.

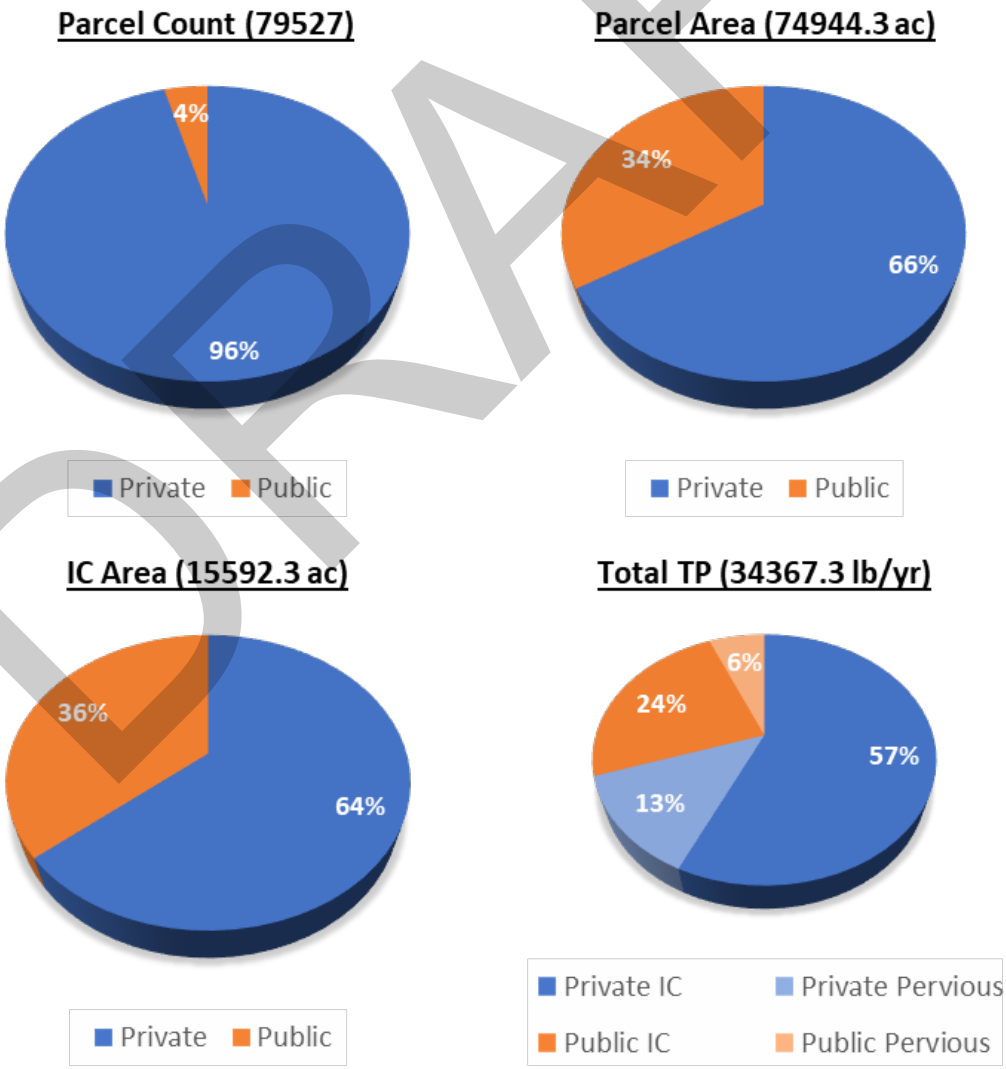

Figure 3-1. Private/Public summaries for all parcels within the Neponset River Watershed.

Table 3-2. Summary of parcel attributes by Use Group and Public/Private designation with TP*

Public/ Private	Use Group	Count	Count (%)	Total Area (ac)	Total Area (%)	IC Area			TP Load (lb/yr)				
						Acre	% IC of Total Area	Parcel Avg. (ac)	IC	Pervious	Total	Total (%)	Parcel Total Avg.
Private	Agriculture	65	0.08	126.74	0.17	20.56	16.22	0.32	36.09	23.32	59.41	0.17	0.91
	Commercial	2,564	3.22	5,186.25	6.92	2,266.98	43.71	0.88	4,083.84	302.19	4,386.03	12.76	1.71
	Industrial	507	0.64	2,241.27	2.99	1,020.67	45.54	2.01	1,835.81	91.33	1,927.14	5.61	3.80
	MultiFamily Res.	13,233	16.64	4,425.76	5.91	1,695.04	38.30	0.13	3,977.59	311.37	4,288.96	12.48	0.32
	Open Land	4,967	6.25	9,841.80	13.13	413.04	4.20	0.08	750.19	1,086.79	1,836.99	5.35	0.37
	Private Inst.	813	1.02	2,667.03	3.56	410.64	15.40	0.51	742.43	296.06	1,038.49	3.02	1.28
	Right-of-Way	113	0.14	54.43	0.07	26.13	48.01	0.23	36.64	2.81	39.45	0.11	0.35
	Single Family Res.	53,929	67.81	24,987.16	33.34	4,105.84	16.43	0.08	8,082.22	2,345.06	10,427.28	30.34	0.19
	Water	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	**76,191**	**95.8**	**49,530.46**	**66.1**	**9,958.90**	**20.1**	--	**19,544.82**	**4,458.92**	**24,003.73**	**69.8**	--
Public	Agriculture	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Commercial	4	0.01	10.46	0.01	7.85	75.02	1.96	14.14	0.36	14.50	0.04	3.62
	Industrial	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MultiFamily Res.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Land	810	1.02	12,303.27	16.42	93.06	0.76	0.11	161.73	1,476.44	1,638.17	4.77	2.02
	Public Inst.	2,288	2.88	4,820.08	6.43	840.61	17.44	0.37	1,461.28	429.17	1,890.44	5.50	0.83
	Right-of-Way	191	0.24	7,258.29	9.68	4,689.99	64.62	24.55	6,557.05	255.43	6,812.48	19.82	35.67
	Single Family Res.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Water	43	0.05	1,021.78	1.36	1.87	0.18	0.04	3.00	4.97	7.97	0.02	0.19
	Subtotal	**3,336**	**4.2**	**25,413.88**	**33.9**	**5,633.38**	**22.2**	--	**8,197.20**	**2,166.37**	**10,363.57**	**30.2**	--
Total		**79,527**	**100**	**74,944.34**	**100**	**15,592.28**	**20.8**	--	**27,742.02**	**6,625.28**	**34,367.30**	**100**	--

* A darker color gradient represents increasing value within a column.

Table 3-3. Summary of parcel attributes by Use Group and Public/Private designation with TN*

Public/ Private	Use Group	Count	Count (%)	Total Area (ac)	Total Area (%)	IC Area			TN Load (lb/yr)				
						Acre	% IC of Total Area	Parcel Avg. (ac)	IC	Pervious	Total	Total (%)	Parcel Total Avg.
Private	Agriculture	65	0.08	126.74	0.17	20.56	16.22	0.32	301.04	164.12	465.16	0.18	7.16
	Commercial	2,564	3.22	5,186.25	6.92	2,266.98	43.71	0.88	34,061.46	2,468.02	36,529.48	14.40	14.25
	Industrial	507	0.64	2,241.27	2.99	1,020.67	45.54	2.01	15,528.90	725.58	16,254.48	6.41	32.06
	MultiFamily Res.	13,233	16.64	4,425.76	5.91	1,695.04	38.30	0.13	24,118.65	2,214.67	26,333.32	10.38	1.99
	Open Land	4,967	6.25	9,841.80	13.13	413.04	4.20	0.08	5,370.44	7,398.24	12,768.68	5.03	2.57
	Private Inst.	813	1.02	2,667.03	3.56	410.64	15.40	0.51	6,214.73	2,024.01	8,238.74	3.25	10.13
	Right-of-Way	113	0.14	54.43	0.07	26.13	48.01	0.23	270.13	20.30	290.43	0.11	2.57
	Single Family Res.	53,929	67.81	24,987.16	33.34	4,105.84	16.43	0.08	58,446.03	16,377.44	74,823.47	29.49	1.39
	Water	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	**76,191**	**95.8**	**49,530.46**	**66.1**	**9,958.90**	**20.1**	--	**144,311.37**	**31,392.38**	**175,703.75**	**69.3**	--
Public	Agriculture	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Commercial	4	0.01	10.46	0.01	7.85	75.02	1.96	119.68	3.23	122.91	0.05	30.73
	Industrial	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MultiFamily Res.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Land	810	1.02	12,303.27	16.42	93.06	0.76	0.11	1,343.55	10,888.38	12,231.94	4.82	15.10
	Public Inst.	2,288	2.88	4,820.08	6.43	840.61	17.44	0.37	12,138.61	3,221.03	15,359.64	6.05	6.71
	Right-of-Way	191	0.24	7,258.29	9.68	4,689.99	64.62	24.55	48,290.44	1,906.40	50,196.84	19.79	262.81
	Single Family Res.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Water	43	0.05	1,021.78	1.36	1.87	0.18	0.04	23.95	46.47	70.42	0.03	1.64
	Subtotal	**3,336**	**4.2**	**25,413.88**	**33.9**	**5,633.38**	**22.2**	--	**61,916.23**	**16,065.52**	**77,981.75**	**30.7**	--
Total		**79,527**	**100**	**74,944.34**	**100**	**15,592.28**	**20.8**	--	**206,227.60**	**47,457.90**	**253,685.50**	**100**	--

* A darker color gradient represents increasing value within a column.

3.2 Commercial, Industrial, Institutional, and Multi-Family Parcels

Commercial, Industrial, Institutional, and Multi-Family parcels make up 22% parcels by count and 19% of area in the Neponset River Watershed (Table 3-4). The greatest number of CIIM parcels are Multifamily Residential. On average, however, these parcels have the lowest IC area and TP and TN loads. Industrial parcels have the highest average IC and load values, followed by Commercial and Institutional. CIIM parcels make up 35% of total IC area and 38% and 39% of total TP and TN load from all IC, respectively. These parcels could be candidates for additional stormwater controls while excluding the designation of the nearly 54,000 private single family residential parcels.

Table 3-4. Summary of private commercial, industrial, institutional, and multifamily parcel attributes in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area			TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	Parcel Avg. (ac)	IC	Pervious	Parcel Total Avg.	IC	Pervious	Parcel Total Avg.
Commercial	2,564	5,186.25	2,266.98	43.71	0.88	4,083.84	302.19	1.71	34,061.46	2,468.02	14.25
Industrial	507	2,241.27	1,020.67	45.54	2.01	1,835.81	91.33	3.80	15,528.90	725.58	32.06
MultiFamily Residential	13,233	4,425.76	1,695.04	38.30	0.13	3,977.59	311.37	0.32	24,118.65	2,214.67	1.99
Private Institutional	813	2,667.03	410.64	15.40	0.51	742.43	296.06	1.28	6,214.73	2,024.01	10.13
Subtotal	**17,117**	**14,520.32**	**5,393.33**	**37.14**	--	**10,639.67**	**1,000.94**	--	**79,923.73**	**7,432.29**	--
Watershed Total (%)	**21.5**	**19.4**	**34.6**	--	--	**38.4**	**15.1**	--	**38.8**	**15.7**	--

3.2.1 *Analysis of CIIM Parcels by IC Area*

Because designating all CIIM parcels may be impractical due to the high number of multifamily residential parcels, it may be possible to designate fewer CIIM properties based on the amount of IC area while still targeting the majority of the nutrient load. The relationship between the number of parcels, the amount of IC area within a parcel, and the total load was evaluated for private CIIM parcels by varying thresholds of IC area as shown Figure 3-2 and Figure 3-3 (A presents similar plots by individual parcel use group). These plots show that while the IC threshold is relatively large (e.g., ≥ 2 ac), the number of parcels potentially designated is relatively small, but accounts for approximately half of the private CIIM total load. As the IC threshold decreases below 1 ac, the number of parcels potentially designated sharply increases, but with lower increases in the total load. IC thresholds below ≥ 0.25 ac exhibit a large increase in the number of parcels potentially designated because more multifamily residential parcels are included (these parcels have an average IC area of 0.1 ac, as shown in Table 3-4).

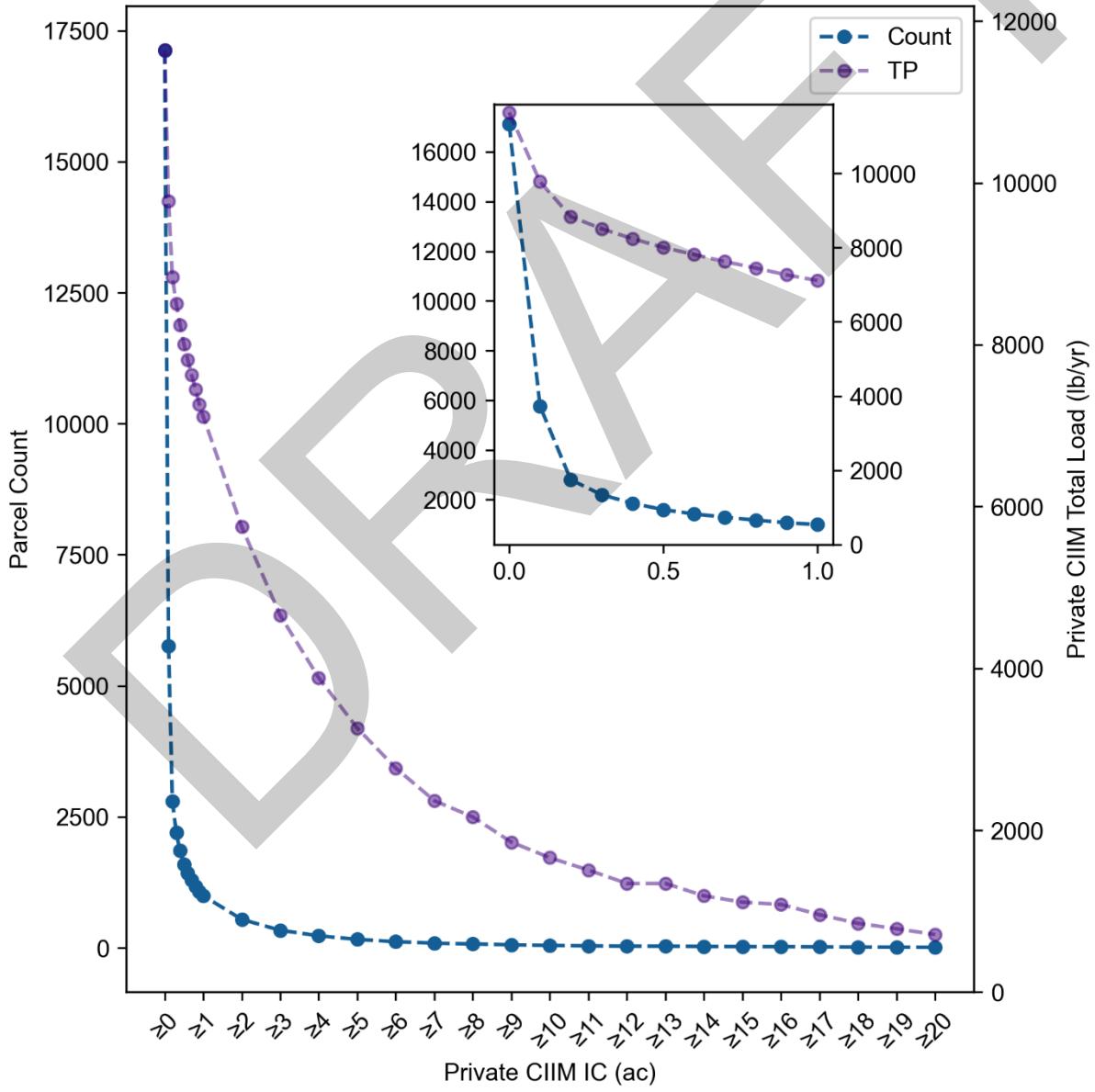

Figure 3-2. Private CIIM parcel count and total TP load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private CIIM parcels.

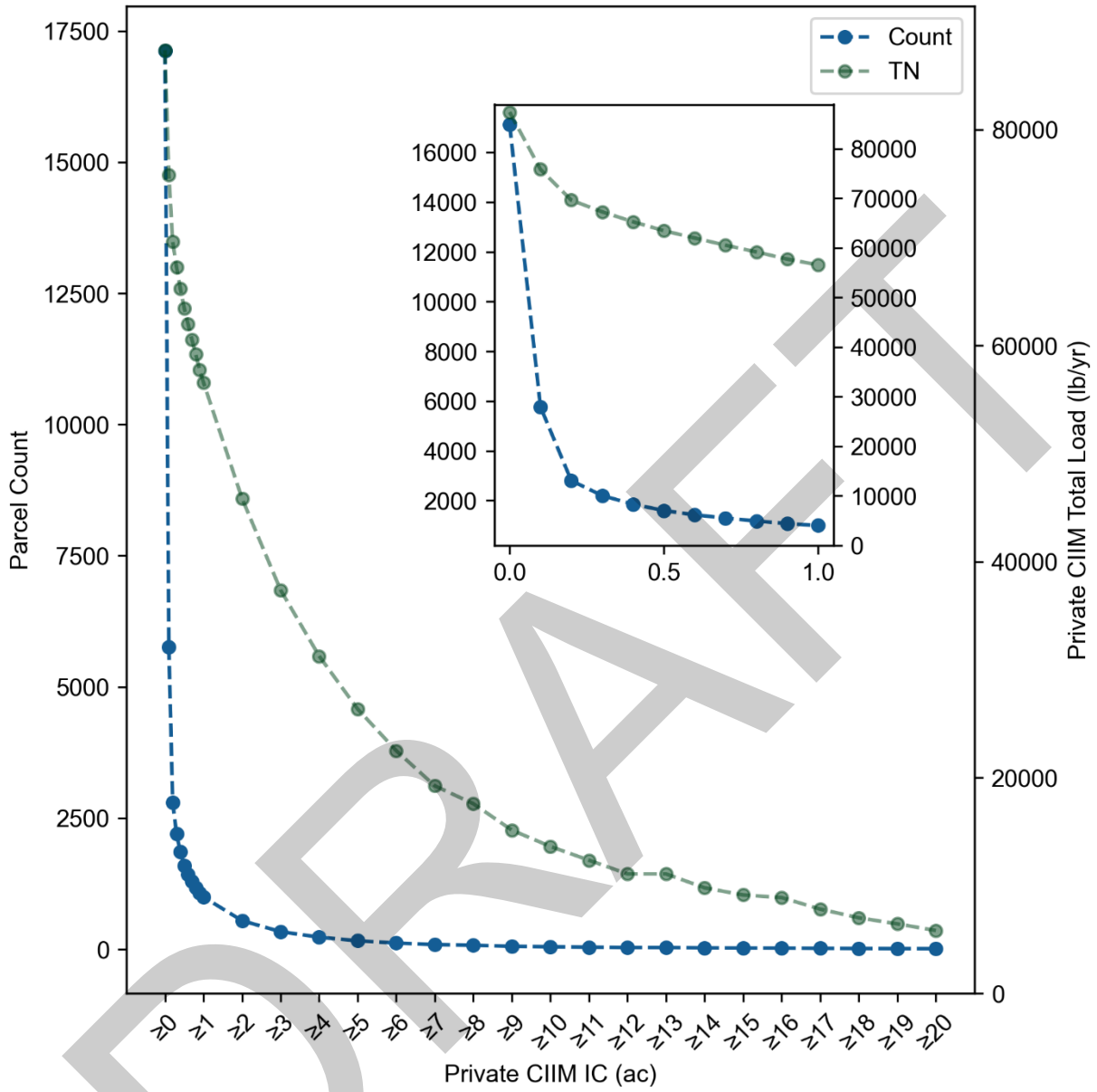

Figure 3-3. Private CIIM parcel count and total TN load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private CIIM parcels.

The parcel count, load, IC relationship was further analyzed for IC thresholds of 0.25 ac, 0.5 ac, 0.75 ac, 1 ac, 2 ac, and 5 ac as shown in Table 3-5 to Table 3-10. These tables show that, for a small percentage of the total number of parcels, a larger proportion of the IC nutrient load can be controlled. For example, private CIIM parcels with ≥ 0.25 ac of IC represent 3% (2,430) of the total number of parcels but account for 29% of the IC TP load and 30% of the IC TN load from all parcels. Larger IC thresholds require designating fewer parcels, but with the potential to treat less of the nutrient load.

Table 3-5. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 0.25 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	1,222	4,782.05	2,107.26	44.07	3,786.92	270.06	4,056.99	31,680.82	2,231.12	33,911.94
Industrial	410	2,124.38	1,011.09	47.59	1,818.89	83.05	1,901.94	15,387.13	659.17	16,046.30
MultiFamily Residential	536	2,100.06	699.39	33.30	1,625.85	179.31	1,805.16	9,964.84	1,279.05	11,243.89
Private Institutional	262	1,905.30	369.82	19.41	668.43	216.99	885.42	5,599.86	1,478.61	7,078.47
Subtotal	**2,430**	**10,911.79**	**4,187.56**	**38.38**	**7,900.09**	**749.41**	**8,649.50**	**62,632.65**	**5,647.96**	**68,280.61**
Watershed Total (%)	**3.1**	**14.6**	**26.9**	--	**28.5**	**11.3**	**25.2**	**30.4**	**11.9**	**26.9**

Table 3-6. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 0.5 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	780	4,525.19	1,949.60	43.08	3,499.58	258.49	3,758.06	29,304.48	2,147.02	31,451.50
Industrial	344	2,076.84	986.25	47.49	1,774.50	81.22	1,855.72	15,012.95	644.72	15,657.67
MultiFamily Residential	303	1,777.46	617.43	34.74	1,432.75	143.86	1,576.61	8,795.68	1,053.26	9,848.94
Private Institutional	170	1,741.69	336.81	19.34	608.84	206.18	815.02	5,102.45	1,398.00	6,500.45
Subtotal	**1,597**	**10,121.18**	**3,890.09**	**38.44**	**7,315.68**	**689.74**	**8,005.42**	**58,215.56**	**5,243.01**	**63,458.57**
Watershed Total (%)	**2.0**	**13.5**	**24.9**	--	**26.4**	**10.4**	**23.3**	**28.2**	**11.0**	**25.0**

Table 3-7. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 0.75 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	593	4,335.04	1,835.92	42.35	3,293.69	250.42	3,544.11	27,585.64	2,089.35	29,674.99
Industrial	297	2,017.31	957.00	47.44	1,721.85	79.18	1,801.03	14,567.31	630.08	15,197.39
MultiFamily Residential	219	1,561.76	565.98	36.24	1,314.16	119.45	1,433.61	8,062.45	889.96	8,952.41
Private Institutional	126	1,656.41	309.78	18.70	560.20	199.73	759.93	4,694.06	1,352.78	6,046.84
Subtotal	**1,235**	**9,570.53**	**3,668.68**	**38.33**	**6,889.90**	**648.78**	**7,538.68**	**54,909.46**	**4,962.17**	**59,871.63**
Watershed Total (%)	**1.6**	**12.8**	**23.5**	--	**24.8**	**9.8**	**21.9**	**26.6**	**10.5**	**23.6**

Table 3-8. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 1 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	470	4,084.48	1,730.21	42.36	3,103.32	240.13	3,343.45	26,005.81	2,014.43	28,020.24
Industrial	253	1,934.04	919.61	47.55	1,654.78	76.02	1,730.80	14,000.96	606.60	14,607.56
MultiFamily Residential	168	1,439.22	521.76	36.25	1,211.01	109.78	1,320.79	7,433.62	812.20	8,245.81
Private Institutional	104	1,579.26	290.18	18.37	525.18	193.24	718.43	4,399.13	1,302.36	5,701.49
Subtotal	**995**	**9,036.98**	**3,461.76**	**38.31**	**6,494.29**	**619.17**	**7,113.46**	**51,839.52**	**4,735.59**	**56,575.11**
Watershed Total (%)	**1.3**	**12.1**	**22.2**	--	**23.4**	**9.3**	**20.7**	**25.1**	**10.0**	**22.3**

Table 3-9. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 2 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	240	3,367.79	1,400.94	41.60	2,508.59	203.15	2,711.74	21,033.47	1,702.59	22,736.06
Industrial	161	1,630.82	782.38	47.97	1,408.65	68.11	1,476.76	11,921.90	546.33	12,468.23
MultiFamily Residential	98	1,096.16	423.35	38.62	981.10	81.18	1,062.28	6,032.13	610.73	6,642.86
Private Institutional	45	1,143.93	210.54	18.40	381.14	117.52	498.66	3,201.30	794.80	3,996.10
Subtotal	**544**	**7,238.71**	**2,817.21**	**38.92**	**5,279.48**	**469.97**	**5,749.45**	**42,188.81**	**3,654.45**	**45,843.25**
Watershed Total (%)	**0.7**	**9.7**	**18.1**	--	**19.0**	**7.1**	**16.7**	**20.5**	**7.7**	**18.1**

Table 3-10. Summary of private commercial, industrial, institutional, and multifamily parcels with IC ≥ 5 ac in the Neponset River Watershed

Use Group	Count	Total Area (ac)	IC Area		TP Load (lb/yr)			TN Load (lb/yr)		
			Acre	% IC of Total Area	IC	Pervious	Total	IC	Pervious	Total
Commercial	77	1,977.31	896.16	45.32	1,597.94	118.95	1,716.90	13,364.99	1,030.01	14,395.01
Industrial	47	855.94	424.09	49.55	764.04	38.31	802.36	6,468.40	298.91	6,767.32
MultiFamily Residential	25	586.64	195.99	33.41	455.01	50.99	506.00	2,777.10	394.07	3,171.17
Private Institutional	12	472.02	115.67	24.51	207.93	28.73	236.66	1,758.59	248.51	2,007.10
Subtotal	**161**	**3,891.91**	**1,631.91**	**41.93**	**3,024.93**	**236.98**	**3,261.91**	**24,369.09**	**1,971.51**	**26,340.60**
Watershed Total (%)	**0.2**	**5.2**	**10.5**	--	**10.9**	**3.6**	**9.5**	**11.8**	**4.2**	**10.4**

Figure 3-4 further illustrates the tradeoff between pollutant reduction and the number of private CIIM parcels with IC area ranging from ≥20 ac to ≥0 ac (i.e., all private CIIM parcels) that would have to install SCMs. This figure assumes that runoff from IC within a parcel would be treated by SCMs sized to achieve a 60% reduction[1]. The "knee" of the curve, where the slope begins to flatten, indicates the IC threshold where the fewest number of parcels can provide the greatest benefit in terms of TP reduction. For the Neponset River Watershed, this appears to lie between parcels with ≥0.25 ac and ≥0.75 ac of IC.

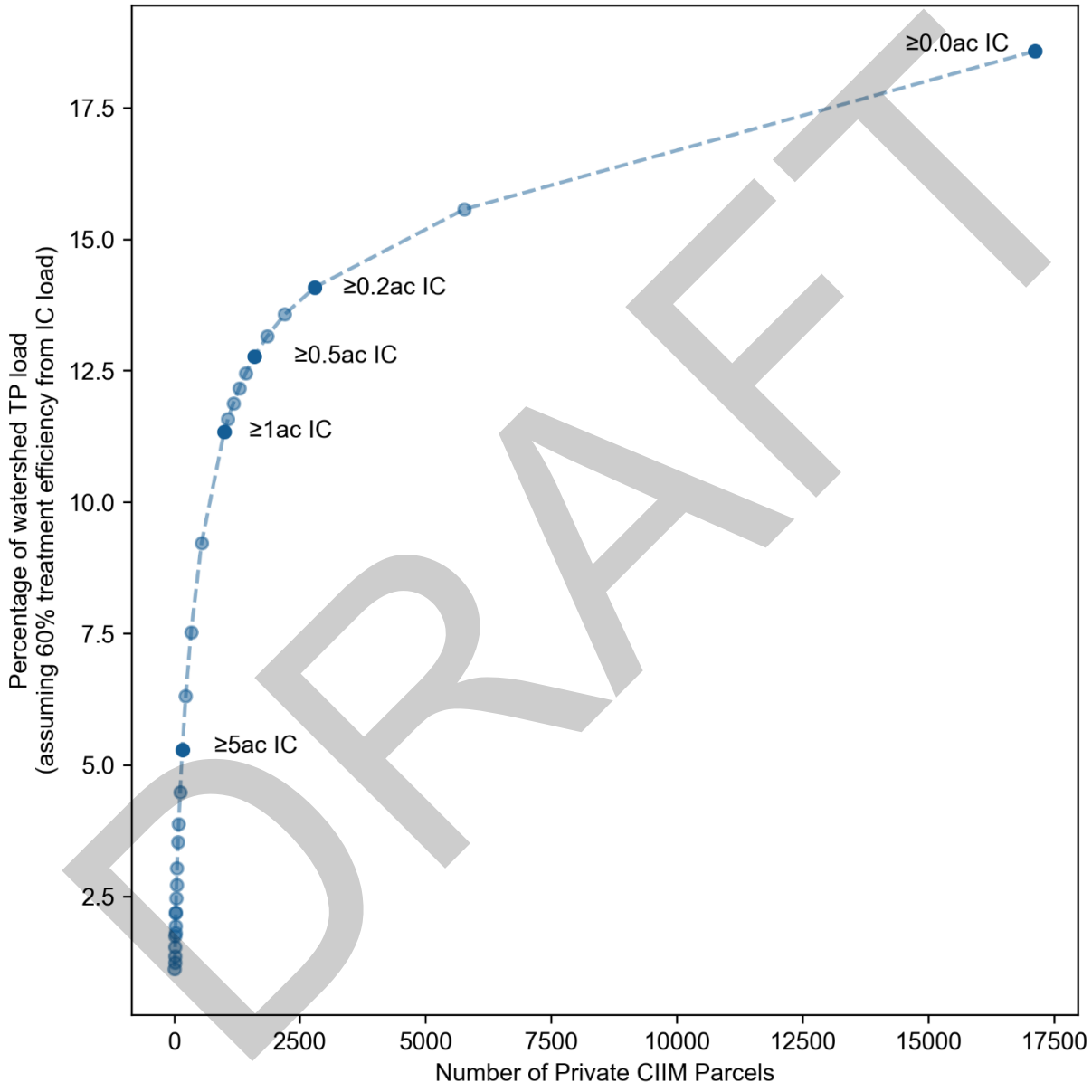

Figure 3-4. Percentage of watershed TP load that can be captured from IC runoff, assuming a 60% treatment efficiency, and the corresponding number of private CIIM parcels based on IC threshold. Labels for IC thresholds correspond to the dark blue dots.

[1] In the absence of a specific TP reduction requirement, 60% was used as a starting point in this analysis to align with MA MS4 permitting.

4 CONCLUSIONS

This report presented a methodology for summarizing and evaluating stormwater pollutant load from parcels within the Neponset River Watershed that may be used by EPA Region 1 to support decisions regarding the control of stormwater runoff from certain private properties to improve water quality. Findings from this analysis include:

1. Private properties contribute nearly three quarters (70%) of the watershed's total TP load.
2. The majority of TP from private properties is generated from impervious cover (81% of load from private properties and 57% of the watershed total load).
3. Private commercial, industrial, institutional, and multi-family residential (CIIM) properties make up 22% of all parcels, but have relatively high percentages of IC and therefore contribute a large proportion of the watershed TP load (34%)
4. Selecting private CIIM parcels based on their IC area (which is a dominate factor in the nutrient load generated) can minimize the number of parcels installing stormwater controls, while providing the greatest nutrient reduction benefit (Table 4-1).

The findings in this report indicate that unattenuated stormwater runoff from private parcels within the Neponset River Watershed contributes the majority of the nutrient load. Without additional controls on stormwater runoff and pollutant loads from these parcels, making meaningful improvements to water quality could be difficult. Designating stormwater discharges from certain classes of private properties for NPDES permits based on the amount of IC area will help reduce the burden on MS4s by targeting properties generating the largest amount of nutrients in stormwater on a per-property scale. In any scenario, municipalities will still need to engage the private property owners with smaller property size or IC size to eventually meet water quality goals. However, 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.

Table 4-1. Summary of private CIIM parcels installing SCMs based on parcel IC area and the reduction achieved in watershed total TP load

IC Threshold (ac)	Parcel Count	Total TP Load (lb/yr)	IC TP Load (lb/yr)	Total TP Treated (%)*
≥0 (All)	17,117	11,640.62	10,639.67	19%
≥0.25	2,430	8,649.50	7,900.09	14%
≥0.5	1,597	8,005.42	7,315.68	13%
≥0.75	1,235	7,538.68	6,889.90	12%
≥1	995	7,113.46	6,494.29	11%
≥2	544	5,749.45	5,279.48	9%
≥5	161	3,261.91	3,024.93	5%

* Percentage calculated as IC load times a 60% treatment efficiency divided by the watershed total TP load of 34,367 lb/yr.

5 REFERENCES

MA Dept. of Revenue Division of Local Services, 2016. PROPERTY TYPE CLASSIFICATION CODES, NON-ARM'S LENGTH CODES, AND SALES REPORT SPREADSHEET SPECIFICATIONS.

MassDEP, 2023. Final Massachusetts Integrated List of Waters for the Clean Water Act 2022 Reporting Cycle. CN 568.1, Massachusetts Department of Environmental Protection, Bureau of Water Resources, Division of Watershed Management, Watershed Planning Program. Worcester.

MassDEP, 2012. Addendum: Final Total Maximum Daily Loads of Bacteria for Neponset River Basin (CN 121.5).

MassDEP, 2002. Total Maximum Daily Loads of Bacteria for Neponset River Basin.

MassGIS (Massachusetts Bureau of Geographic Information Systems), 2016. Full documentation for MassGIS ' 2016 Land Use / Land Cover Data.

Paradigm Environmental, 2023a. Task 4A-B Technical Memo Neponset River Watershed Spatial Data and Mapping Analyses. Prepared for the U.S. EPA.

Paradigm Environmental, 2023b. Task 3C Technical Report Mystic River Watershed Property Parcel Analyses. Prepared for the U.S. EPA.

U.S. EPA, 2022a. 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.

U.S. EPA, 2022b. Mystic River and Neponset River Watershed Analysis RFQ.

U.S. EPA, 2022c. 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.

USEPA, 2020. Mystic River Watershed Alternative TMDL Development for Phosphorus Management-Final Report. Boston, MA.

APPENDIX A

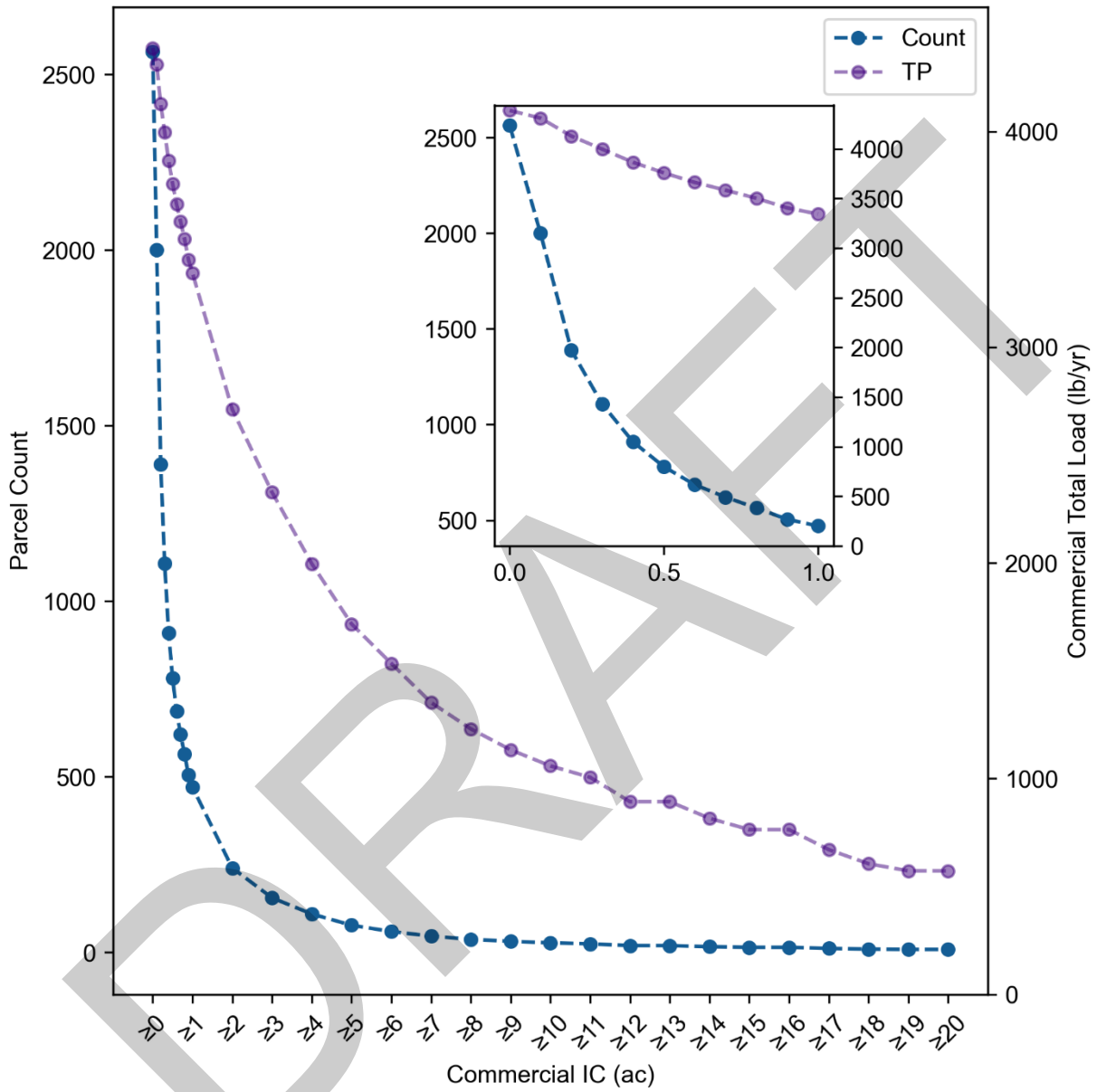

Figure C-1. Private commercial parcel count and total TP load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private commercial parcels.

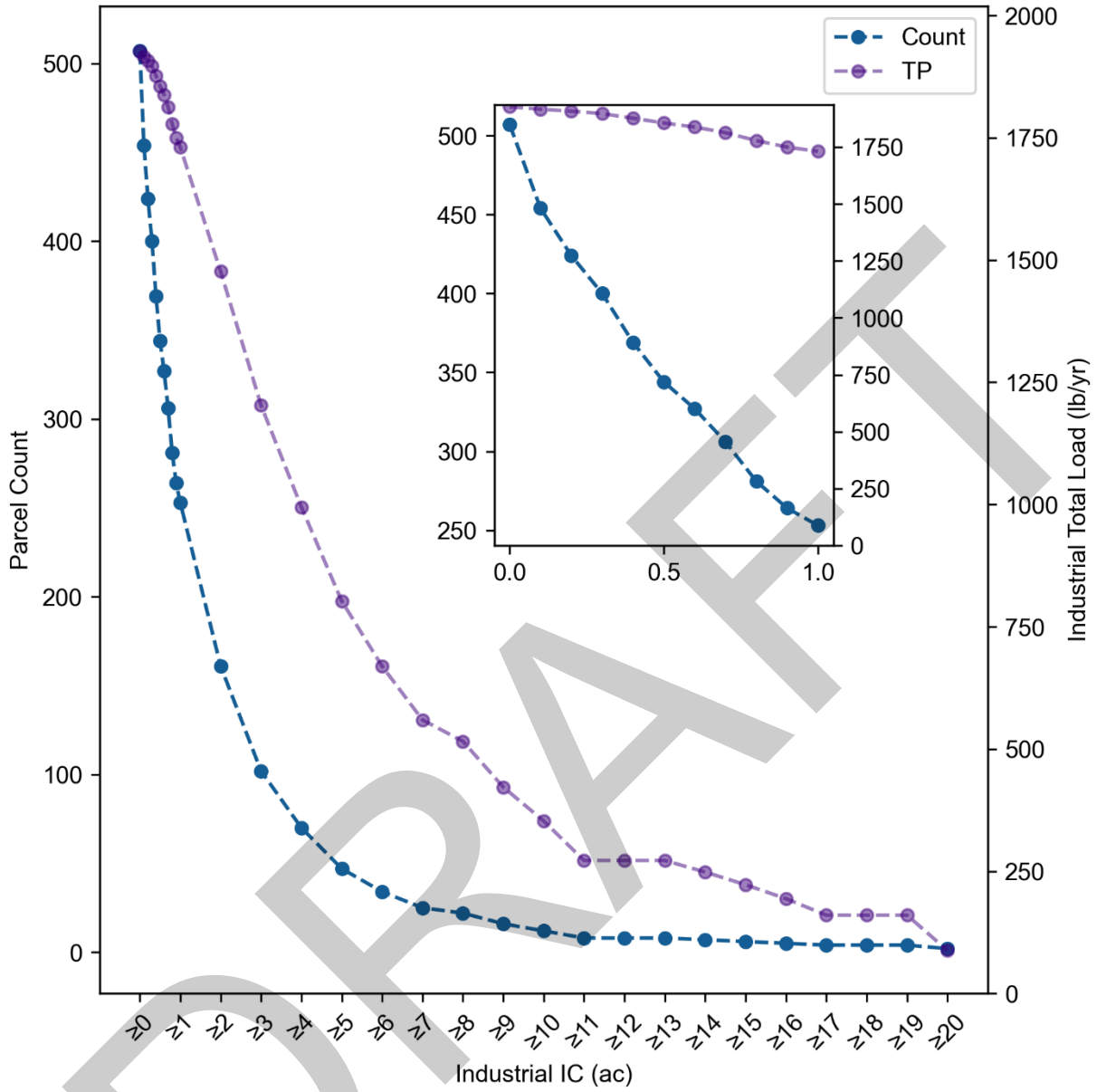

Figure C-2. Private industrial parcel count and total TP load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private industrial parcels.

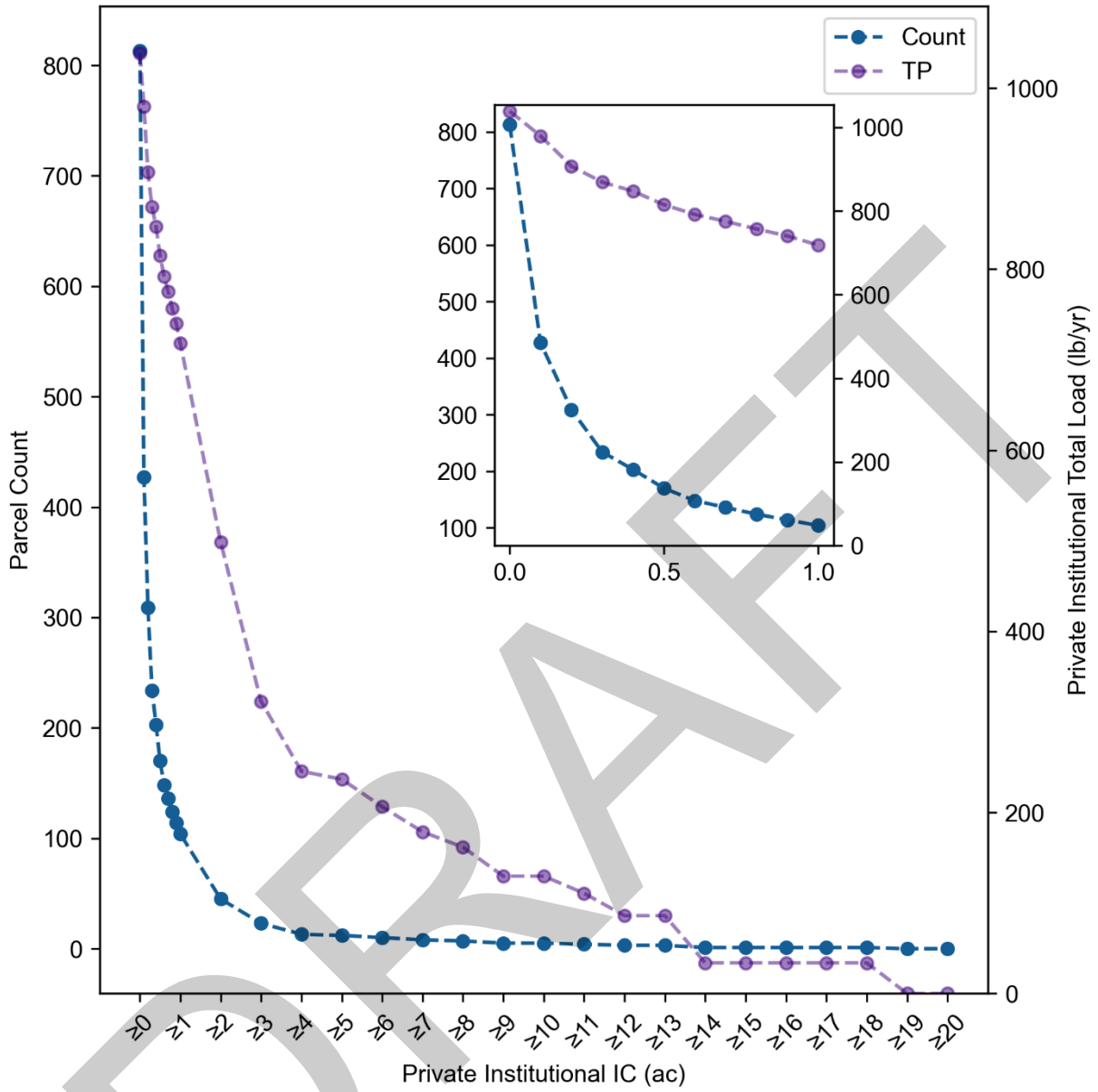

Figure C-3. Private institutional parcel count and total TP load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private institutional parcels.

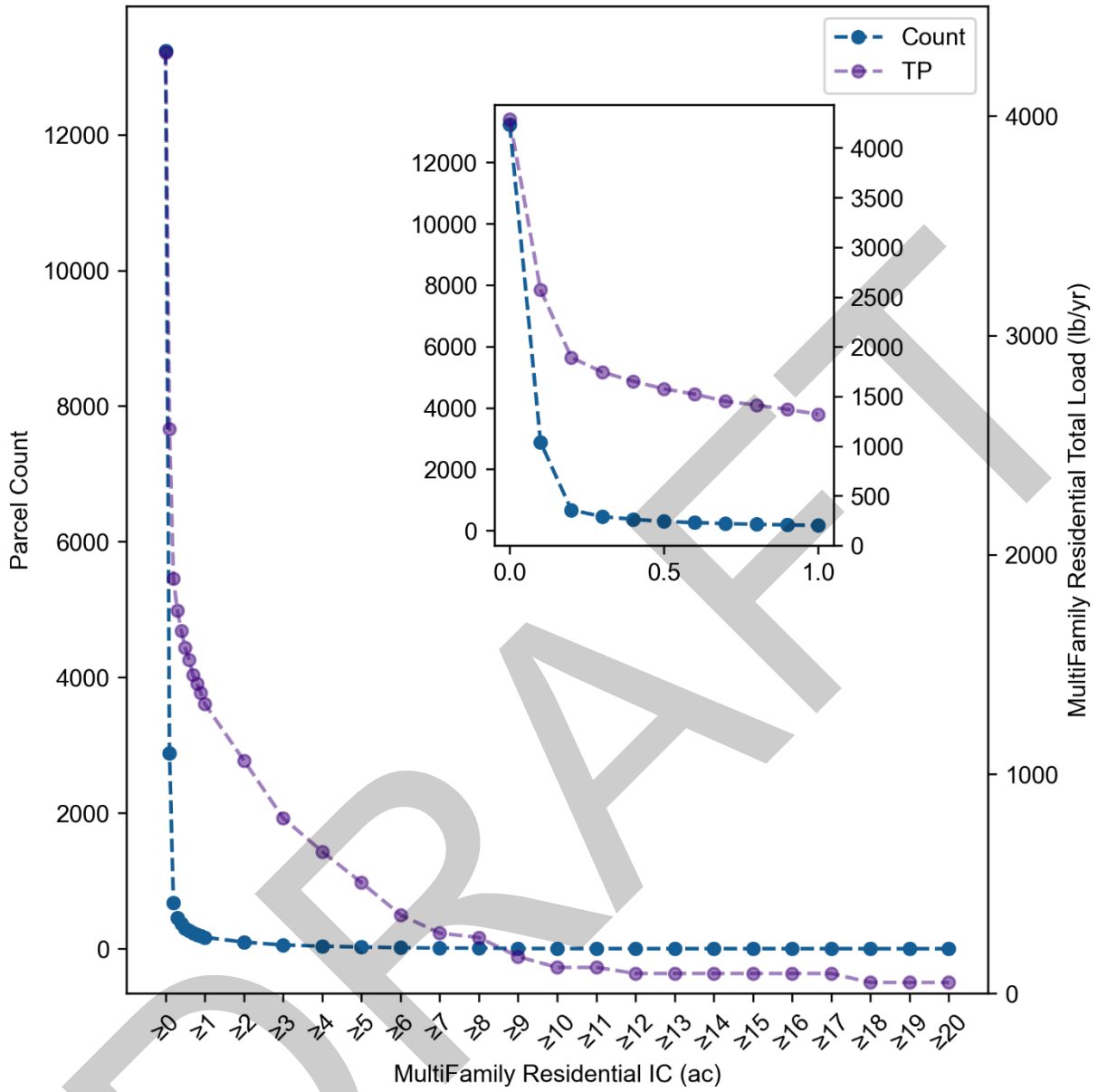

Figure C-4. Private multifamily residential parcel count and total TP load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private multifamily residential parcels.

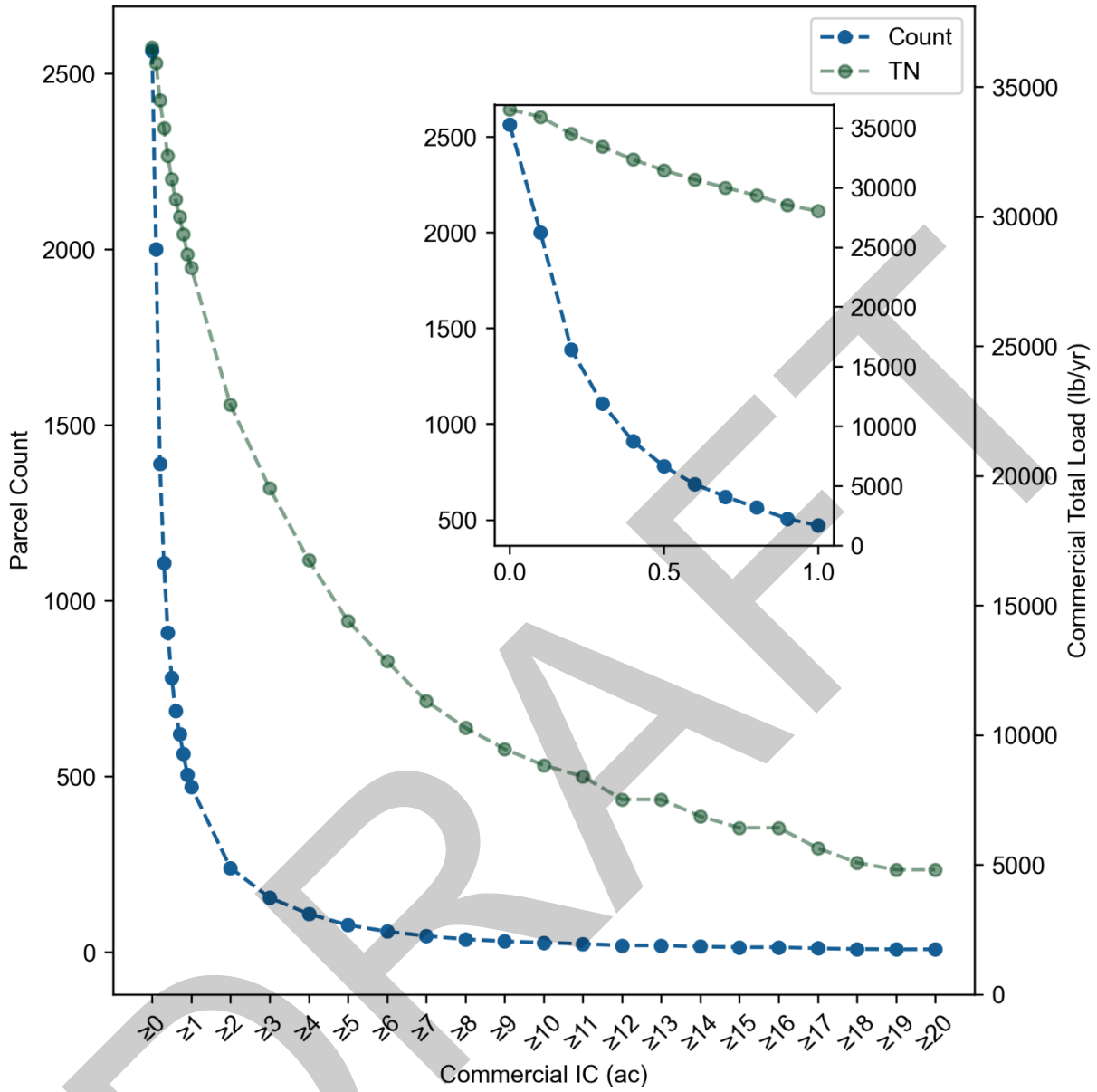

Figure C-5. Private commercial parcel count and total TN load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private commercial parcels.

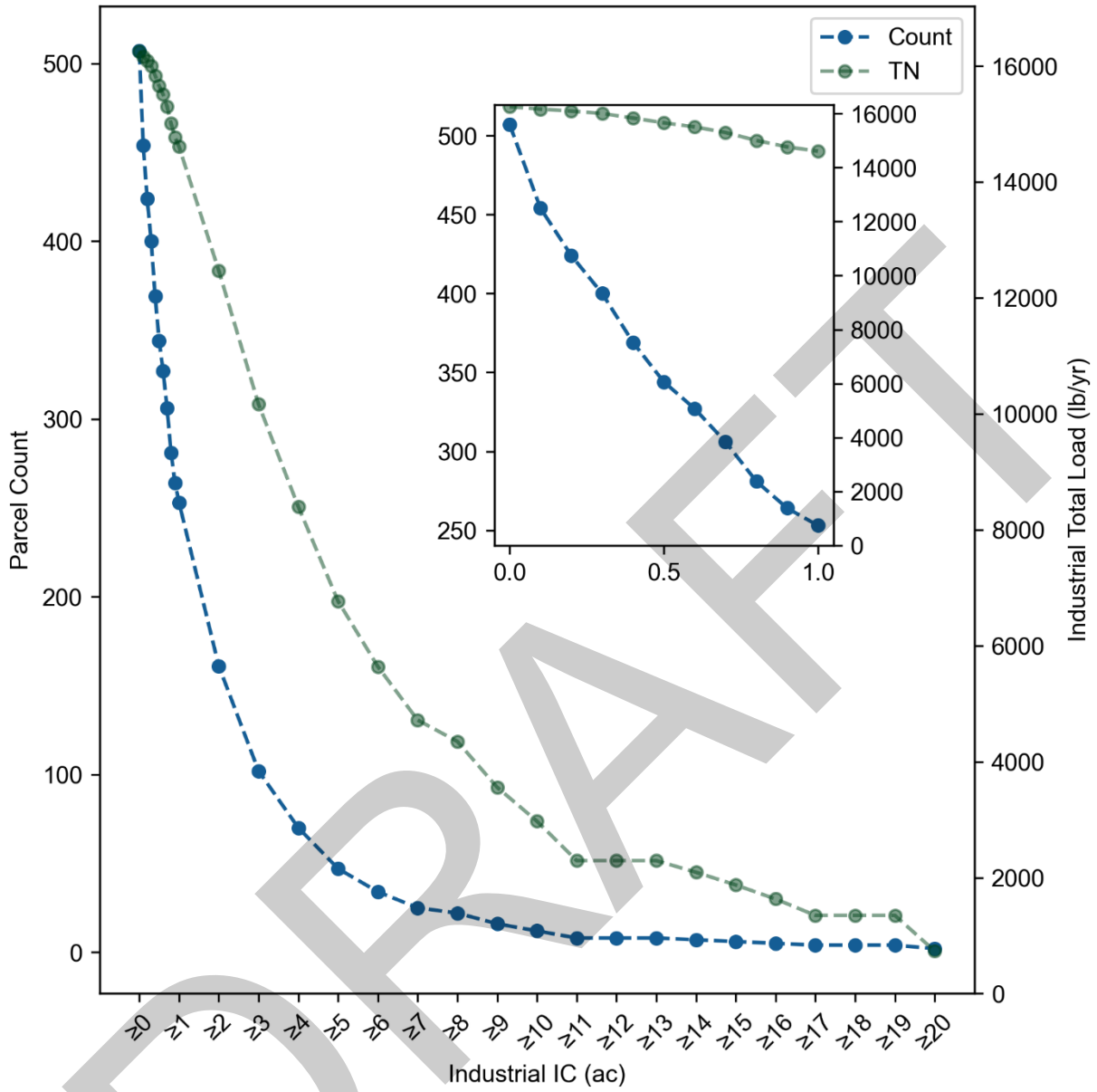

Figure C-6. Private industrial parcel count and total TN load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private industrial parcels.

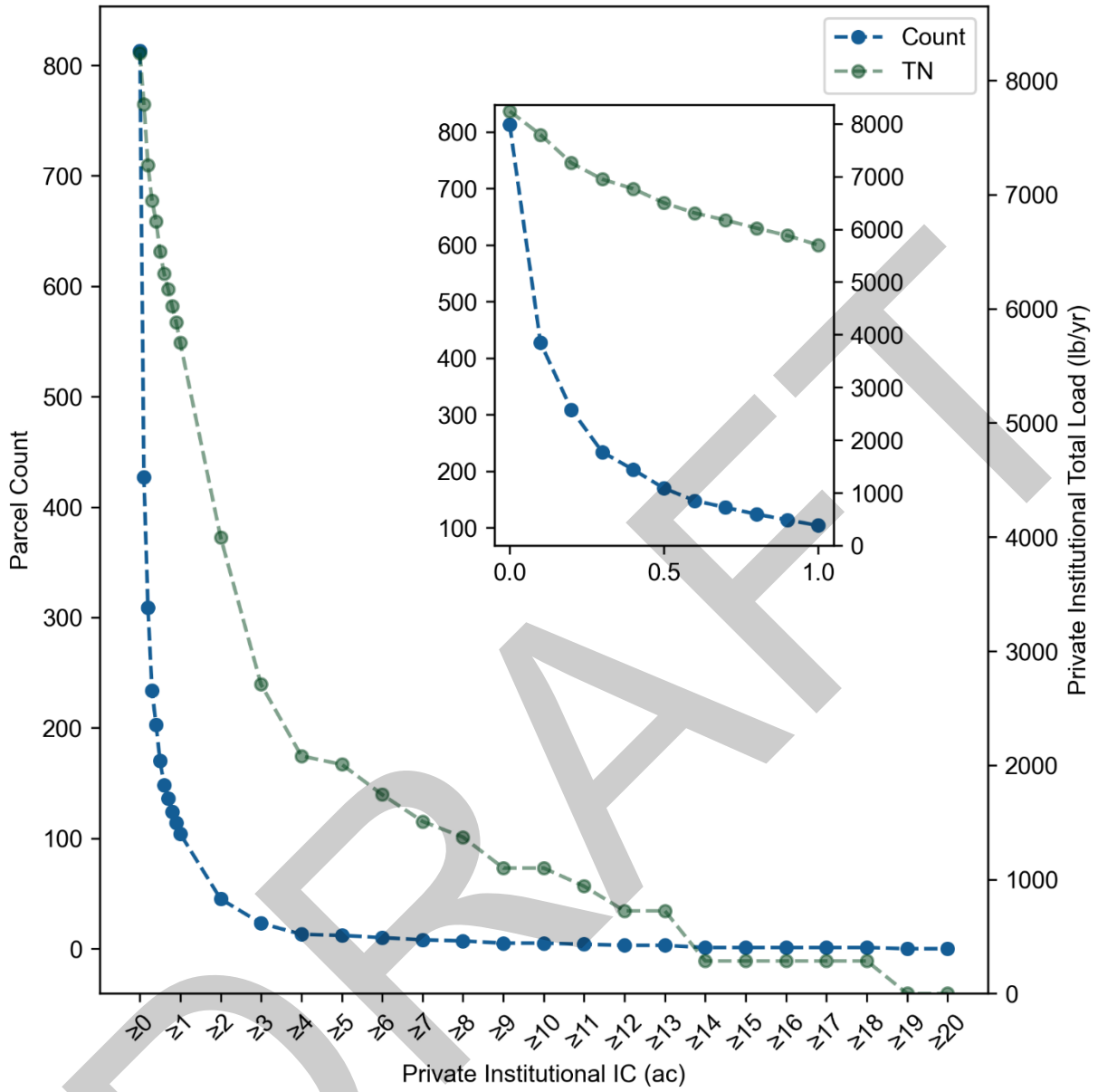

Figure C-7. Private institutional parcel count and total TN load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private institutional parcels.

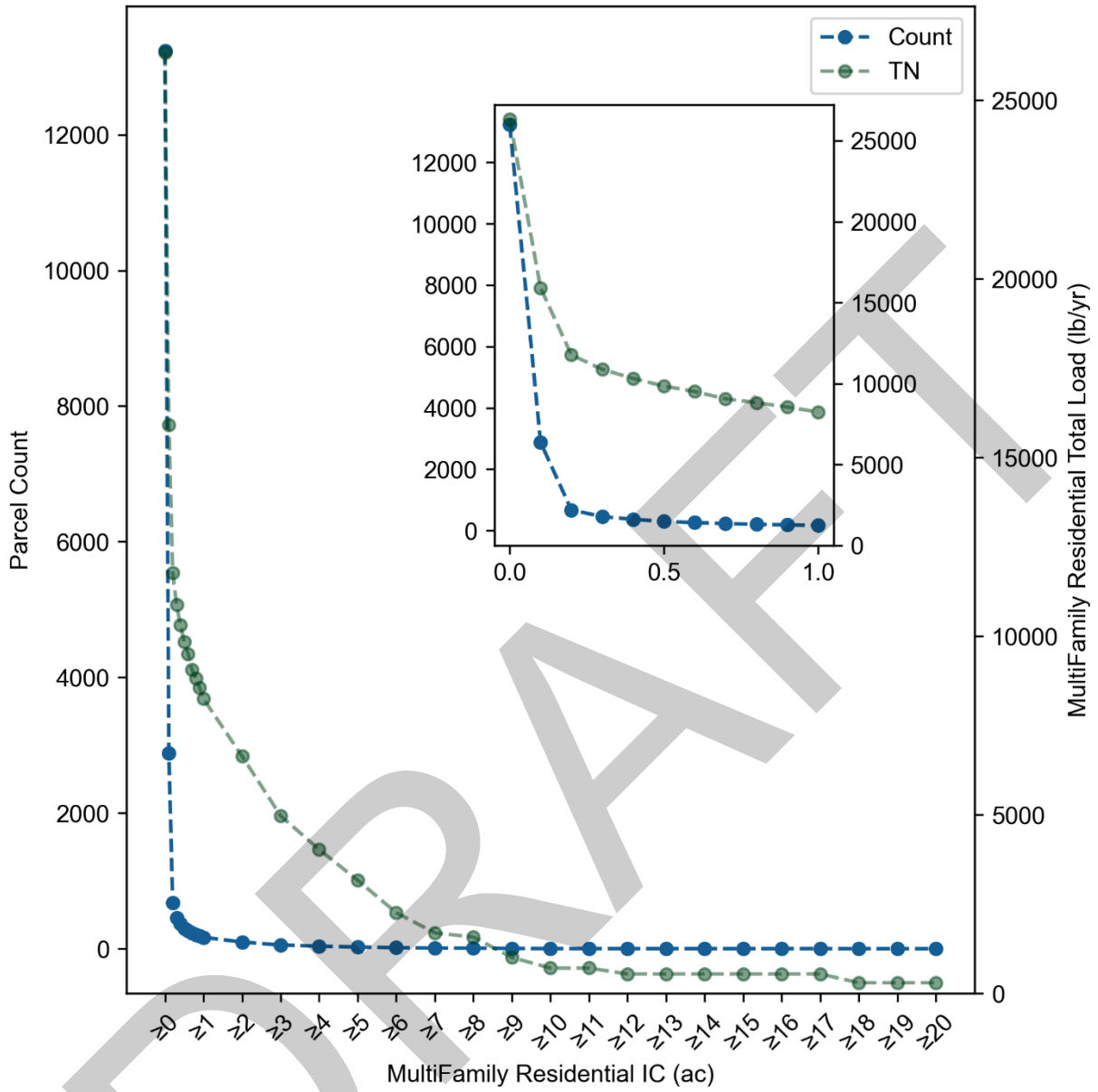

Figure C-8. Private multifamily residential parcel count and total TN load by parcel IC area. Note that a threshold of ≥ 0ac IC includes all private multifamily residential parcels.