DRAFT: JANUARY 15, 2019 | Do not distribute

Cambridge Cool Factor

January 29, 2020 | Cambridge Climate Resilient Zoning Task Force Meeting

Agenda

1. Overview and Approach
Step-by-step overview of how scores are calculated based on zoning district open space requirements and examples of common typology scores

2. Cool Factor Strategies (please see worksheet)
Definitions, prerequisites, and scores

3. Case Studies and Testing
Impacts of Cool Factor on multiple zoning districts and project types

4. Questions and Next Steps

Cool Factor Achieves many CRZTF Objectives

1. Elevate and Floodproof
2. Design to Protect/Recover
3. Promote Passive Resilience

RESILIENT BUILDINGS

4. Green Infrastructure
5. Preserve Vegetation
6. Create Vegetation
7. Limit Paved Areas
8. Provide Shading
9. Use Reflective Surfaces

SITE/COOL FACTOR

10. Shelter in Emergencies
11. Create Emergency Plans
12. Implement Area-Wide Strategies (Social Resilience)

EMERGENCY RESPONSE PLANNING

13. Implement Area-Wide Strategies (Hazards)

Introduction

The Cambridge Cool Factor introduces performance-driven standards which contribute to public realm cooling, the mitigation of heat island effects, and a greener Cambridge.

CRZTF goals + Cool Factor approach

- **Effectiveness**
  value strategies that have demonstrated temperature reduction
- **Differentiation and Choice**
  favor performance driven criteria over prescriptive codes
- **People, Communities and Equity**
  encourage public realm enhancements
- **Flexibility**
  shape an easily implementable and adjustable tool
- **Quality**
  encourage greener open space and site design

Current zoning open space requirements

Different standards for open space in zoning do not directly address cooling qualities.

Private Open Space. Open to the sky, unobstructed, and meant to be enjoyed by residents. Required for residential developments and must have a minimum 15’ dimension.

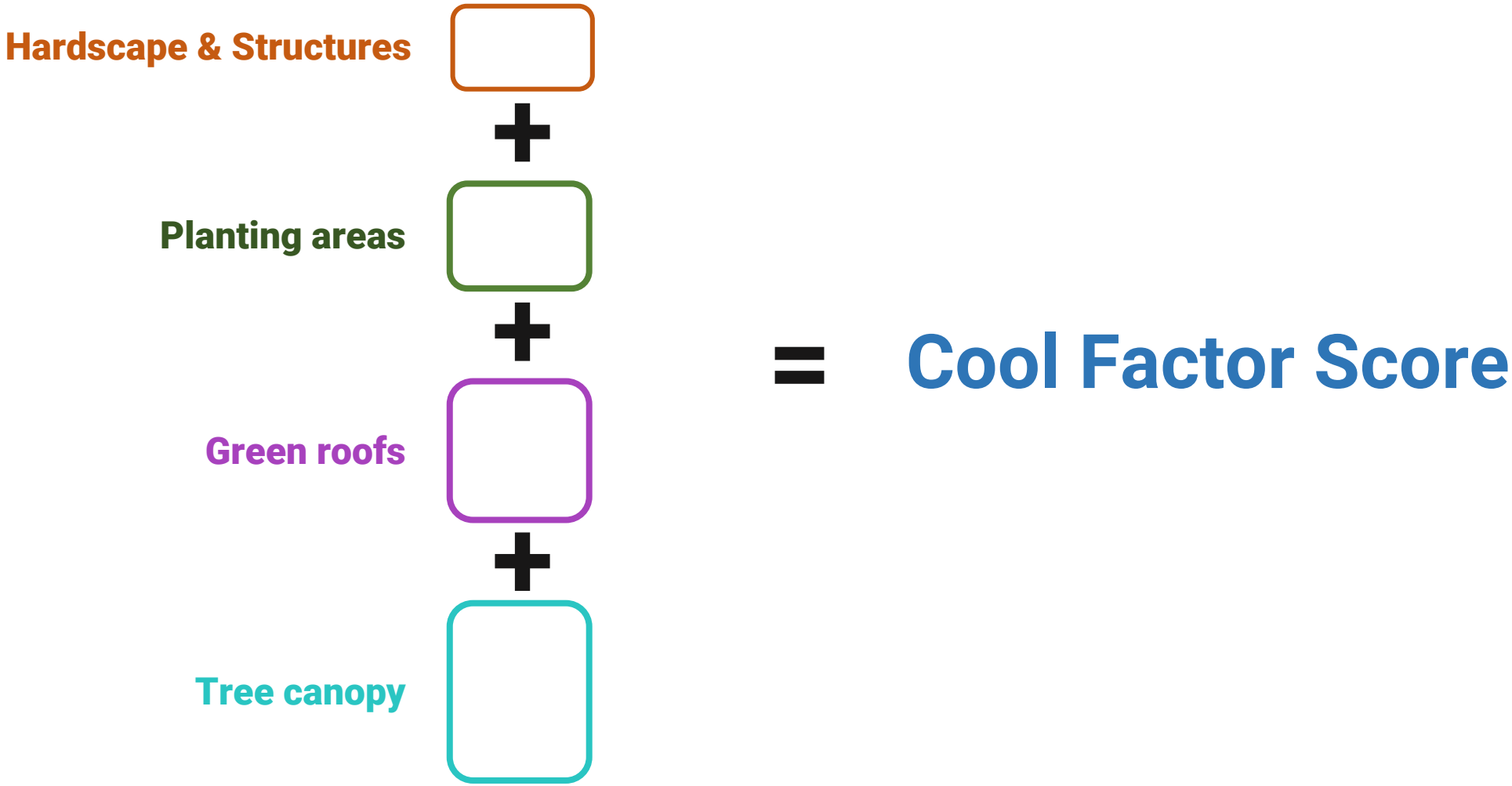
Permeable Open Space. Permeable but not necessarily planted. Must account for at least 50% of required open space in low-density residential districts; at least 25% of total lot area in Alewife Overlay Districts.

Green Area Open Space. Must contain planted materials or water features. Required for front yards in some districts.

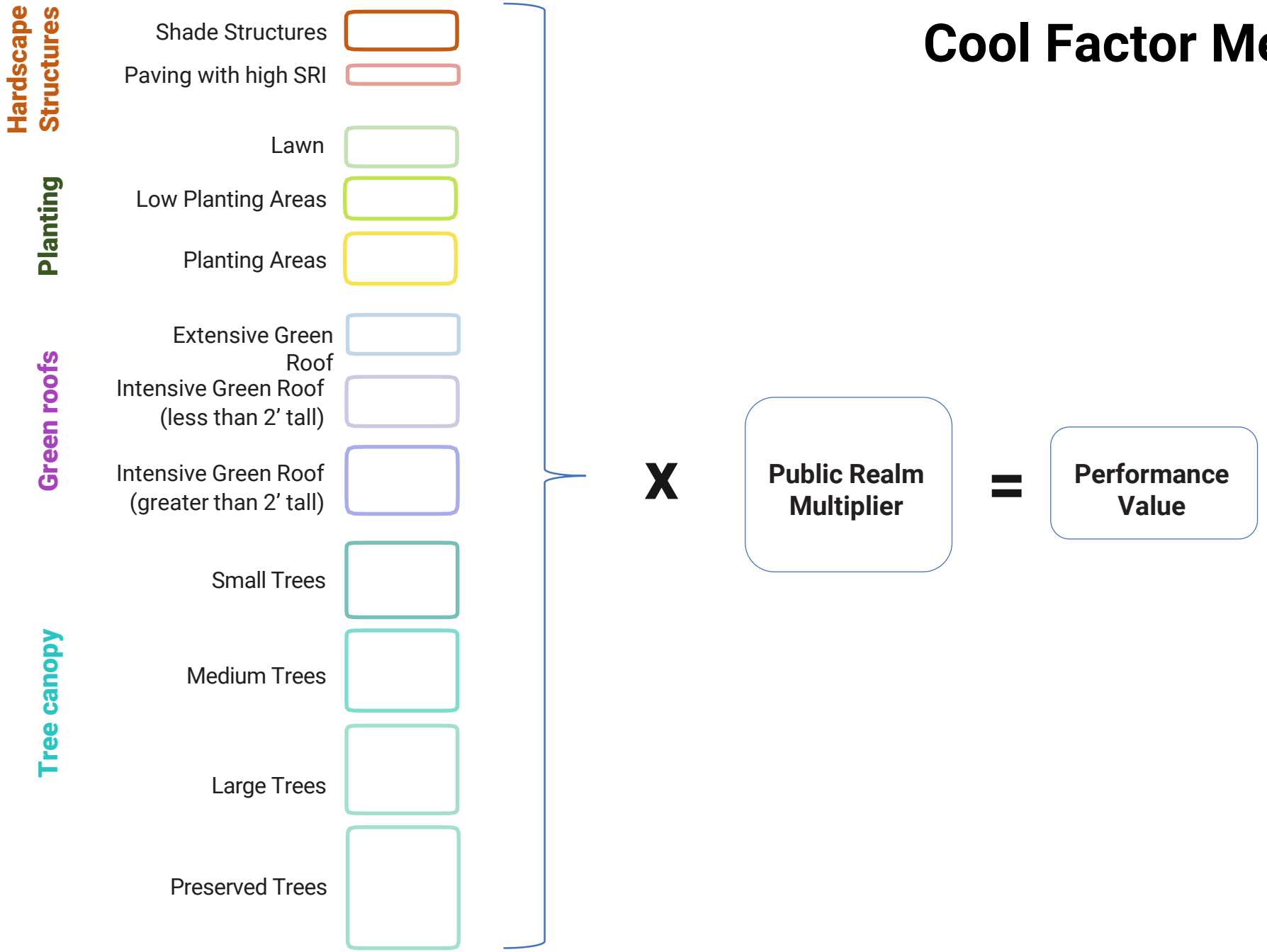
Publicly Beneficial Open Space. Intended for general public enjoyment (but not necessarily park space). Required in some areas zoned for larger-scale redevelopment.

A performance based approach

A property owner selects and implements several strategies to reduce heat from a menu of options in order to meet a set score, the ***cool factor.***



Cool Factor Menu of Options



Possible zoning changes to support Cool Factor implementation

1. To facilitate implementation, accessible green roofs should not be included in the FAR calculation

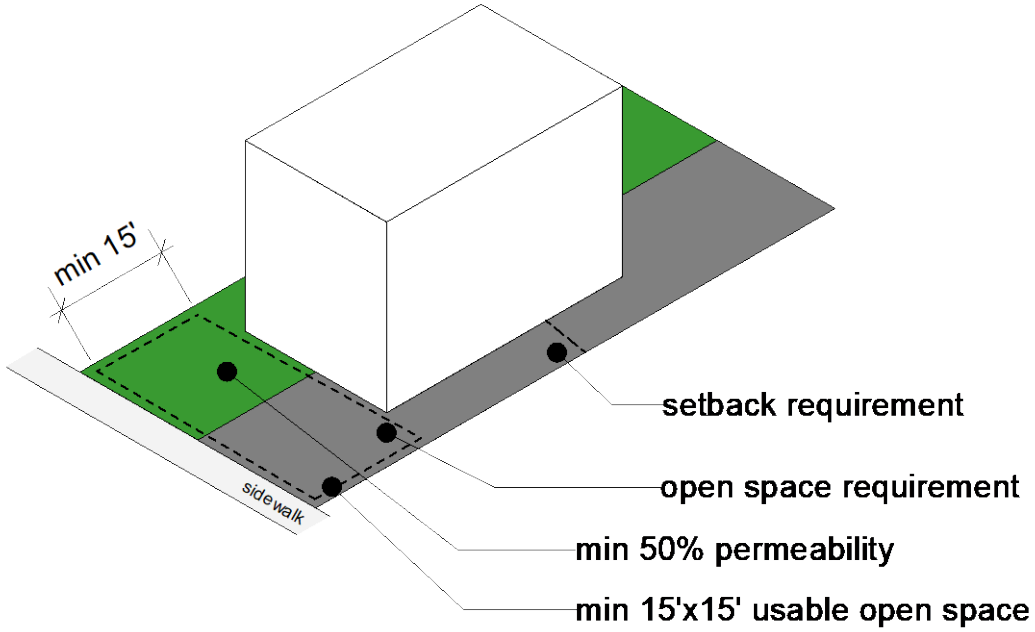
2. To facilitate implementation, shaded structures over open space should not be included in the FAR calculation

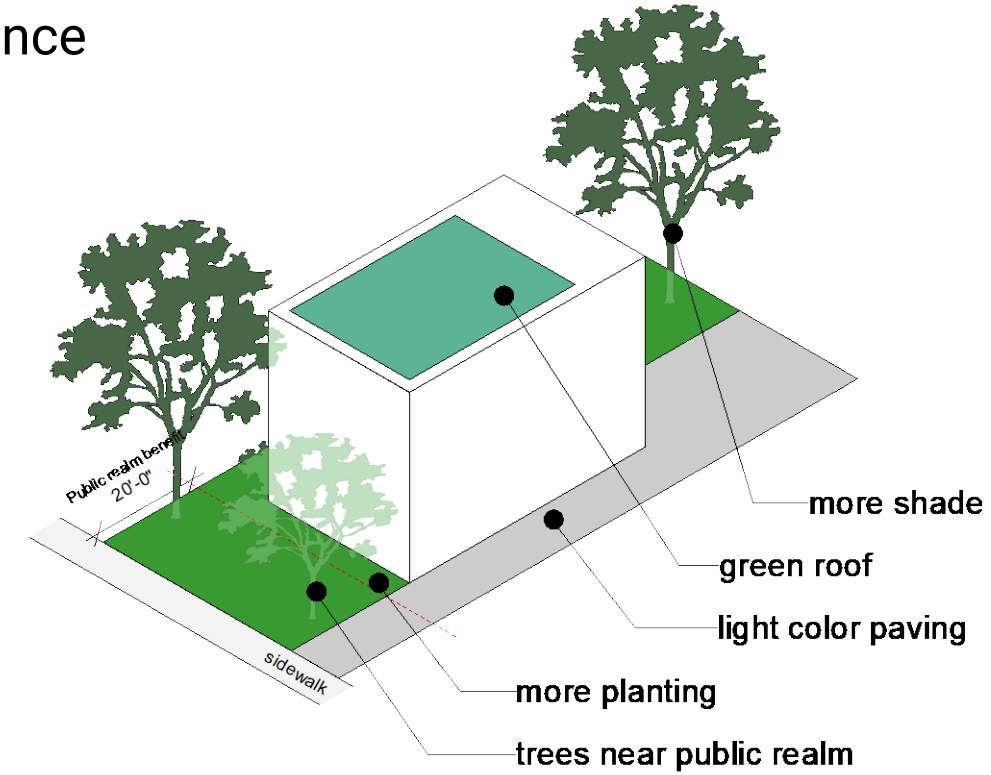
Cool Factor Scoring Method

Scoring Approach

- **Simple**
  All projects aim for the same score
- **Differentiated**
  Value derives from open space requirement by zoning district
- **Strong**
  Even sites with no required open space should contribute
- **Clear**
  All open space should contribute to cooling

Simple
A range of options encourage overall cooling performance





TRADITIONAL ZONING

COOL FACTOR

OPEN SPACE | PERMEABILITY | + | SHADE | COOL SURFACES | PLANTING

Differentiated

Each parcel contributes what it can based on amount of open space required.

Office					
Zoning District	1	2A	2	3	3A
Open Space	15%	15%	15%	10%	10%

Business										
Zoning District	A	A-1	A-2	A-3	A-4	B	B-1	B-2	C	C-1
Open Space	0%	0%	0%	30%	0%	0%	?	?	0%	0%

Industrial							
Zoning District	A-1	A-2	A	B-1	B-2	B	C
Open Space	0%	0%	0%	30%	0%	0%	0%

Residential												
Zoning District	A-1	A-2	B	C	C-1	C1-A	C-2	C-2B	C-2B	C-3	C-3A	C-38
Open Space	50%	50%	40%	36%	30%	15%	15%	15	15%	10%	10%	10%

***Challenge**: the current zoning does not have a minimum OS requirement for all zoning districts.*

Strong

Set a minimum of 15% (possibly higher for larger sites).

Office					
Zoning District	1	2A	2	3	3A
Open Space	15%	15%	15%	10%	10%

Business										
Zoning District	A	A-1	A-2	A-3	A-4	B	B-1	B-2	C	C-1
Open Space	0%	0%	0%	30%	0%	0%	?	?	0%	0%

Industrial							
Zoning District	A-1	A-2	A	B-1	B-2	B	C
Open Space	0%	0%	0%	30%	0%	0%	0%

Residential												
Zoning District	A-1	A-2	B	C	C-1	C1-A	C-2	C-2B	C-2B	C-3	C-3A	C-38
Open Space	50%	50%	40%	36%	30%	15%	15%	15	15%	10%	10%	10%

Note: *Minimum value does not require projects to provide 15% open space. The minimum value, however, is used to calculate the cool factor value each site provide.*

Method

Calculate a site's target cooling area by multiplying site area by open space requirement.

COOLING TARGET = **PARCEL AREA** x **ZONING OPEN SPACE REQUIREMENT**

AT LEAST 15%
POTENTIALLY MORE ON LARGER PARCELS

Clear

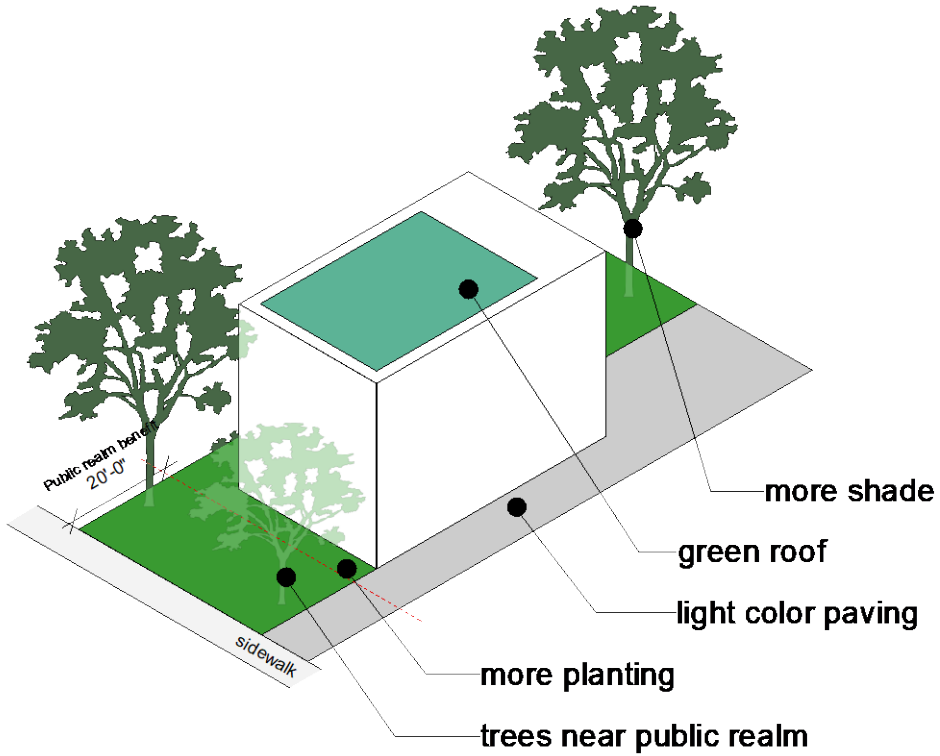
All sites should have the same goal, as much cooling as practical.

TOTAL VALUE OF STRATEGIES (weighted by performance value)

COOLING TARGET (set by property type)

=

COOL FACTOR SCORE



Method Example

Determine the value of all cooling strategies from the score sheet.

$$\frac{\text{TOTAL VALUE OF STRATEGIES}}{\text{COOLING TARGET}} = \text{COOL FACTOR SCORE}$$

$$\frac{\text{4,875 SF}}{\text{4,320 SF}} = \text{1.13} \geq \text{1}$$

PASS

Cool Factor Strategies Overview

Definitions, prerequisites, performance, scoring

Cool Factor Score Sheet

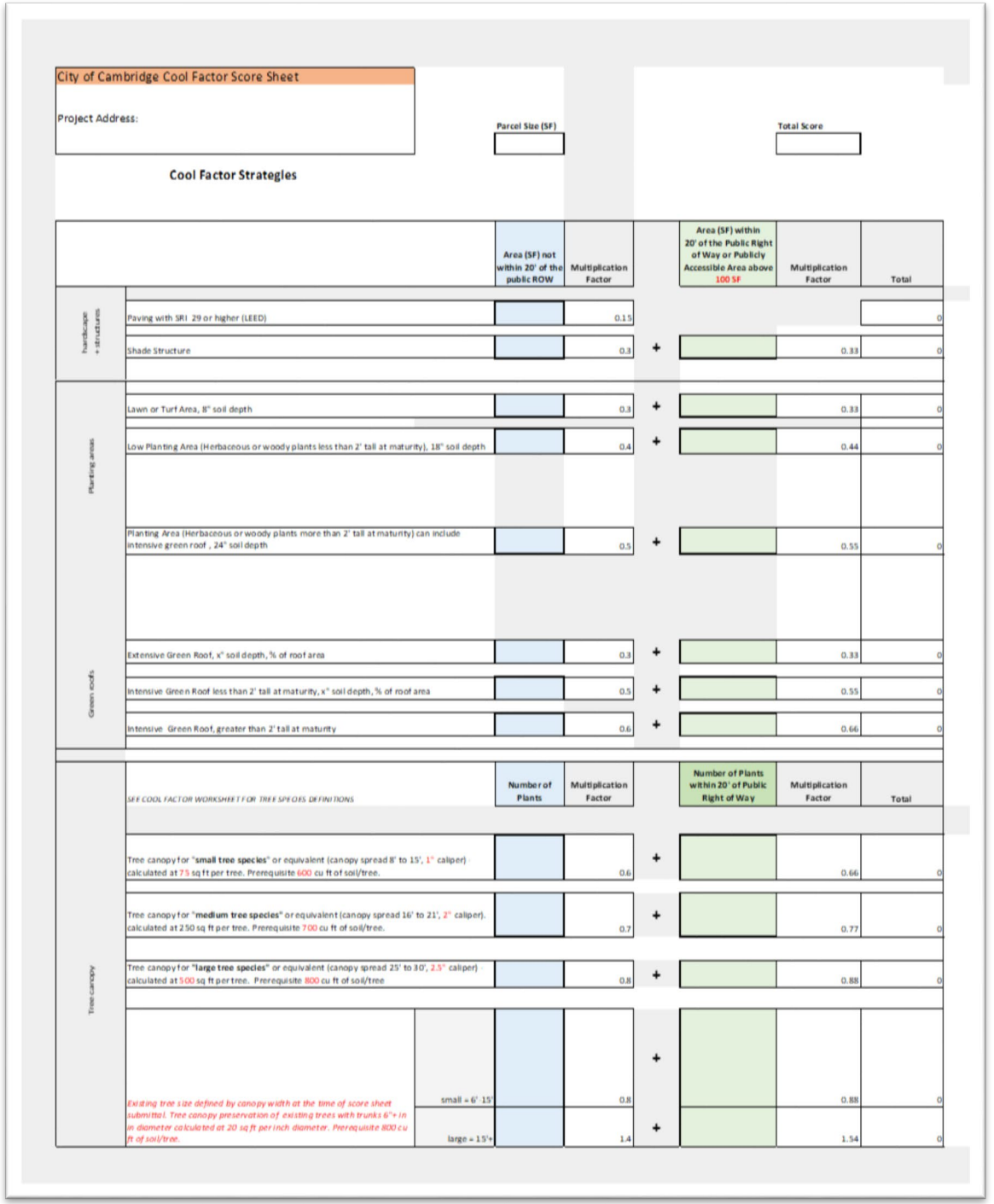
See score sheet and guidance document

Hardscapes and Structures

Planting Areas

Green Roofs

Tree canopy



City of Cambridge Cool Factor Score Sheet

Project Address:

Parcel Size (SF)

Total Score

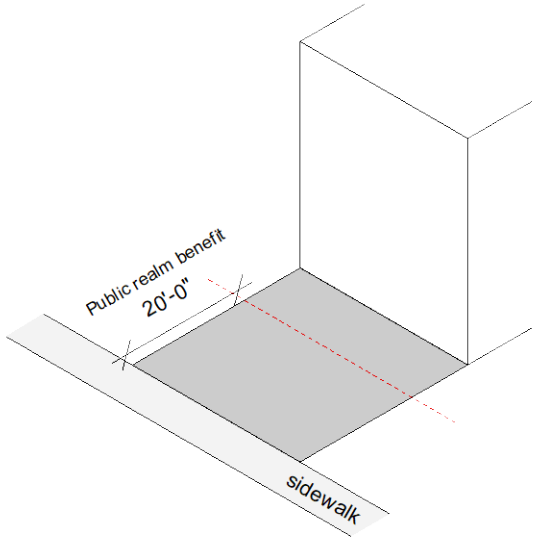
Cool Factor Strategies

		Area (SF) not within 20' of the public ROW	Multiplication Factor		Area (SF) within 20' of the Public Right of Way or Publicly Accessible Area above 100 SF	Multiplication Factor	Total
hardscape + structures	Paving with SRI 29 or higher (LEED)		0.15				0
	Shade Structure		0.3	+		0.33	0
Planting areas	Lawn or Turf Area, 8" soil depth		0.3	+		0.33	0
	Low Planting Area (Herbaceous or woody plants less than 2' tall at maturity), 18" soil depth		0.4	+		0.44	0
	Planting Area (Herbaceous or woody plants more than 2' tall at maturity) can include intensive green roof , 24" soil depth		0.5	+		0.55	0
Green roofs	Extensive Green Roof, x" soil depth, % of roof area		0.3	+		0.33	0
	Intensive Green Roof less than 2' tall at maturity, x" soil depth, % of roof area		0.5	+		0.55	0
	Intensive Green Roof, greater than 2' tall at maturity		0.6	+		0.66	0

		Number of Plants	Multiplication Factor		Number of Plants within 20' of Public Right of Way	Multiplication Factor	Total
Tree canopy	SEE COOL FACTOR WORKSHEET FOR TREE SPECIES DEFINITIONS						
	Tree canopy for "**small tree species**" or equivalent (canopy spread 8' to 15', 1" caliper) calculated at 75 sq ft per tree. Prerequisite 600 cu ft of soil/tree.		0.6	+		0.66	0
	Tree canopy for "**medium tree species**" or equivalent (canopy spread 16' to 21', 2" caliper). calculated at 250 sq ft per tree. Prerequisite 700 cu ft of soil/tree.		0.7	+		0.77	0
	Tree canopy for "**large tree species**" or equivalent (canopy spread 25' to 30', 2.5" caliper) calculated at 500 sq ft per tree. Prerequisite 800 cu ft of soil/tree		0.8	+		0.88	0
	Existing tree size defined by canopy width at the time of score sheet submittal. Tree canopy preservation of existing trees with trunks 6"+ in in diameter calculated at 20 sq ft per inch diameter. Prerequisite 800 cu ft of soil/tree. small = 6'-15'		0.8	+		0.88	0
	large = 15'+		1.4	+		1.54	0

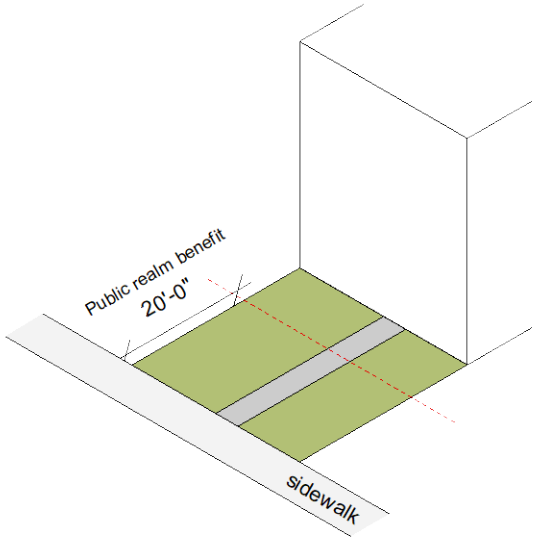
Overview of Strategies

Cool factor encourages a range of strategies toward a goal.



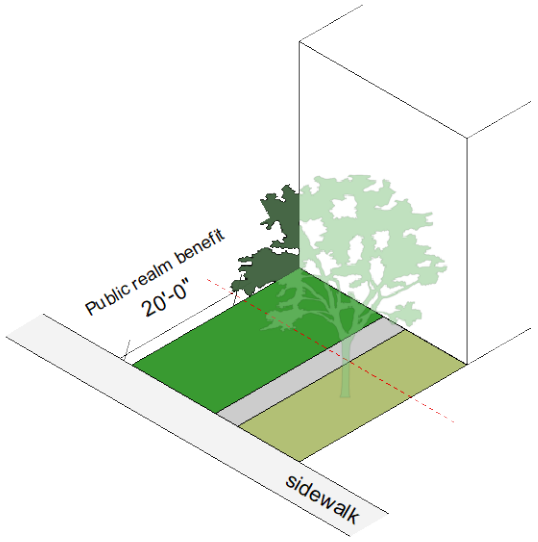
0.15

high SRI paving



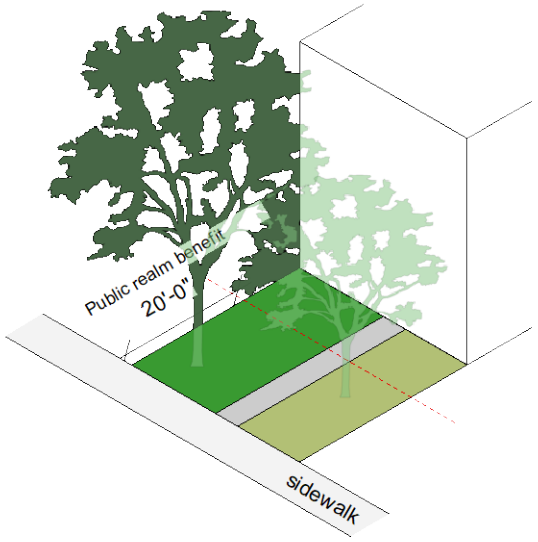
0.28

turf
high SRI paving



0.57

medium tree
planting
turf
high SRI paving



1.02

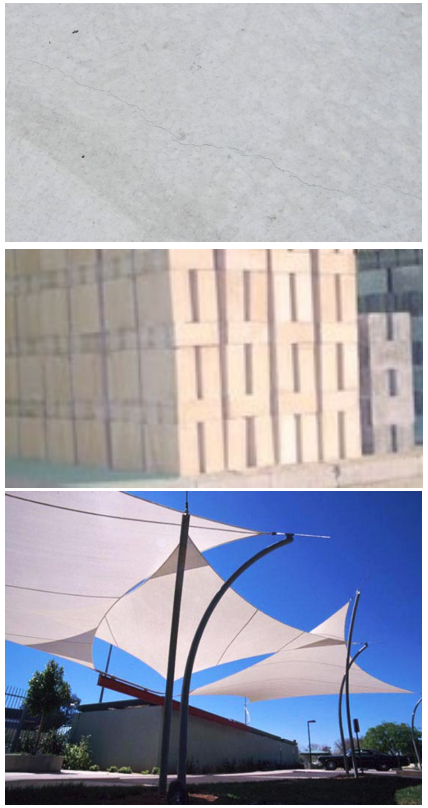
medium and large tree
planting
turf
high SRI paving

Overview of Strategies
Hardscape + structures

Cool Factor Strategy	Relative Temperature Reduction	Multiplication Factor
Paving with SRI of 39 or higher * Aligned with LEED V4 requirements	Reflective 'cool' materials contributed to at least 1˚ F and in many cases an excess of 3˚ F. **On a hot day contributed to reduction of up to 6˚ F** (Louisville Urban Heat Management, Urban Climate Lab)	0.15
Shade structure with SRI of 39 or higher * Aligned with LEED V4 requirements	Shaded surfaces, may be **20–45°F cooler** than the peak temperatures of unshaded materials. (Environmental Protection Agency)	0.3

*additional weight for public realm cooling

Strategy examples



Solar Reflectance Index

The Solar Reflectance Index (SRI.) is a measure of a constructed surface material's, "ability to reject solar heat, as shown by a small temperature rise.

It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100."

Source: Berkeley Lab, Heat Island Group

Comparing SRI/SR Standards

LEED V4

Surface/Structure Type	Initial SRI	3-year Aged SRI
Low slope ≤ 2:12	82	64
Steep slope > 2:12	39	32
	Initial SR	3-year Aged SR
Shade structure	0.33	0.28
Paving materials	0.33	0.28

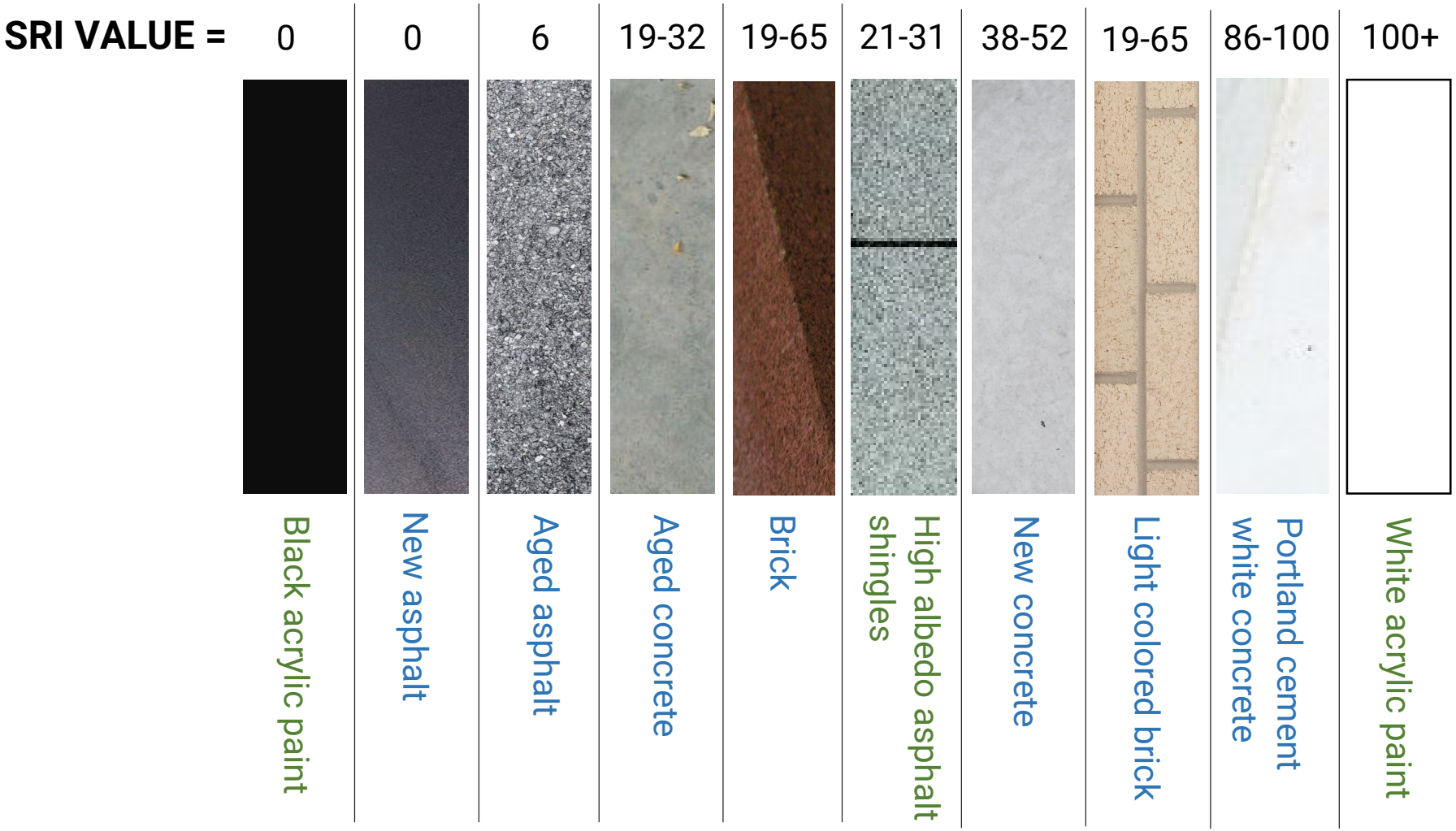
City of Los Angeles Cool Roof Ordinance

Surface/Structure Type	Initial SRI	3-year Aged SRI
Low slope ≤ 2:12	75	N/A
Steep slope > 2:12	16	N/A

Somerville Zoning

Surface/Structure Type	Initial SRI	3-year Aged SRI
Low slope ≤ 2:12	82	64
Steep slope > 2:12	39	32
Parking cover	39	32
	Initial SR	3-year Aged SR
Paving materials	0.33	0.28

Understanding SRI range of values for materials



Hardscape

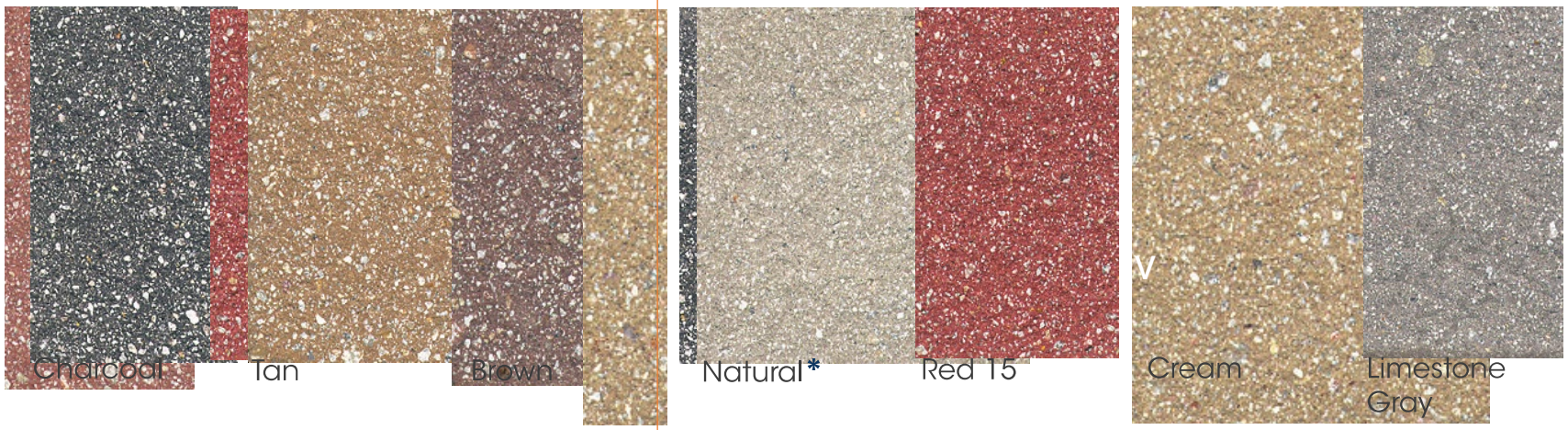
Shade structure

Understanding material SRI values

Meets SRI requirements

Standard paver colors

Source: Hanover Paver



SRI Value	29	25	33	28	45	41	39	40

Overview of Strategies
Planting areas

Cool Factor Strategy + Prerequisites	Relative Temperature Reduction	Multiplication Factor
Lawn or turf area * Minimum 8” soil depth	**Between 1 and +2°F of cooling from tree planting and grass cover** (Louisville Urban Heat Management Study, Urban Climate Lab) *Taller planting + wider diameter canopy provides more shaded surface*	0.3
Low planting area – includes herbaceous or woody plants less than 2’ tall at maturity * Minimum 18” soil depth		0.4
Planting area – includes herbaceous or woody plants greater than 2’ tall at maturity * Minimum 24” soil depth		0.5

Example of planting types

*additional weight for public realm cooling

Overview of Strategies
Green roof types

Green Roof
lightweight with a shallow layer of growing substrate of less than 200 mm deep, requiring minimal maintenance. They generally have lower water requirements and use small, low-growing plant species, particularly succulents.

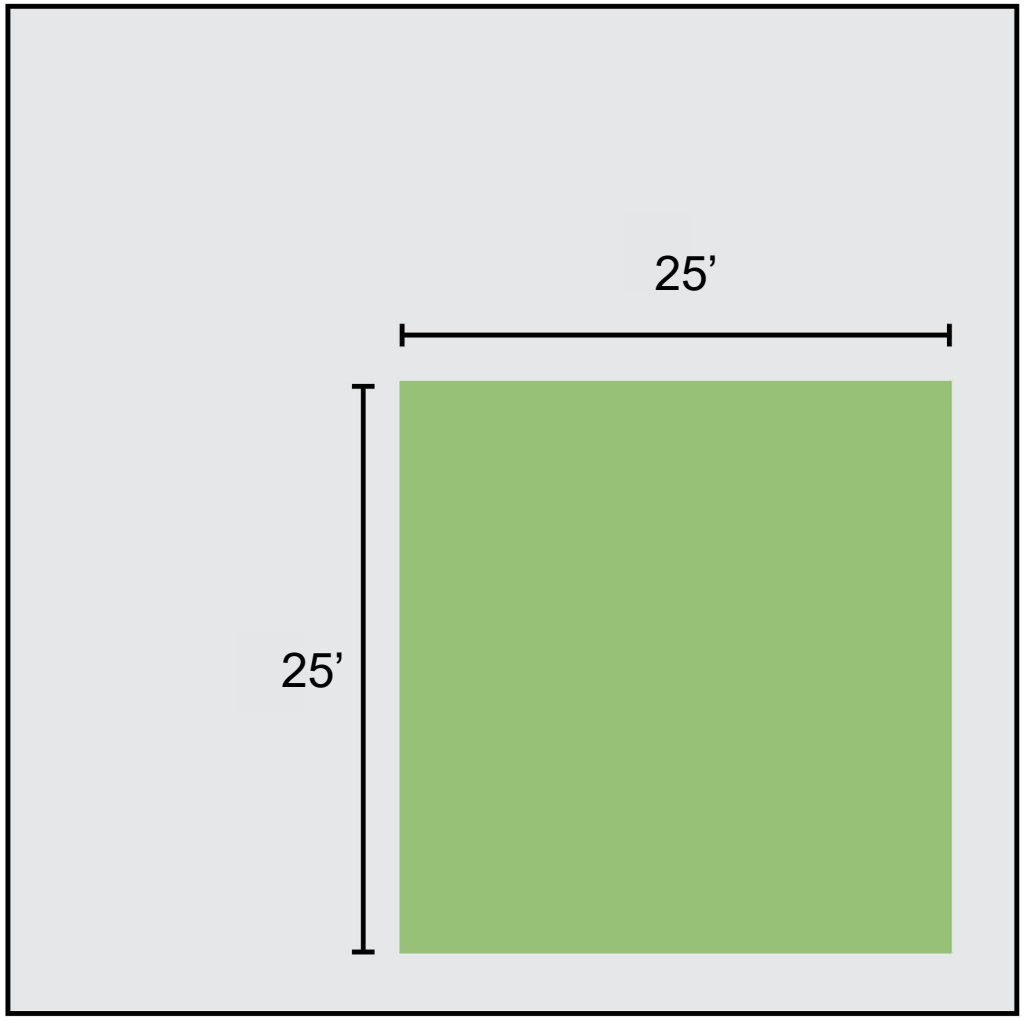
Intensive Green Roof
generally heavier, with a deeper layer of growing substrate, and support a wider variety of plant types. Intensive green roofs need more irrigation and maintenance than extensive roofs, and are highly engineered landscapes, often built directly on structures with considerable weight load capacity.

(https://www.growinggreenguide.org/technical-guide/introduction-to-roofs-walls-and-facades/green-roof-definition/)

*** Both green roof types can be accessible to occupants depending on type of building structure*

Overview of Strategies

Green roofs – calculations



Green roof will have minimum area requirement to facilitate most efficient cooling through contiguous planted area

Possible suggestion 25’ x 25’ for large parcels; or 50% of the total roof area for small parcels

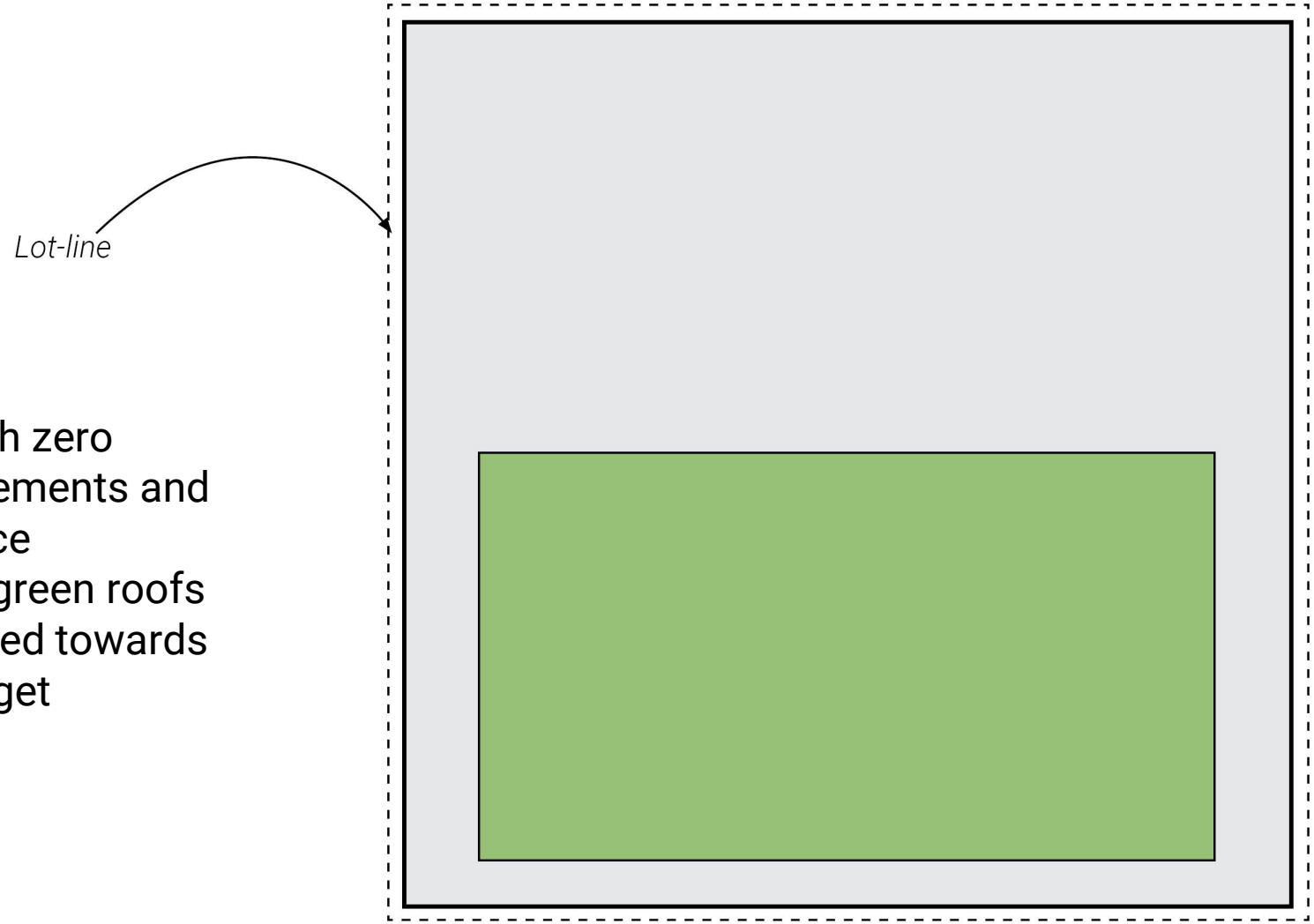
Hardscapes and walkways should be subtracted from the Green Roof Area, and only the ‘planted areas’ should be counted.

Green Area

Hardscape, walkway

Overview of Strategies

Green roofs and the ‘cool factor area’



For parcels with zero setback requirements and zero open space requirements, green roofs could be counted towards the cooling target

Overview of Strategies
Green roofs

Cool Factor Strategy + Prerequisites	Relative Temperature Reduction	Multiplication Factor
Extensive green roof * Minimum 4” soil depth	Green roof temperatures can be **30–40°F lower than those of conventional roofs and can reduce city-wide ambient temperatures by up to 5°F.** (Environmental Protection Agency) *Taller planting + wider diameter canopy provides more shaded surface*	0.3
Intensive green roof, less than 2’ tall at maturity * Minimum 18” soil depth		0.4
Intensive green roof, greater than 2’ tall at maturity * Minimum 24” soil depth		0.5

*additional weight for public realm cooling

Example of roof types

Overview of Strategies
Tree canopy: new trees

Cool Factor Strategy + Prerequisites	Relative Temperature Reduction	SF per tree	Multiplication Factor
Tree canopy for “small tree species” or equivalent • Canopy spread of 8’-15’, 1” caliper • minimum 600 cu ft of soil/tree	Shaded surfaces may be **20–45°F cooler** than the peak temperatures of unshaded materials. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by **2–9°F** (Environmental Protection Agency) *Taller planting + wider diameter canopy provides more shaded surface*	75	0.6
Tree canopy for “medium tree species” or equivalent • Canopy spread of 16’-21’, 1” caliper • minimum 700 cu ft of soil/tree		250	0.7
Tree canopy for “large tree species” or equivalent • Canopy spread of 25’-30’, 2.5” caliper • minimum 800 cu ft of soil/tree		500	0.8

*additional weight for public realm cooling

Example of tree species types

Overview of Strategies

Tree canopy: existing / tree preservation

Existing tree size defined by canopy width at the time of score sheet submittal. Tree canopy preservation of existing trees with trunks 6"+ in diameter calculated at 20 sq ft per inch diameter. Prerequisite 800 cu ft of soil/tree.

Cool Factor Strategy + Prerequisites	Relative Temperature Reduction	Multiplication Factor
Tree canopy for “small trees” • Canopy spread of 6’-15’	Shaded surfaces may be **20–45°F cooler** than the peak temperatures of unshaded materials. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by **2–9°F** (Environmental Protection Agency) *Taller planting + wider diameter canopy provides more shaded surface*	0.8
Tree canopy for “large trees” • Canopy spread of 16’+		1.4

*additional weight for public realm cooling

Cool Factor Site Testing

Parcel test overview

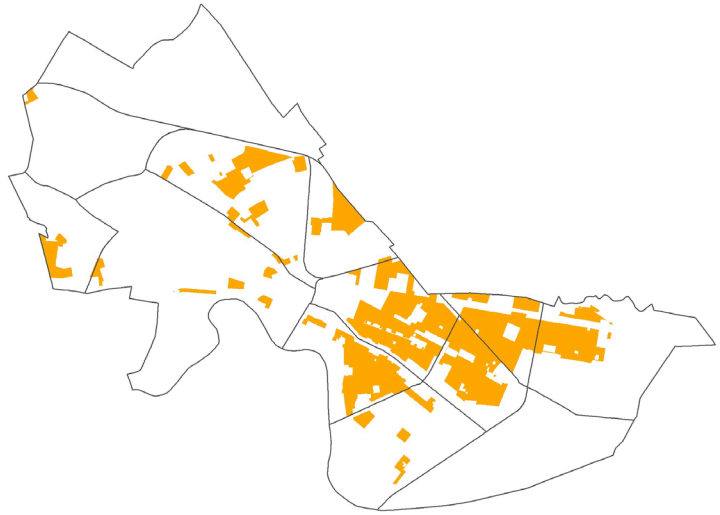
- Tested one ‘typical parcel’ per zoning district
- Exercise driven by zoning open space and set back requirements
- Explored which strategies are feasible per parcel type
- Compared scores across zoning districts to understand if cool factor is effective and scoring seems reasonable

Cool Factor test on ‘typical’ parcels

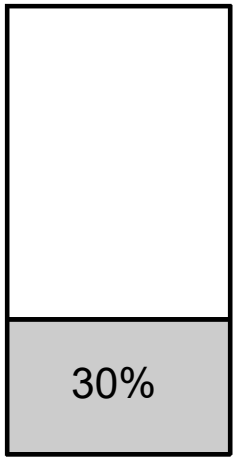
Zoning District	Land Use	Open space requirement	Site
Residential B	Residential	40%	Rindge Ave
Residential C-1	Multi-family dwellings	36%	Typical parcel
Business A-2	Residential with Commercial	none	Mass Ave
Industry B	Office	none	Main Street

Residential C-1

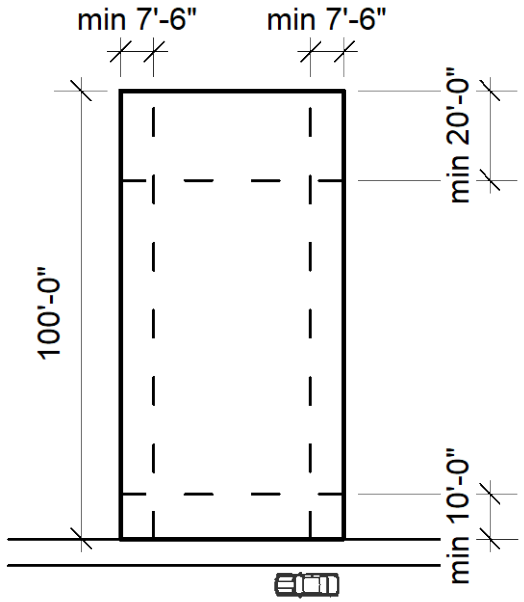
Multi-family dwellings



Existing open space requirement

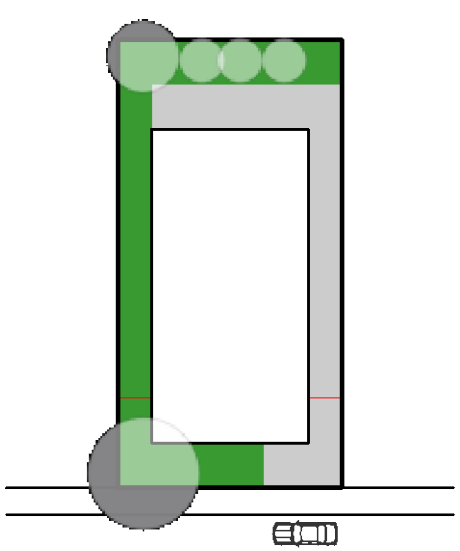


Setback requirement



Achieving Cool Factor

Residential C-1



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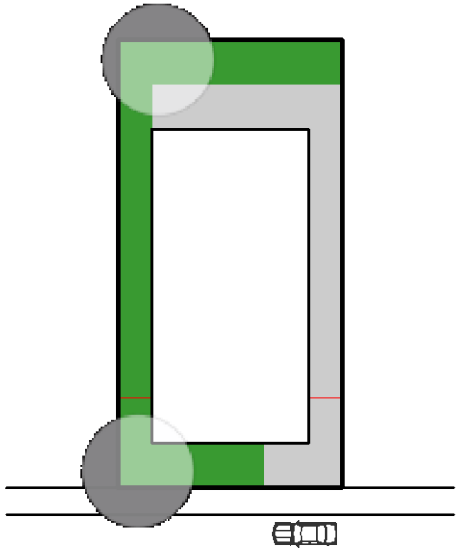

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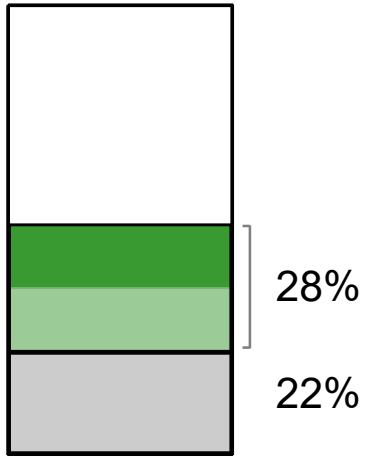


planting

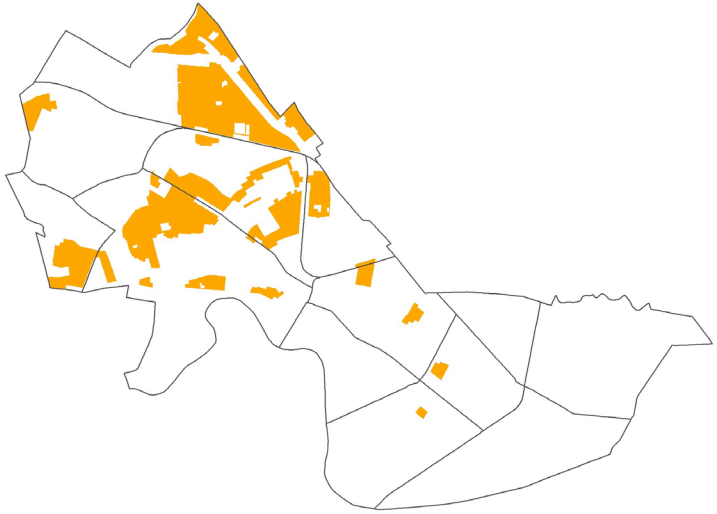
canopy over planting

high SRI paving

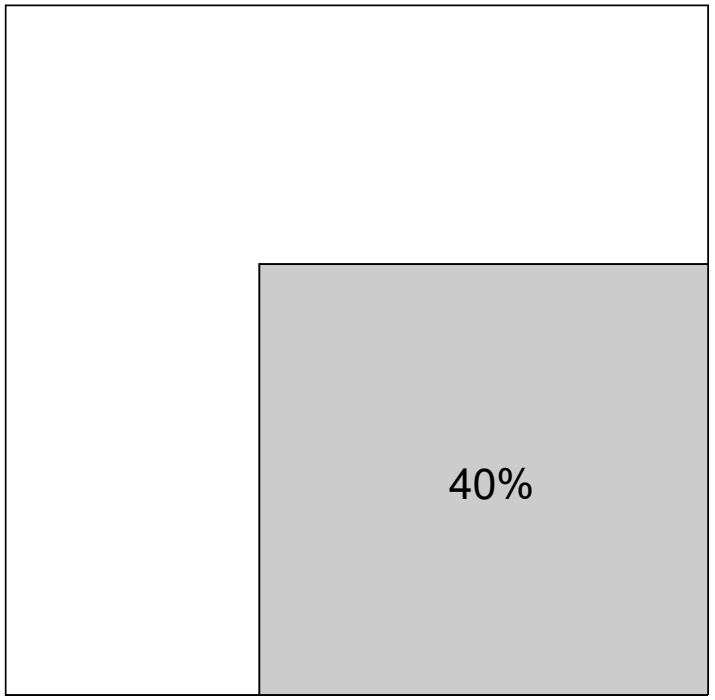
canopy over high SRI paving

Residential B

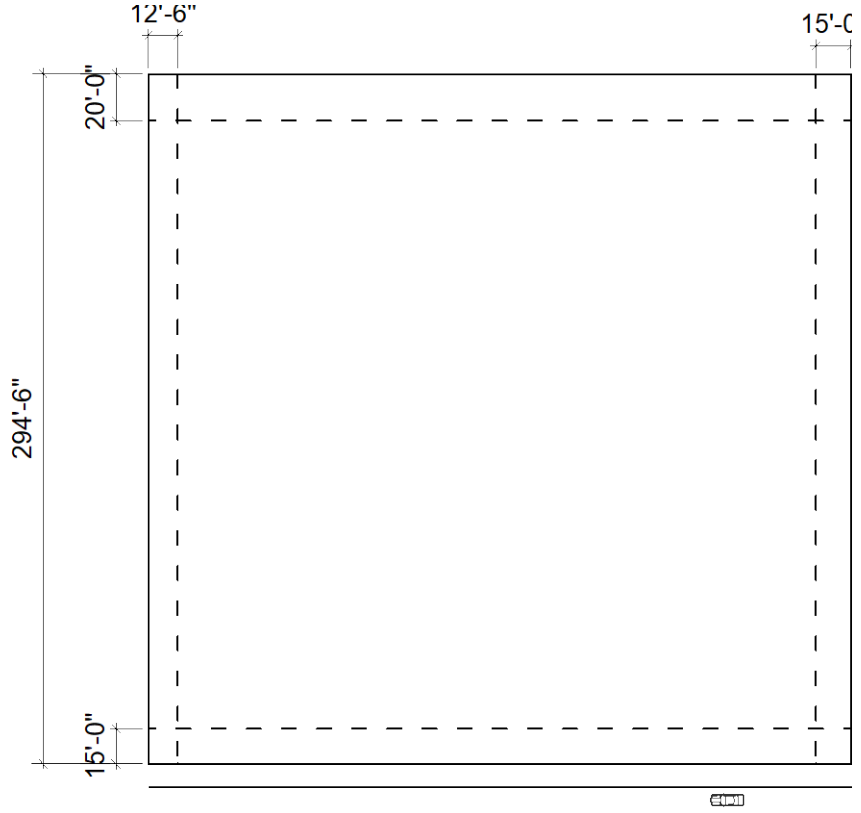
Two family or semi-detached dwellings



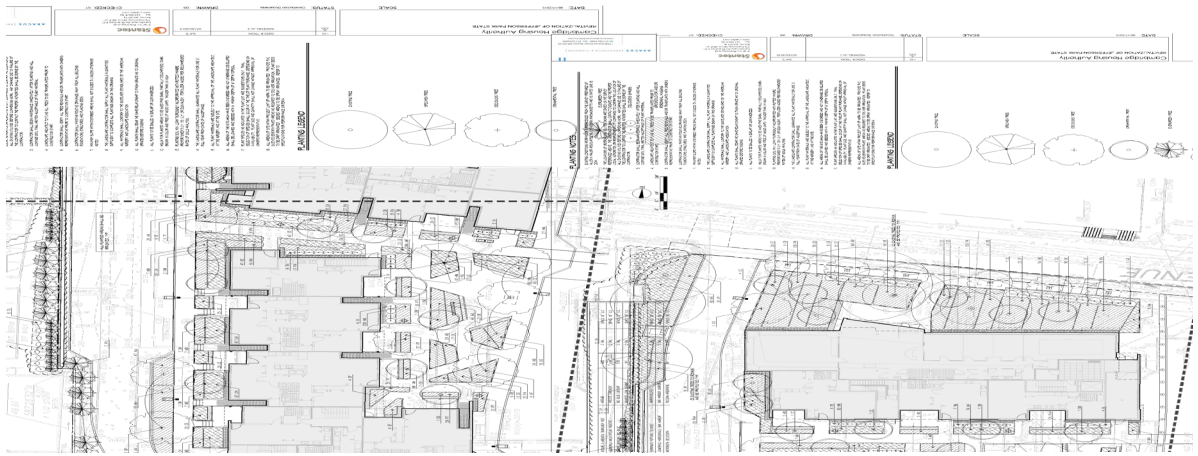
Existing open space requirement



Setback requirement



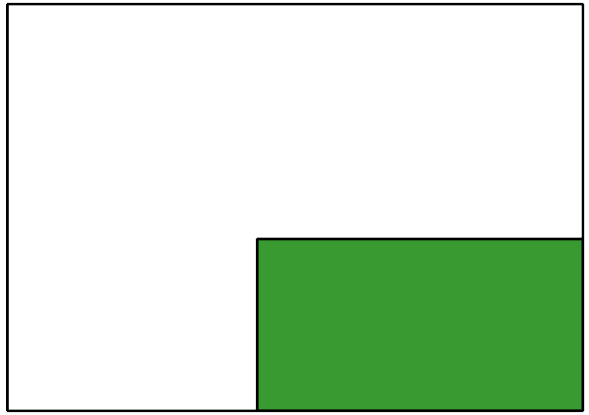
Residential B



1.13

Strategies utilized:

- Low planting area
- Small, medium, large trees

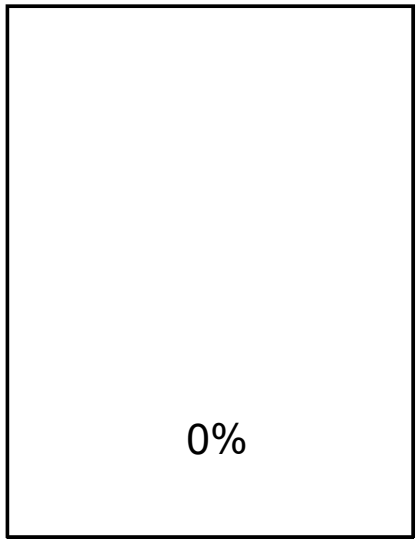


24% planting

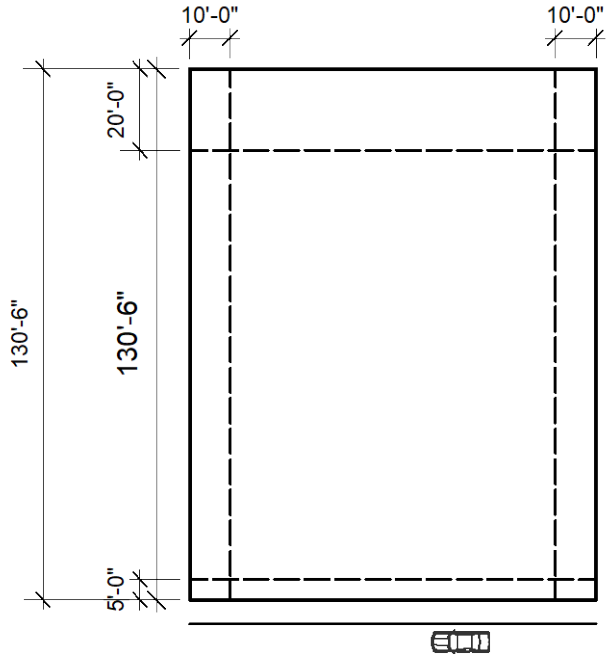
21% canopy over planting

Business A2

Existing open space requirement

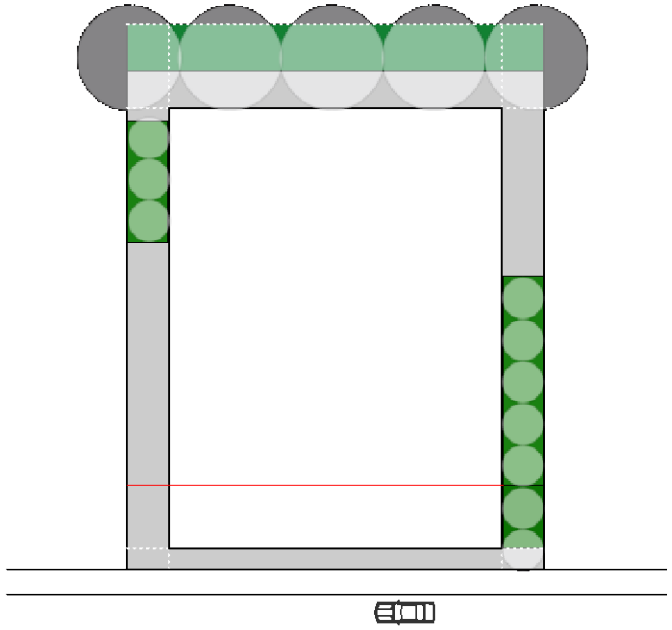


Setback requirement

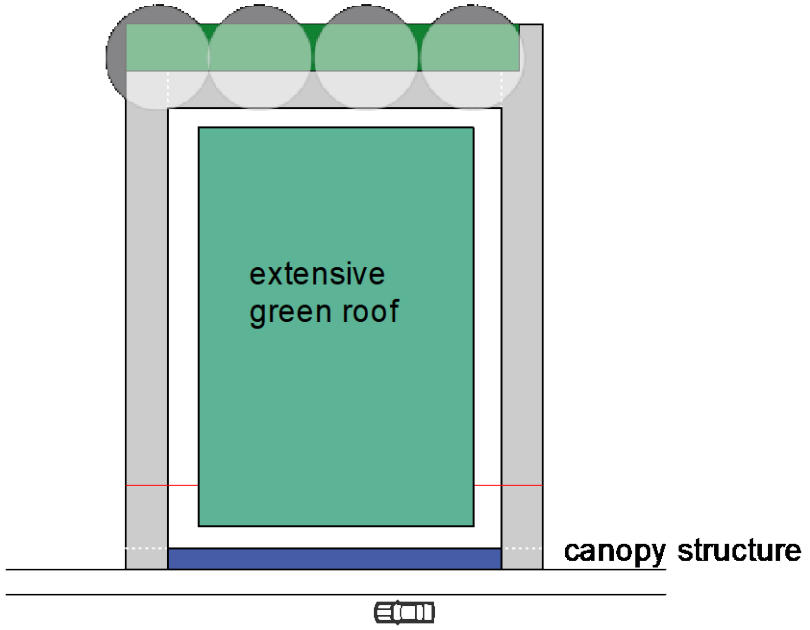


Achieving Cool Factor

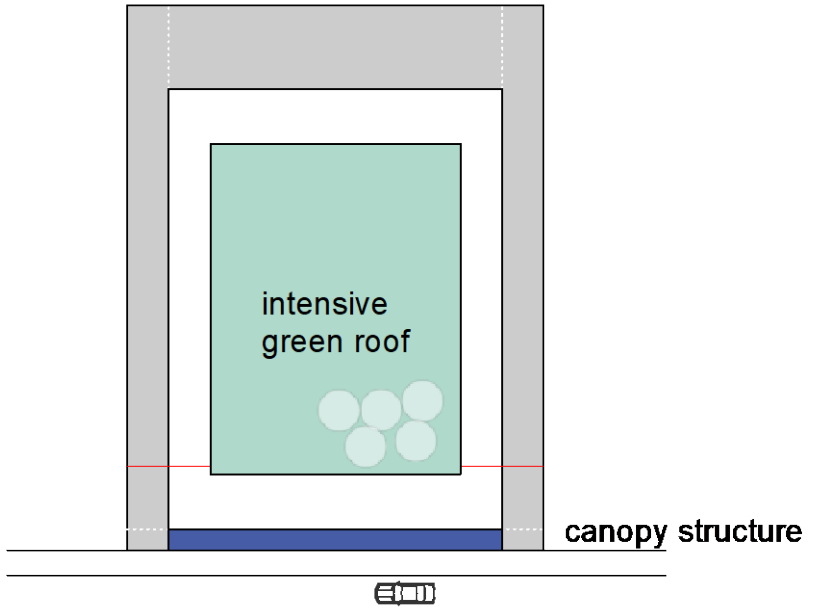
Business A2 Typology



0.8



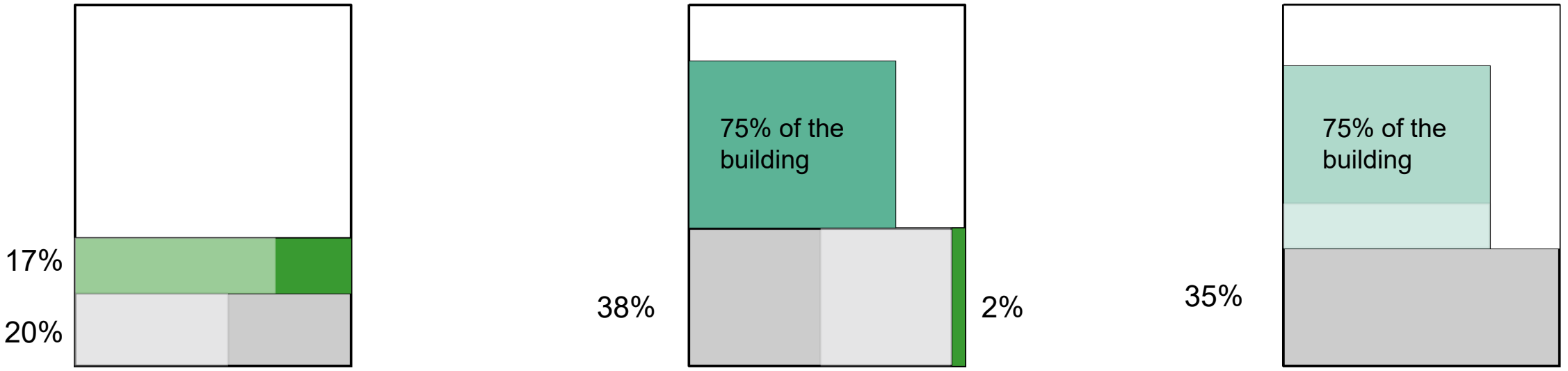
1.0



1.0

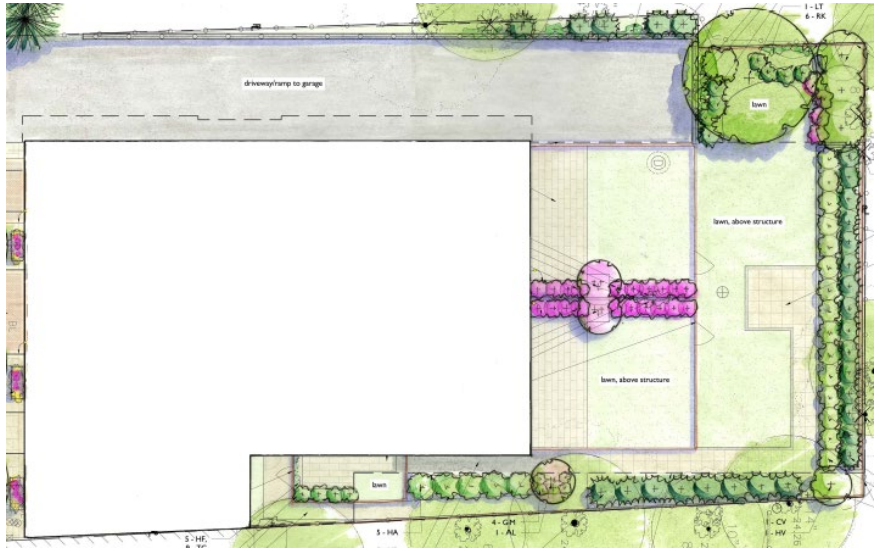
Ways of achieving Cool Factor

Business A2 Typology



planting canopy over planting high SRI paving canopy over high SRI paving green roof intensive green roof

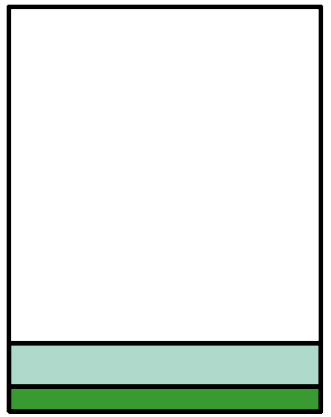
Business A2



0.61

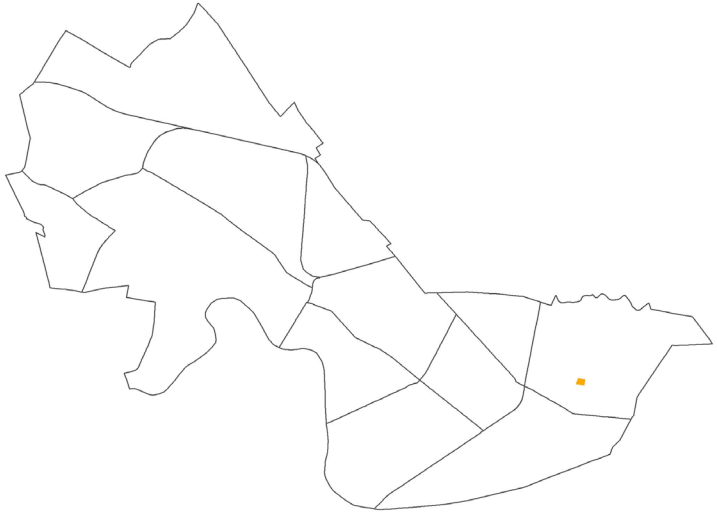
Strategies utilized:

- Green roof
- Low planting area
- Small, medium trees



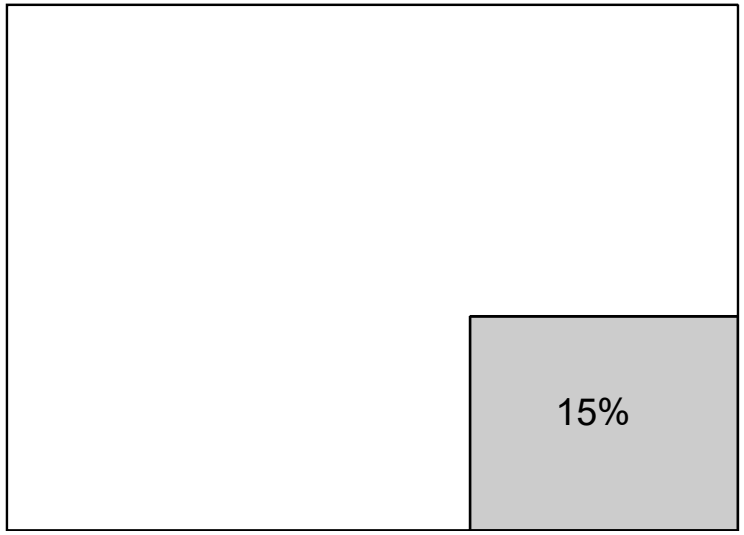
6%		planting
5%		canopy over planting
11%		intensive green roof

Industry B



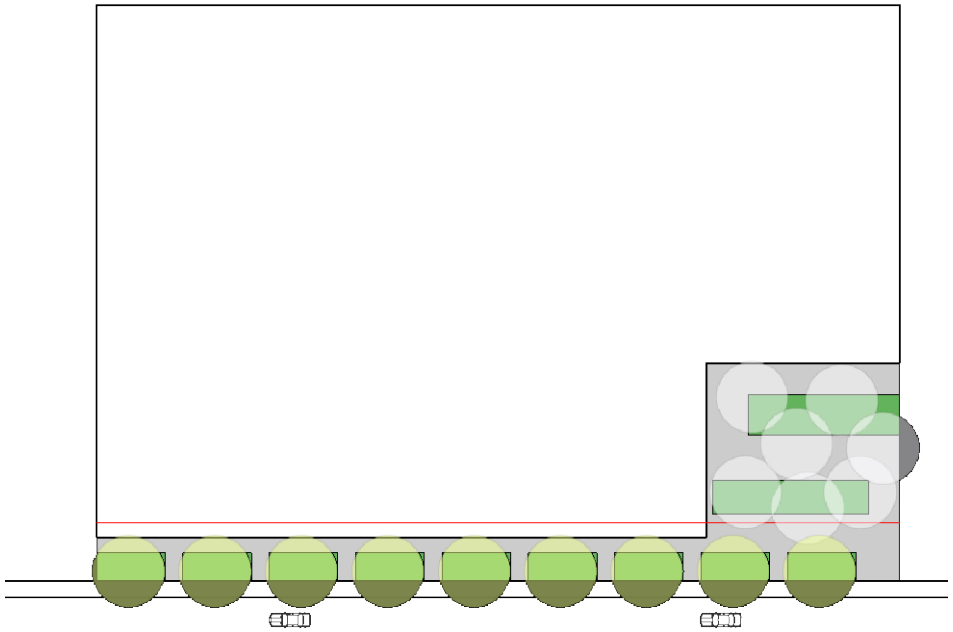
existing open space/setback requirement

through Article 19

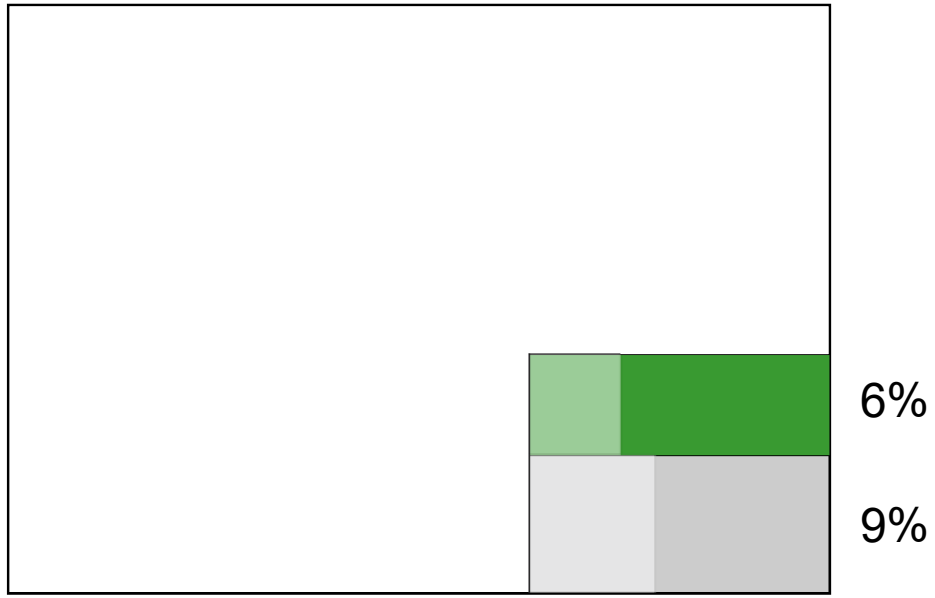


Achieving Cool Factor

Industry B Typology – landscape strategy



1.02



planting

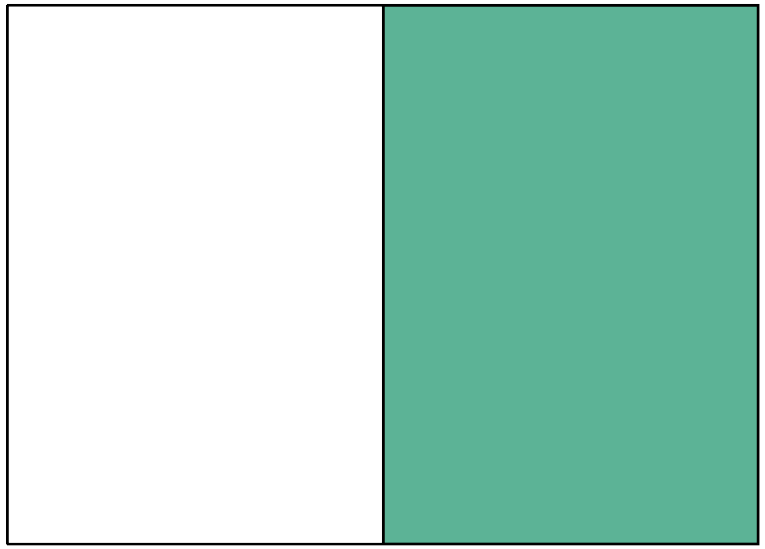
canopy over planting

high SRI paving

canopy over high SRI paving

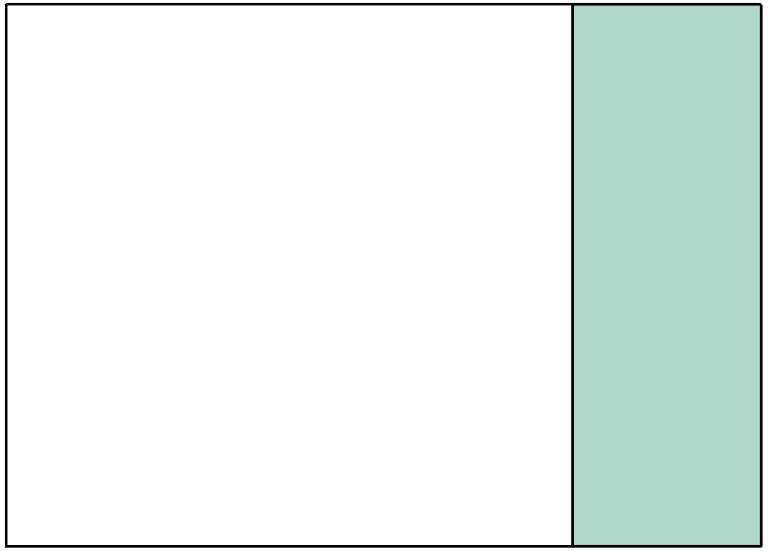
Achieving Cool Factor

Industry B Typology – green roof strategy



50% green roof

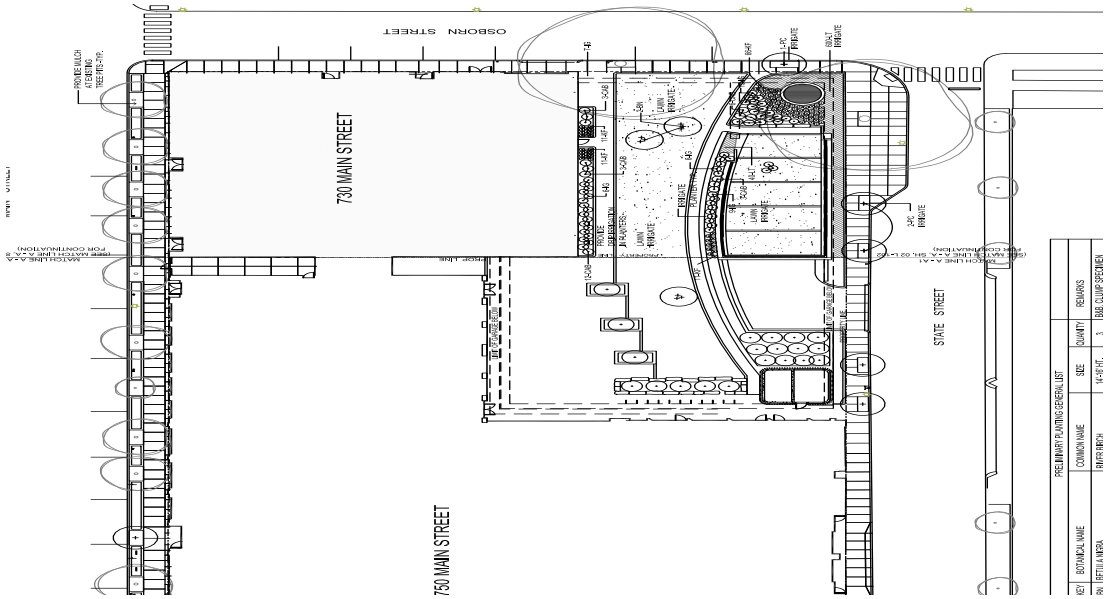
1.0



25% intensive green roof

1.0

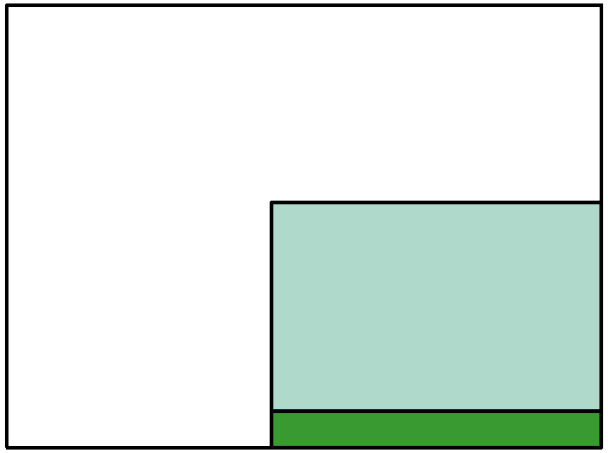
Industrial B



1.37

Strategies utilized:

- Green roof
- Lawn/low planting area
- Tree preservation



5%		planting
5%		canopy over planting
26%		intensive green roof

Cool factor test cases

Conclusions, Questions

Do these scores make sense? Should they be weighted differently?

Zoning District	Land Use	Zoning open space req.	Site	Cool Factor Score
Residential B	Residential	40%	Rindge Ave	1.13
Residential C-1	Multi-family dwellings	36%	Typical parcel	1.0
Business A-2	Residential with Commercial	none	Mass Ave	0.61
Industry B	Office	None	Main Street	1.37

Key findings, questions, next steps

Key findings

- The Cool factor is successful in:
  - Making a difference compared with the base zoning requirements for open space
  - Weighting -- ‘good projects’ received ‘good’ cool factor scores

- It is less clear if the Cool factor can:
  - Significantly encourage greening of the public realm
  - Encourage cooling strategies on already built projects

Discussion

- Do you agree that the target should be calibrated by zoning open space requirements?
- Should there be a minimum cooling target based on parcel size (i.e. 15%)?
- Does the current weighting system seem reasonable and feasible? Should it be more ambitious?
- Is this a tool that can be applied easily and effectively by property owners and developers?