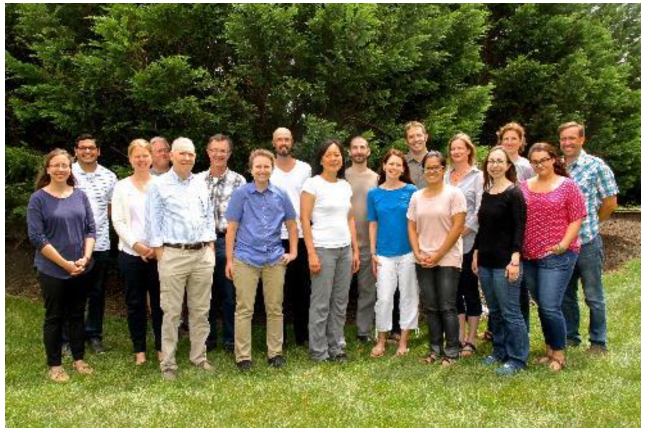
Making Urban Trees Count

Quantifying and Crediting Stormwater Benefits

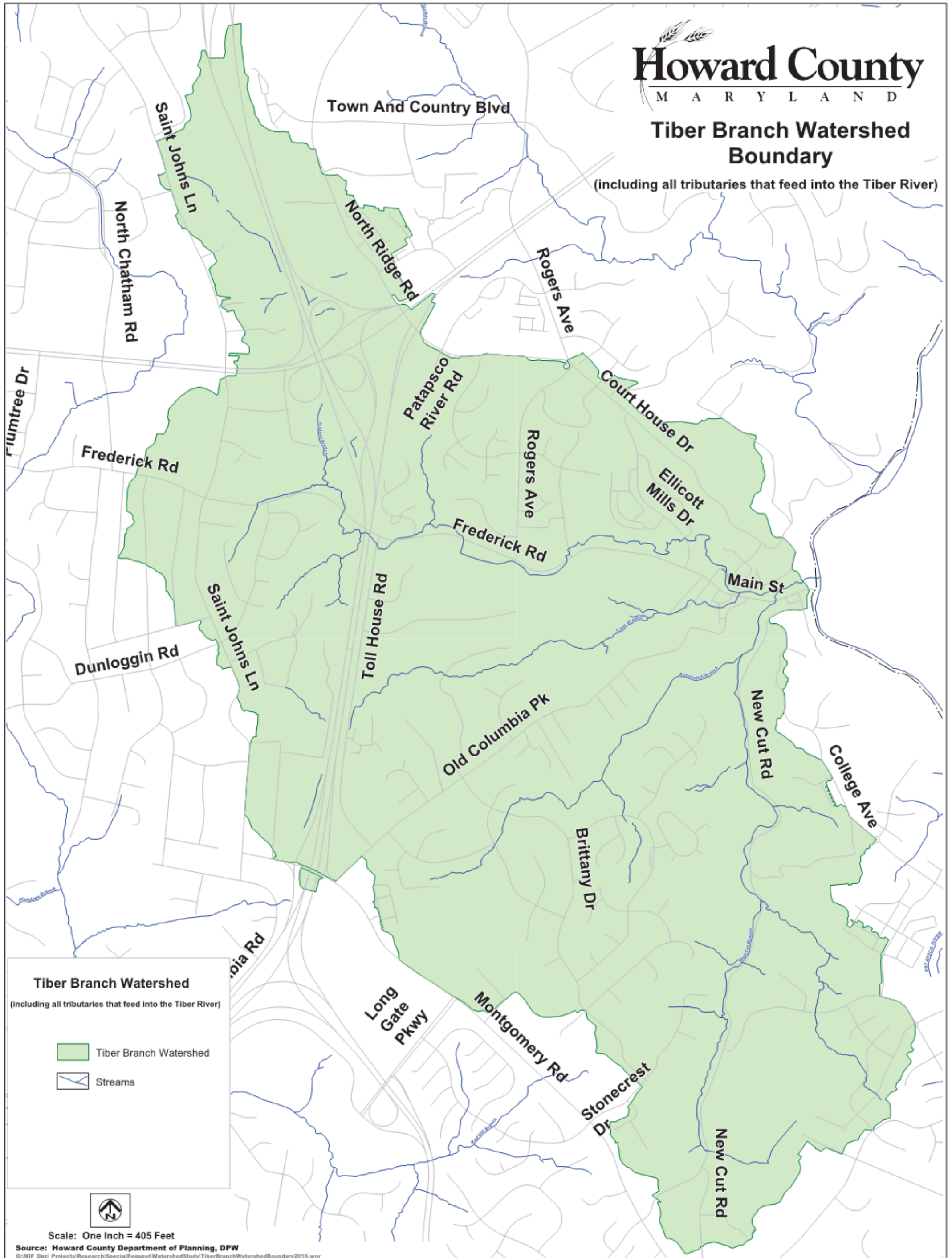
Bill Hodgins, P.E.
Senior Water Resources Engineer



About the Center for Watershed Protection

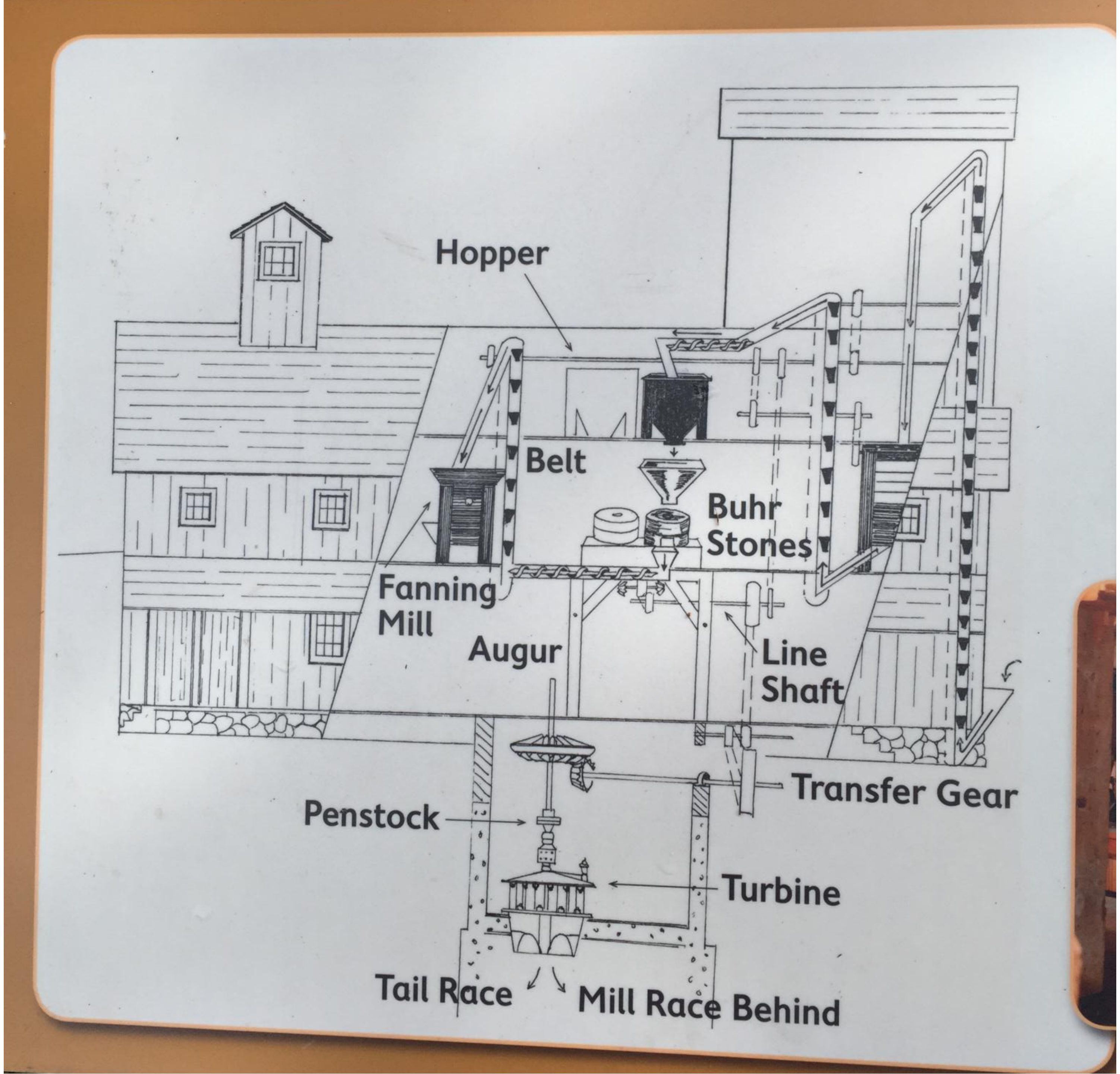
www.cwp.org

- Founded in 1992 – celebrating 25 years!
- 501 (c) 3 nonprofit; works to protect, restore and enhance our waterways
- Diverse client base of government agencies, foundations, watershed organizations and firms across the country
- Headquartered in Ellicott City, MD with offices in VA, PA, NY and SC.



ELLICOTT CITY HISTORIC DISTRICT
Howard County Local District established 1974
National Register District established 1978

Center for Watershed Protection



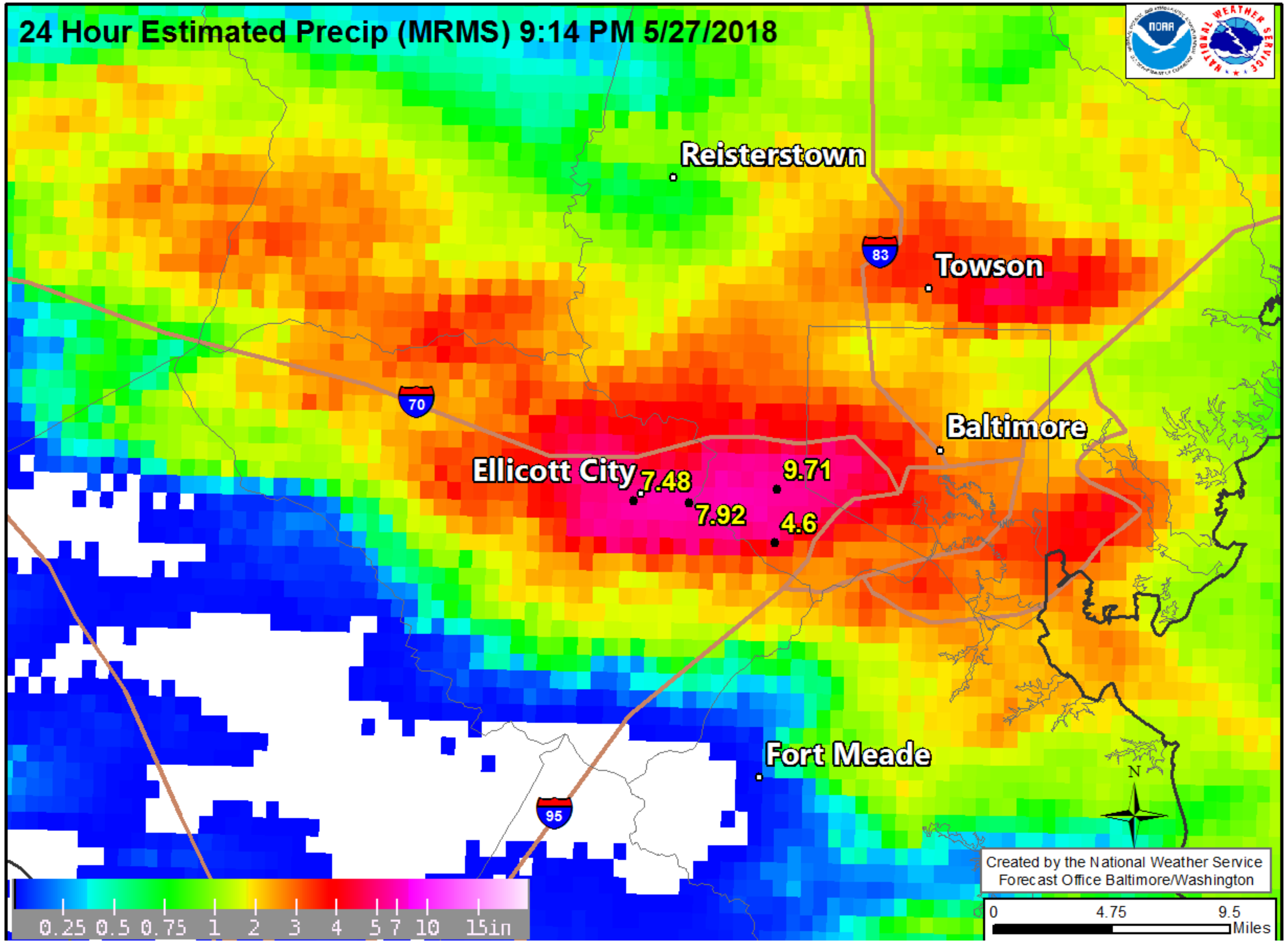
Center for Watershed Protection

May 27 2018

Ellicott City, MD – May 27, 2018

Duration	Max Rainfall in Duration	Time of Occurrence
1 minute	0.16”	4:15pm-4:16pm
5 minutes	0.56”	4:15pm-4:20pm
10 minutes	0.96”	4:11pm-4:21pm
15 minutes	1.44”	4:06pm-4:21pm
30 minutes	1.84” 1.84”	3:53pm-4:22pm 5:20pm-5:50pm
60 minutes	2.68” 2.84”	3:20pm-4:20pm 5:00pm-6:00pm
2 hours	5.00”	3:53pm-5:53pm
3 hours	6.56”	3:15pm-6:15pm

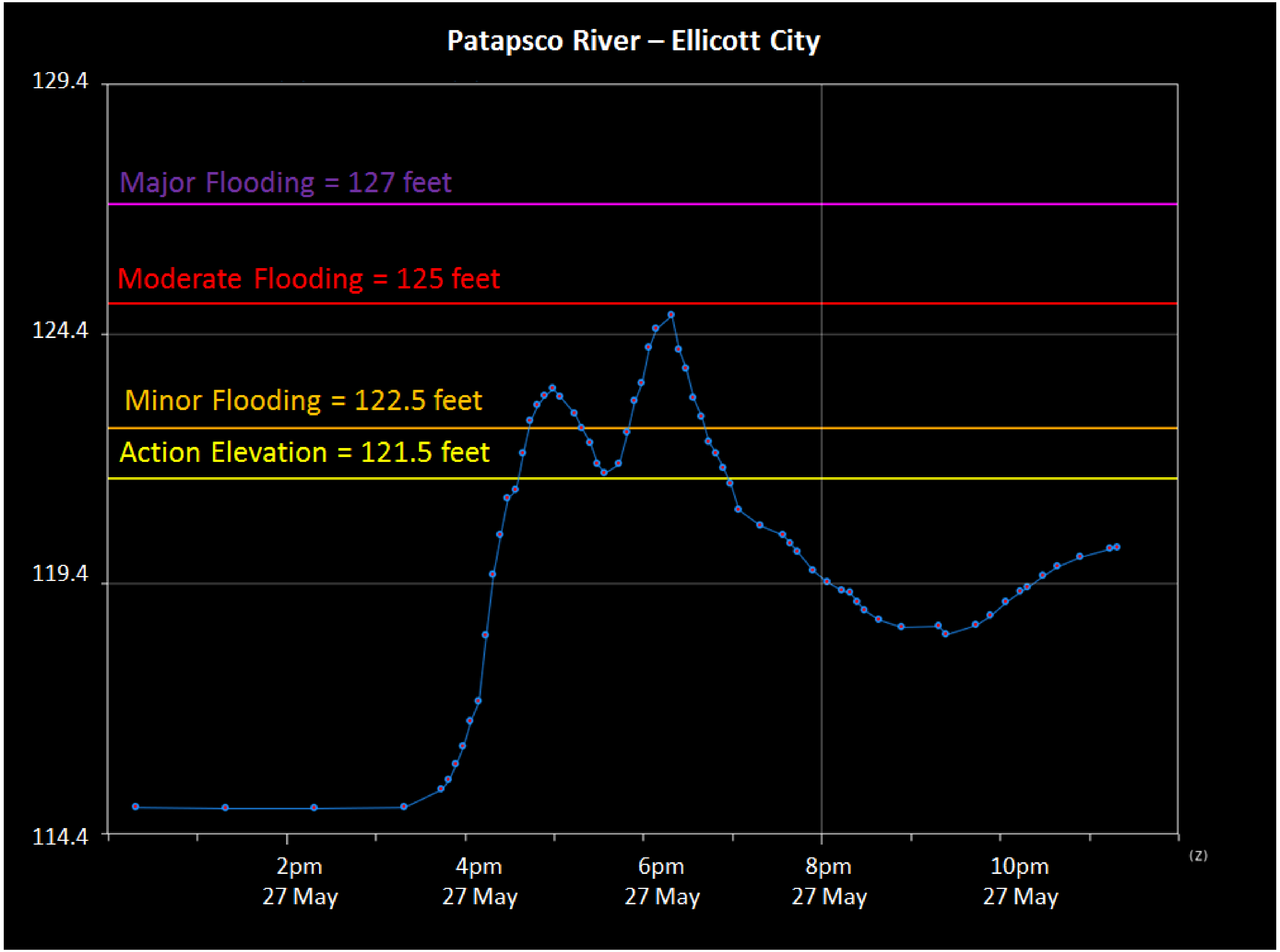
Information obtained from the Ellicott City (ELYM2) rain gauge.
Data is preliminary and subject to correction. This gauge reports in 0.04” increments.



https://www.weather.gov/lwx/EllicottCityFlood2018

Center for Watershed Protection

- Two distinct periods of heavier rain
- 1.5-2 inches from & flood warning at 3:12 pm
- 6 inches by 5:15 pm




SUN
0:24 / 1:37


SUN
0:19 / 1:37

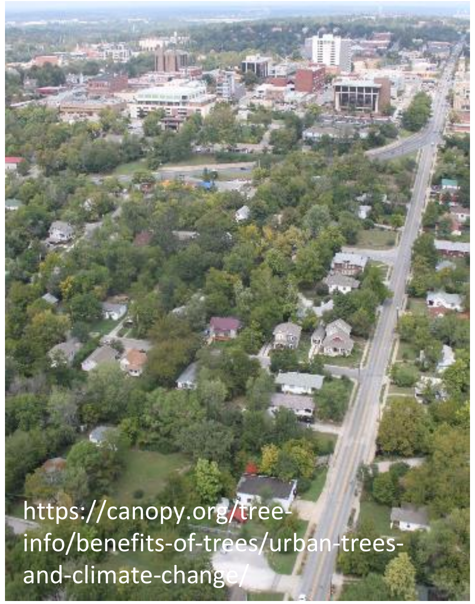
0:05 / 1:37

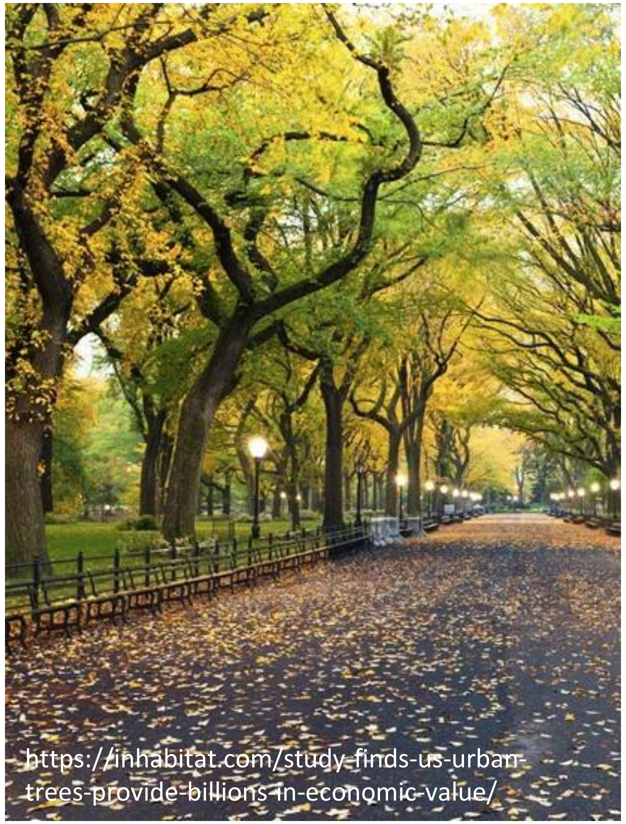
1:27 / 1:37


0:05 / 1:55

Outline

- Effectiveness of urban trees on reducing runoff
- Existing crediting methods
- Example tree crediting
- New crediting framework
- Research Needs & Next steps


https://canopy.org/tree-info/benefits-of-trees/urban-trees-and-climate-change/


https://inhabitat.com/study-finds-us-urban-trees-provide-billions-in-economic-value/

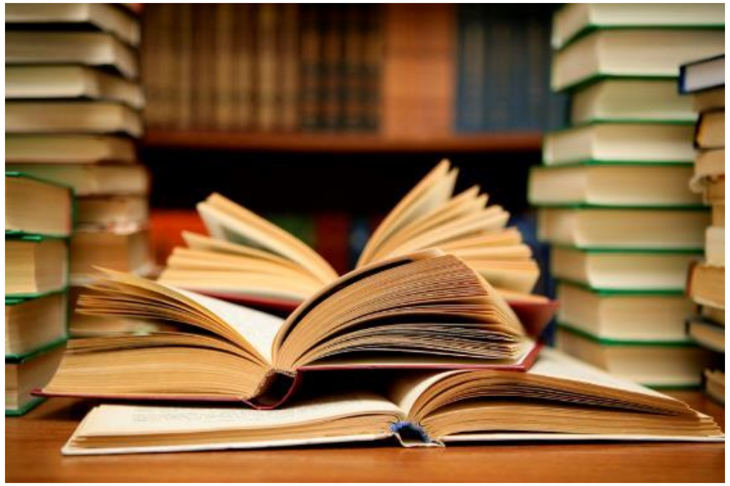
Center for Watershed Protection

Runoff and Pollutant Removal Capabilities of Urban Trees

CENTER FOR WATERSHED PROTECTION

State of the Science

- U.S. Forest Service Grant (14-DG-11132540-104)
- Reviewed **159** studies that address the WQ benefits of urban trees
  - **49** Studies focus on the hydrologic benefits of urban trees
    - Quantify one or more component of the trees hydrologic cycle
    - Inform estimates of runoff reduction of urban trees
- Reviewed studies on the WQ benefits of non-urban forests
  - May be considered as an upper limit to any urban tree credit



Stormwater BMPs

NRCS National Engineering Handbook - TR-55

Runoff Reduction Method

Georgia Manual

SCS Runoff Curve Number Method (CN)

- $Q=(P-I_a)^2/[(P-I_a)+S]$
  - Q = runoff (in)
  - P = rainfall (in)
  - S = potential maximum retention after runoff begins (in)
  - I_a = initial abstraction (in)

SCS Runoff Curve Number Method (CN)

$I_a = 0.2S$

$S = (1000/CN) - 10$

As CN increases S decreases

As S decreases I_a decreases

As I_a decreases Q (runoff) increases

SCS Runoff Curve Number Method (CN)

Table 9–5 Runoff curve numbers for urban areas [1/]

Cover description cover type and hydrologic condition	Average percent impervious area [2/]	-- CN for hydrologic soil group -- A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

1/ Average runoff condition, and $I_a = 0.2S$.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3/ CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage

Stormwater retained based on CN

Stormwater BMPs that retain stormwater

The Urban Tree Canopy

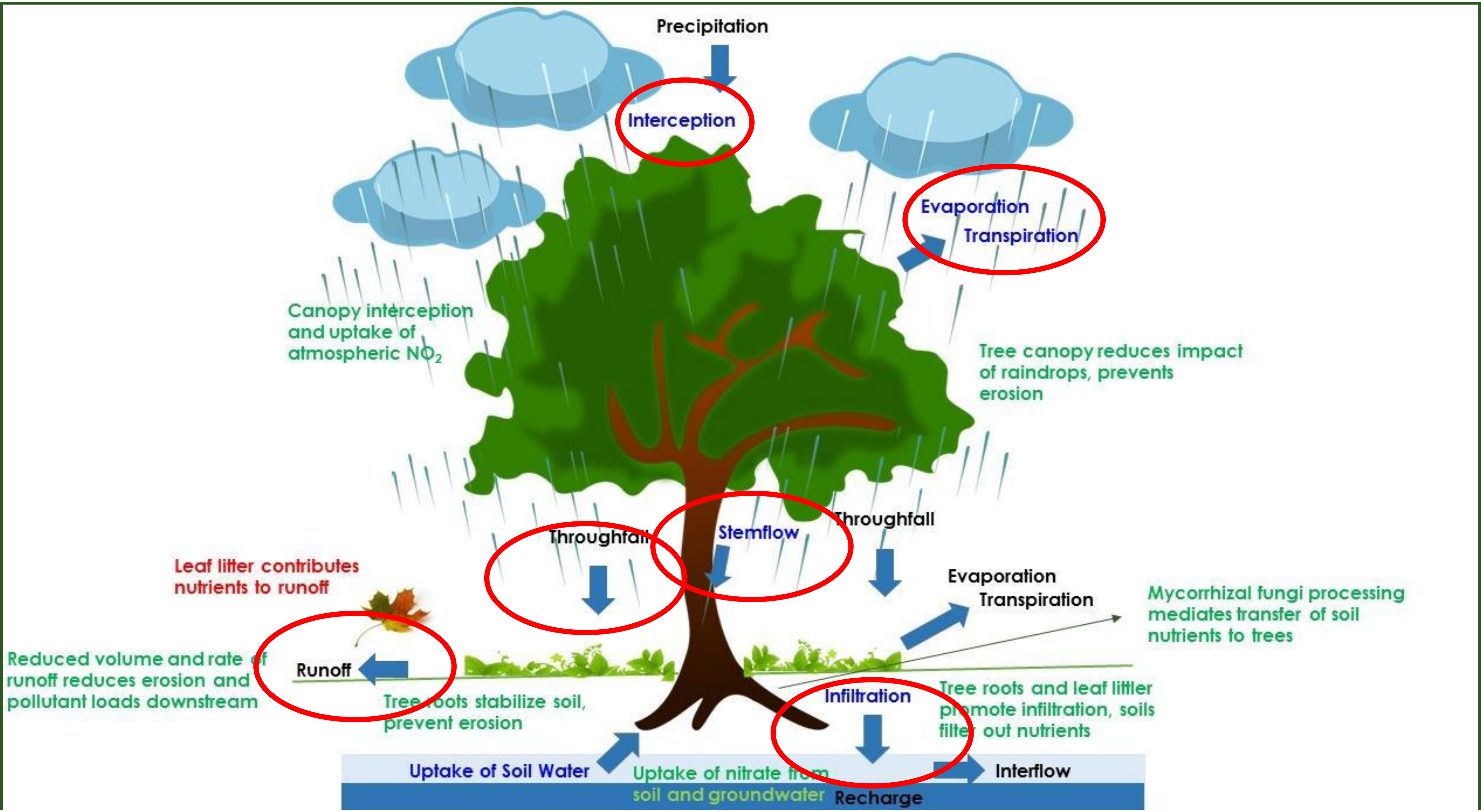
CBT Expert Panel to determine pollution control performance estimates for expanded urban tree canopy

Center for Watershed Protection

Urban Trees are Different

- No defined drainage area
- Water quality benefits inferred from volume reduction
  - Large number of variables affect performance
  - Benefits INCREASE over time
- Urban conditions
- Concerns about maintenance
- Consequently, lack of incentive to use them unless there are available ‘credits’

CENTER FOR WATERSHED PROTECTION


Precipitation
Interception
Evaporation
Transpiration
Canopy interception and uptake of atmospheric NO_2
Tree canopy reduces impact of raindrops, prevents erosion
Throughfall
Stemflow
Throughfall
Leaf litter contributes nutrients to runoff
Evaporation
Transpiration
Mycorrhizal fungi processing mediates transfer of soil nutrients to trees
Reduced volume and rate of runoff reduces erosion and pollutant loads downstream
Runoff
Tree roots stabilize soil, prevent erosion
Infiltration
Tree roots and leaf litter promote infiltration, soils filter out nutrients
Uptake of Soil Water
Uptake of nitrate from soil and groundwater
Interflow
Recharge

Benefits of Trees to Urban Stormwater

- Tree canopy retains rainfall
  - ~20% annual rainfall under canopy
  - First 2-4 mm of rainfall
  - 0.2 mm per m2 of leaf area
- Stemflow
  - Directs up to 15% of interception to soil
- Canopy cover reduces rainfall intensity
  - Deciduous canopy 15 – 21%
  - Coniferous canopy 21 – 52%

- Trees increase infiltration under canopy
  - Up to 350%
- Trees transpire 50 to 450 gallons/day
  - Species and microclimate dependent

How Trees and Urban Forest Systems Affect Stormwater Runoff, Kuehler , 2016

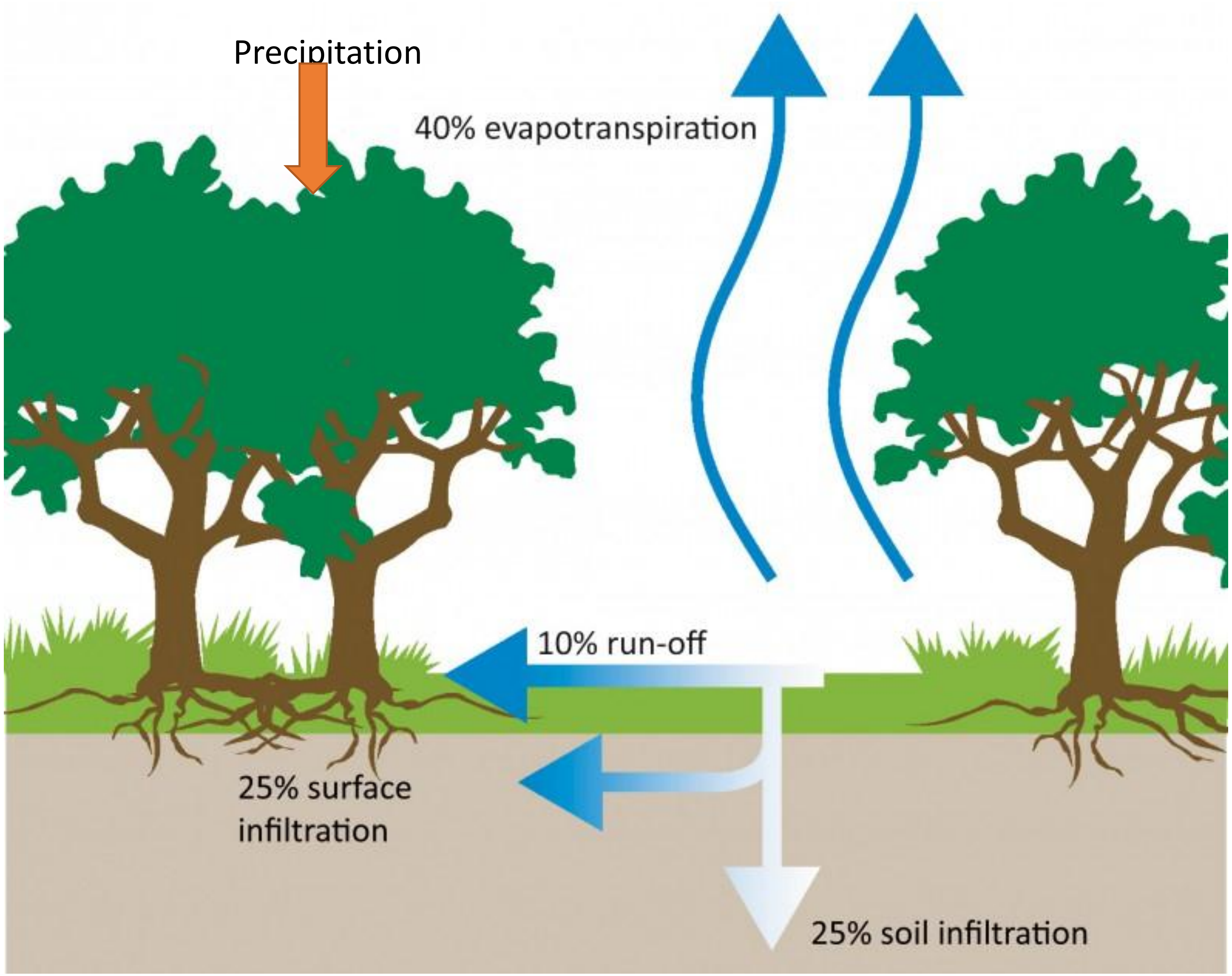
CENTER FOR WATERSHED PROTECTION

Water Balance Approach

General Mass Balance:

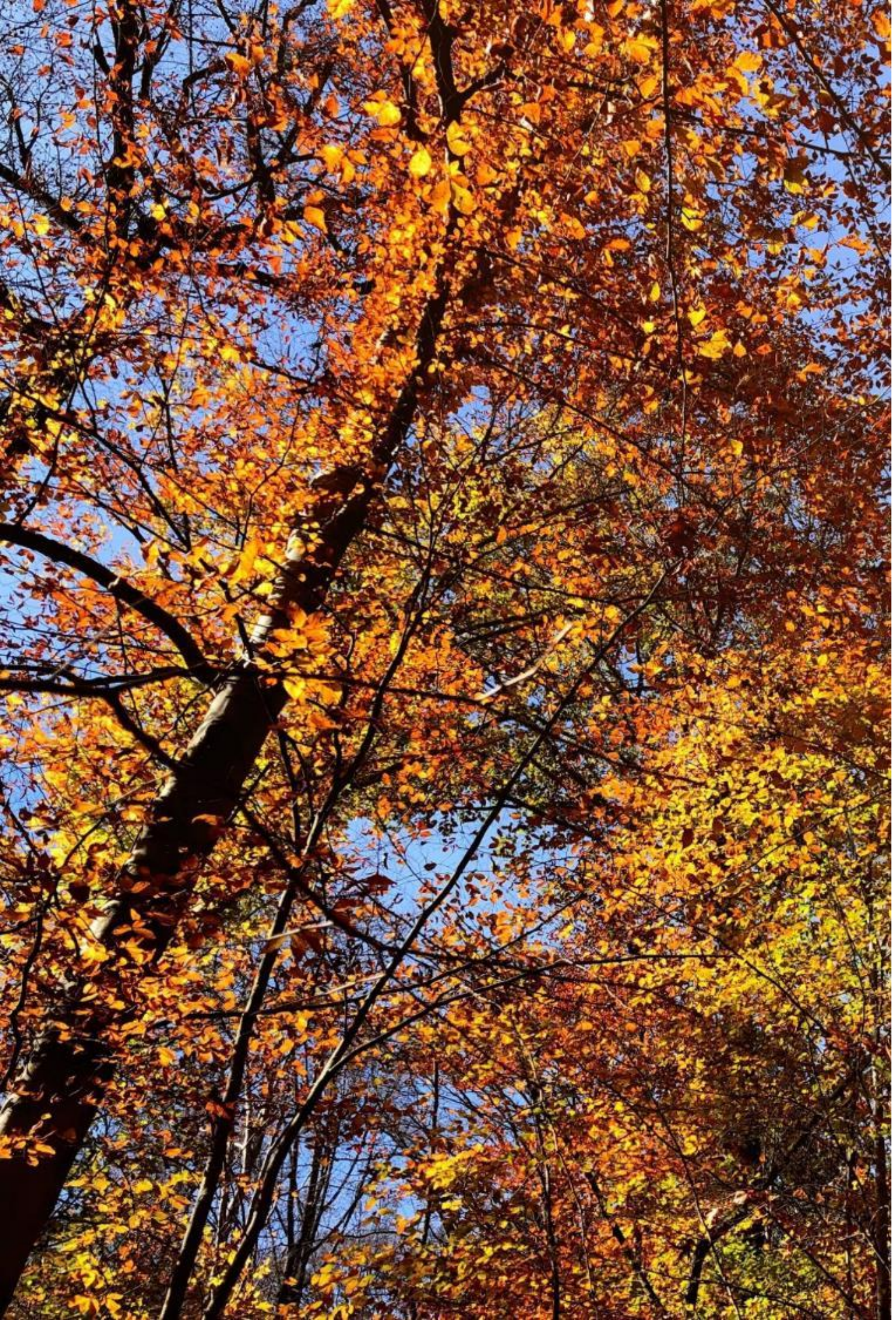
Input = Outputs + **Storage**

The ability of an urban tree to reduce runoff is determined by how much rainfall is intercepted and evaporated or infiltrated into the soil



http://www.urbangreenbluegrids.com/uploads/Hittestress_illustraties-3-e1370973625797-793x630.jpg

Center for Watershed Protection



Variability

- Process and mechanisms for reducing runoff and pollutants are well known
- The amount by with trees reduce runoff is highly variable
  - Example
    - Interception alone is impacted by:
      - Rainfall intensity
      - Duration and frequency of rainfall
      - Leaf area
      - Leave angle distribution
      - Leaf surface characteristics
      - Meteorological factors (wind speed, vapor pressure, etc.)

Interception

Values found in the literature on annual rainfall interception by urban trees and forests.

Urban Trees and Forests

- ✓ 6.5-66.5% for all Trees
- ✓ 6.5-27% for deciduous trees
- ✓ 27-66% for evergreen species

Natural Forests

- ✓ 10-22% Deciduous forest
- ✓ 15-46% evergreen forests
- ❖ Generally agree that evergreen intercept more rainwater than deciduous trees

Table 1. Rainfall Interception Studies of Urban Trees

Study	Location	Interception (% of annual rainfall)[1]	Species/Condition[2]	Type of Study[3]
Kirnbauer et al. 2013	Hamilton, Ontario, CA	6.5-11 17-27	G. biloba (D), P. acerifolia (D), A. saccharinum (D) L. styraciflua (D)	Modeling
Livesley et al. 2014	Melbourne, Victoria, Aus.	29 44	E. saligna (E) E. nicholii (E)	Measured
Xiao and McPherson 2002	Santa Monica, CA	27.3 15.3 66.5	All park and street trees Small jacaranda mimosifolia (D) Mature tristania conferta (E)	Modeling
Xiao et al. 1998	Sacramento County, CA	11.1	Tree canopy in the County	Modeling
Xiao et al. 2000	Davis, CA	15 27	Pear (D) Oak (E)	Measured
Xiao and McPherson 2011a	Oakland, CA	14.3 25.2 27.0	Sweetgum (D) Gingko (D) Lemon (E)	Measured
Wang et al. 2008	Baltimore, MD	18.4	Tree canopy in Dead Run subwatershed (D)	Modeling
Band et al. 2010	Fairfax, VA	14.5	Tree canopy in Accotink watershed (D)	Modeling
Band et al. 2010	Baltimore, MD	15.7	Tree canopy in Gwynns Falls watershed (D)	Modeling
Band et al. 2010	Montgomery County, MD	19.6	Tree canopy in Rock Creek watershed (D)	Modeling
Asadian and Weiler (2009)	Vancouver, BC	49 61	Douglas fir (E) Western red cedar (E)	Measured

Center for Watershed Protection

Evapotranspiration

Occur simultaneously and difficult to distinguish

No studies that quantify annual ET; evaluate 1 or more factors that influence ET.

Factors

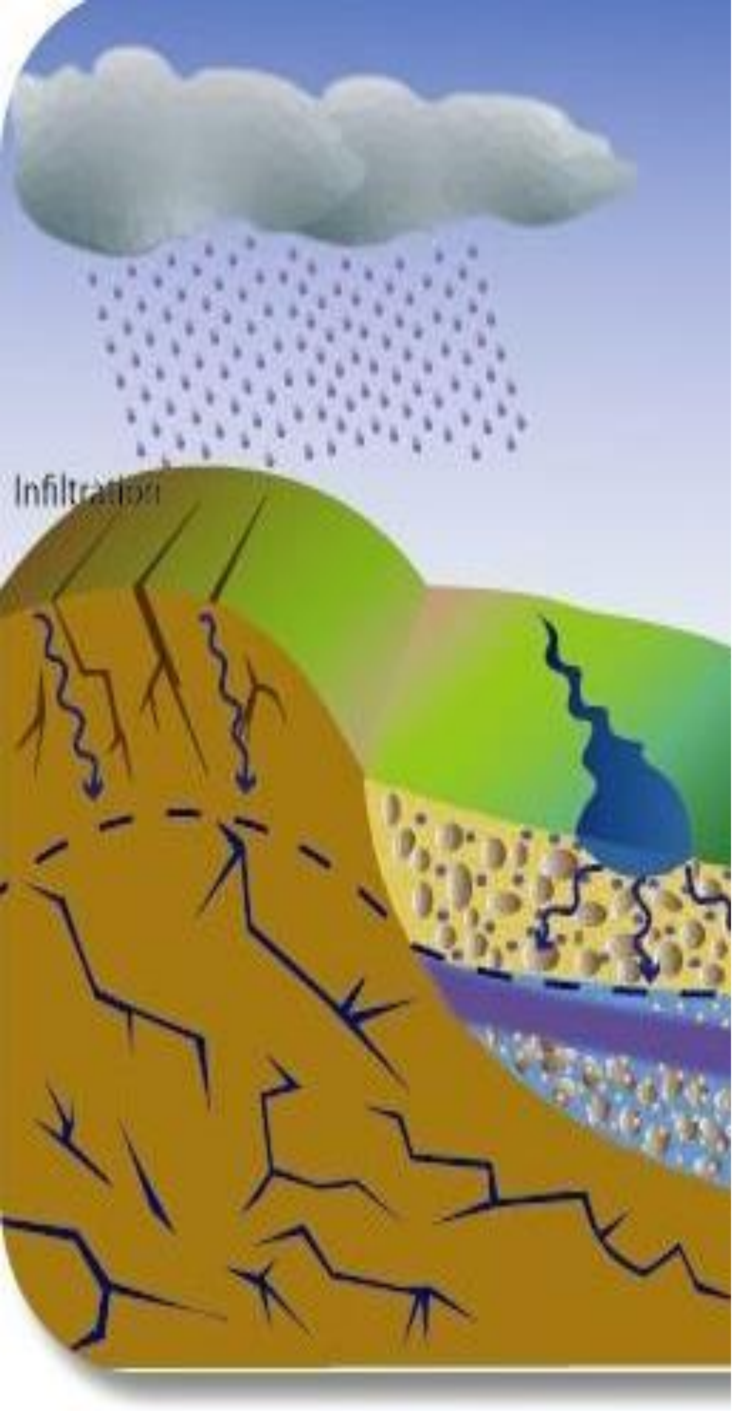
- ✓ Rain fall interception
- ✓ Total leaf surface area
- ✓ Available water capacity
- ✓ Transpiration rates of urban trees

Transpiration

- ✓ 0.1 to 2.39 mm/day- Urban Trees
- ✓ 0.5 to 2.39 mm/day- Undisturbed

Table 3. Transpiration Rates by Urban Trees During the Growing Season

Study	Location	Average Daily Transpiration Rate (mm/day)	Species / Condition[1]	Type of Study
Wang (2012)	Beijing, China	1.47	Horse Chestnut - Aesculus chinensis (D), 10.5-19.2 DBH	Measured
Chen et al. (2011)	Liaoning Province, China	1.31-1.51	Cedrus deodara, Zelkova schneideriana, Metasequoia glyptostroboides, Euonymus bungeanus	Measured
Peters et al. (2010)	Minneapolis St. Paul, Minnesota	1.1[2]	Fraxinus Pennsylvanica, Quercus rubra, Juglans nigra, Tilia Americana, Ulmus pumila, Ulmus thomasii (D)	Measured
		1.9[2]	Picea glauca, Picea pungens, Pinus strobes, Picea abies, Pinus nigra, Pinus sylvestris (E)	Measured
Cermak et al. (2000)	City of Brno, Czech Republic	2.17	Red Maple - Acer campestre L (D), roots covered by asphalt, 18” DBH, shaded	Measured
		2.39	Red Maple - Acer campestre L (D), roots covered by asphalt, 50” DBH, exposed to sunlight	
Pataki et a. (2011)	Los Angeles, CA	0.1-2.2	Urban forest plots with mixed species	Measured



Infiltration

Limited studies directly quantified the effects of urban trees on soil infiltration

- ✓ Bartens et.a. (2008)- Trees increase infiltration rates by 63% over unplanted controls and 153% for severely compacted oils

Improvements in engineered soils

- ✓ Bartens et. al. (2009)- Green ash grown in CU Soils increased infiltration rates by 27 times compared to unplanted control
- ✓ Le Coustumer et. al. (2012)- Found hydraulic conductivity declined over time for both vegetated and unvegetated biofilters expect those planted with trees.

Non-Urban

- ✓ Miambo et. al. (2005)-Soil infiltration rates under tree canopy were 50% higher than outside the canopy.

Runoff Reduction

Interception and evapotranspiration + improved infiltration = reduced runoff

Most studies on RR provided by urban forests use hydrologic models

The most common models

- American Forest's CITYgreen software
  - TR-55 based, uses curve numbers
- US Forest Service's i-tree (formerly known as UFORE)
  - Based on hydrodynamic canopy models.

Studies of Runoff Reduction by Urban Trees

Study	Results	Description
American Forests (1999)	19% increase in runoff	Modeled increase in runoff associated with loss of 14% forest cover
Armson et al. (2013)	58% reduction in runoff in summer and 62% in winter	Measured reduction from plot containing a tree pit and surrounded by asphalt
Wang et al. (2008)	2.6% runoff reduction	Modeled reduction associated with increasing tree cover over turf from 12 to 40%
	3.4% runoff reduction	Modeled reduction associated with increasing tree cover over impervious surface from 5 to 40%
Xiao and McPherson (2011b)	88.8% runoff reduction	Measured runoff reduction for bioswale integrating structural soils and trees[1]
Page et al. (2014)	80% runoff reduction	Measured runoff volume captured and treated by Silva Cell with tree[1]
Sanders (1986)	7% increase in runoff	Modeled increase in runoff associated with loss of 22% forest cover
	5% reduction in runoff	Modeled reduction associated with increasing tree cover over non-surfaced areas from 37% to 50%

CENTER FOR WATERSHED PROTECTION

Urban Tree Growth and Survival

Urban trees exist in a harsh environment and tree growth particularly as it relates to crown spread and root growth can be impacted by design, installation, and/or management.

Planting Area Size and Soil Volume

Available soil volume is the most commonly cited factors affecting tree growth and survival.

- ✓ Koeser (2013) found that trees in Milwaukee were more likely to die as planting space decreased
- ✓ Sanders and Grabosky (2014) found that reduced soil access of trees in parking lots was consistently associated with reduced tree size
- ✓ Sander and Grabosky (2013) survey of trees in New Jersey found that trees with more available soil grew larger than trees with a small amount.

Engineered Soils

- At sites where planting space is limited, structural soils (or similar) can be used to provide additional soil volume for trees. These soils support the adjacent pavement and allow tree roots to grow underneath.
- Rahman et al (2011) found that Chanticleer a commonly planted urban tree in Manchester, UK, grew almost twice as fast in structural soil than when planted into 1.5 m^2 cut out pits in pavement.

Soil Volume Recommendations for Urban Trees (Modified from Lindsey and Bassuk 1991)

Study	Minimum Soil Volume Recommendations	Basis for Recommendation
Kent et al (2006)	1,500 ft^3	Study evaluated 1,127 parking lot trees at Walt Disney World and found 100% trees planted in 1,500ft^3 of soil were in good condition
Lindsey and Bassuk (1991)	220 ft^3 for a medium sized tree, or 2ft^3 of soil per ft^2 of crown projection	Based on estimates of whole tree water loss using pan evaporation data
Urban (1999)	400ft^3 bare minimum, but 1,000ft^3 for optimal growth	
Cervelli (1986)	570ft^3	
Arnold (1980)	224ft^3 for a 21-40 foot high tree	
Bakker (1983)	2.5ft^3 of soil for every ft^2 of crown projection	
Vrecenak and Herrington (1984)	5,543ft^3 for a 64ft diameter tree	
Perry (1985)	600ft^3 for a 10” caliper tree	
Kopinga (1985)	2,500 ft^3 for a large tree	
Helliwell (1986)	Rooting volume of 1/10^{th} of the canopy volume	
Moll and Urban (1989)	1,200ft^3 for a tree with expected caliper	

Existing Stormwater Credit Methods for Trees

Review of Existing Tree Stormwater Credits

Community	Type of Credit	Credit for a Deciduous Tree
Sacramento, CA	IC	100ft^2 – 200 ft^2
Seattle, WA	IC	20ft^2 – 50 ft^2
Pine Lake, GA	Volume	<12" DBH: 10 gallons/in; >12" DBH: 20 gallons/in
Washington, DC	Volume	10ft^3
Vermont	Volume	5ft^3
Minnesota	Volume and P load	Depends on soil volume and other factors
Chesapeake Bay Program*	N, P and S load	Relative reduction % for area tree planted

*Source: Stone Environmental, 2014, *Law and Hanson, 2016*

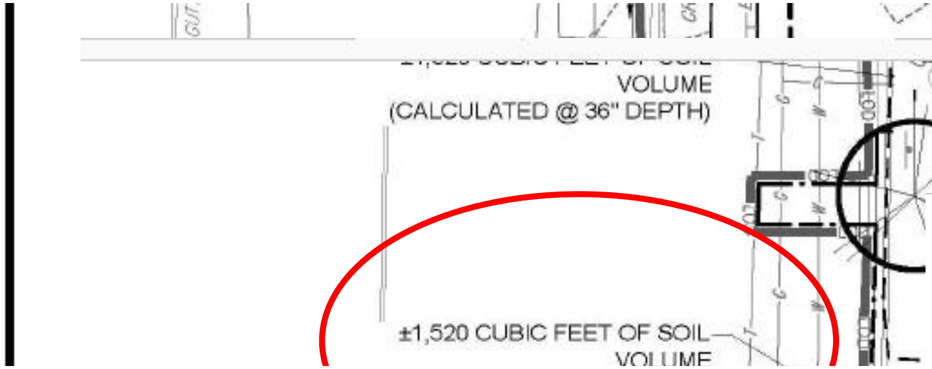
Washington DC

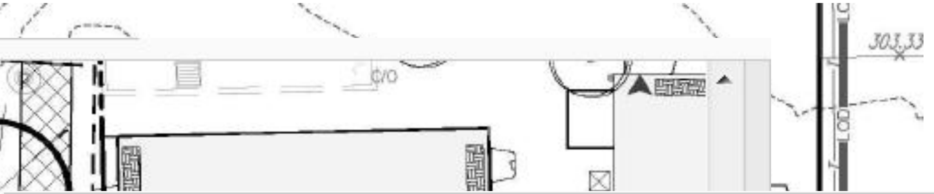
Preserved tree credit

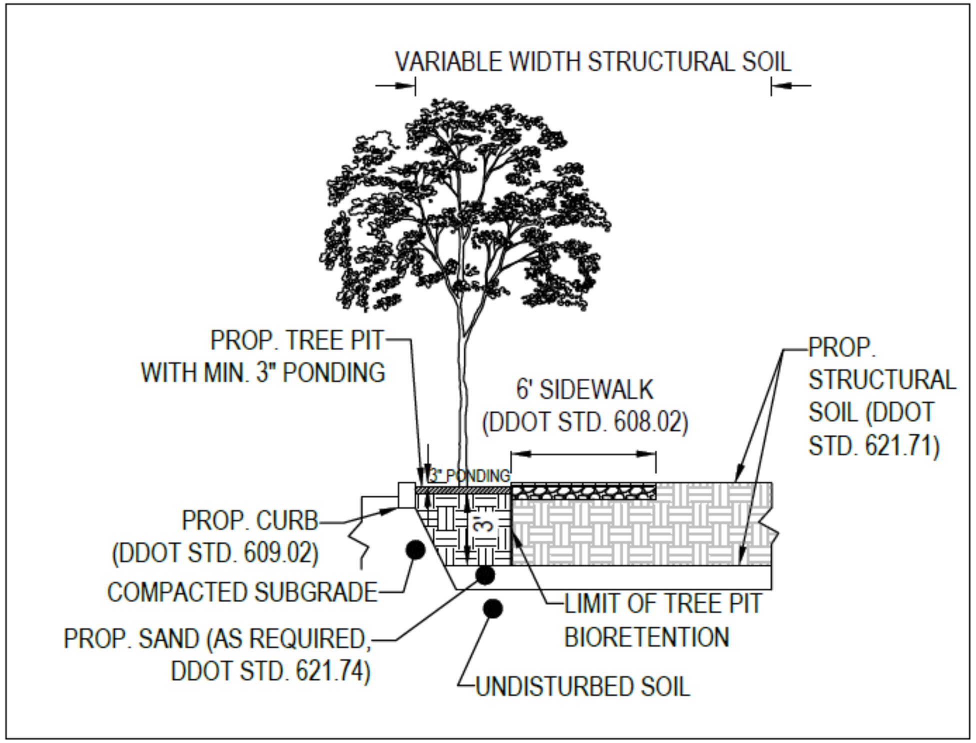
- Receive 20 ft^3 of stormwater treatment
- Tree must be in LOD
- Tree must be healthy (as determined by professional)
- Tree must have min 35’ canopy spread

Planted tree credit

- Receive 10 ft^3 of stormwater treatment
- Tree can be in LOD or Public Right-of-Way
- Tree must have expected min 35’ canopy spread
- Individual tree must have 1500 ft^3 of soil
- Trees with shared tree pit must have 1000 ft^3







TYPICAL TREE PIT WITH STRUCTURAL S(

NOT TO SCALE

NOTE: ONLY STRUCTURAL SOIL BENEATH TREE WITH 3" PONDING IS COUNTED AS TREE PIT BIORETENTION FOR STORMWATER RETENTION VALUE.

PUBLIC RIGHT-OF-WAY STORMWATER MANAGEMENT NARRATIVE

THIS PROJECT WILL DISTURB 10,270 SF OF AREA WITHIN THE PUBLIC RIGHT-OF-WAY. THE REQUIRED STORMWATER RETENTION VOLUME FOR THE DISTURBANCE WITHIN THE RIGHT-OF-WAY IS 879 CF (SEE CALCULATIONS SHEET C-600).

A CONTINUOUS PLANTING STRIP WITH ENGINEERED SOIL AND 3 INCHES OF PONDING IS PROPOSED TO PROVIDE RETENTION VOLUME. STRUCTURAL SOIL SHALL BE AMEREQ STRUCTURAL SOIL OR APPROVED EQUAL (PER DDOT STANDARD). THREE (3) INCHES OF PONDING WILL BE PROVIDED FOR 2,502 SF OF THE CU SOIL.

STORAGE VOLUME PROVIDED	= SA x (MEDIA DEPTH x RETENTION CAPACITY + PONDING)
	= 2,502 SF x (3 FEET x .15 + .25 FEET) = 1,751.4 CF
SWRv PROVIDED	= 0.6 x STORAGE VOLUME
	= 0.6 x 1,751.4 CF = 1,050.8 CF

TOTAL CDA = 6,605 SF
MAX SWRv = 790 CF

SWRv PROVIDED = 790 CF

THE PROPOSED STRUCTURAL SOIL BIORETENTION FACILITIES WILL PROVIDE THE REQUIRED PUBLIC RIGHT-OF-WAY STORMWATER RETENTION VOLUME.

ADDITIONALLY, A TOTAL OF 14 STREET TREES WILL BE INSTALLED AND PLANTED ALONG GEORGIA AVENUE AND ELDER STREET. SEE SHEET L-102 FOR PLANTING PLAN. NEWLY PLANTED TREES WITH A MATURE SPREAD OF AT LEAST 35 FEET RECEIVE 10 CF OF RETENTION STORAGE.

MAX SWRv FROM TREE PLANTING = 140 CF

TOTAL SWRv PROVIDED = 930 CF

PHASE 2 TREE PRESERVATION FENCING

ARBORIST RECOMMENDATIONS FOR BOX ELDER TO REMAIN

thecareoftrees.
Our Business is People And Their Love for Trees®

The Care of Trees
8000 Queenair Drive
Gaithersburg, MD 20879

Tel: 301.444.9041
Fax: 301.444.9049
Web: www.thecareoftrees.com

Elm Street Development
7201 Georgia Ave NW
Washington DC

Primary Reason for Visit:

Inspection of the larger trees on the property to assess the condition and health in regards to maintaining greenspace for the property. There are currently Four trees of significance to look at, a double leader Boxelder along the alleyway and Three Maples along Elder Street. The following observations were made by Tony Faoro, an ISA Certified Arborist.

Observations:

Tree #1 - Boxelder Double leader one stem approximately 23" in diameter and the other stem approximately 28" in diameter. The tree is located along the rear border of the property and the alleyway. Overall condition is fair to good. The tree has a moderate amount of dieback but that is to be expected given the size location and lack of care. The alley side of the tree appears to have had past pruning done, most likely to reduce conflicts with larger vehicles. The base of the tree is covered in ivy so it is hard to see the base and the union of the two stems. I think with some sanitation pruning to remove hazardous dead limbs and a slight crown reduction over the property to help make the tree more symmetrical, the tree is worth salvaging. I would also recommend the installation of at least one support cable. I did not observe any insect or disease related issues at the time of my inspection.

Tree #2 – Maple 21" in diameter located at the corner of Elder and Georgia. The tree appears to be in good health with minimal dieback in the canopy. The tree has an old wound at approximately 5' to 6' above the ground and the wound is about 2.5' in length. Judging by the callus tissue that has formed I would estimate that it happened about 10 years ago. The wound is a weak spot in the tree and increases the potential for failure. The crown above the wound leans out over the road thus making the location of the wound more critical. Due to the size and location of this wound in conjunction with the lean and weight of the crown I would recommend the removal of this tree.

Tree #3 - Norway maple 23" in diameter located along Elder St. (The second tree in from Georgia) This tree has significant dieback at the top of the tree (30 to 40%). This is a good visual indicator that the root system is most likely failing. Too much of the tree has declined and I would not recommend trying to salvage this tree. Removing this tree would create more usable space for additional plant material or trees.

Tree #4 – Maple 23" in diameter located along Elder Street (Third tree in off of Georgia) This tree has a straight trunk with no visible signs of decay or cavities. It does branch out into separate stems with a tight union that has potential to split. The biggest issue with this tree is location and proximity to a retaining wall that needs to be replaced.

Recommendation:

"Making Urban Trees Count": A stormwater credit framework for urban tree planting

- To provide science-based credit to encourage use of trees to meet stormwater management requirements
- Elements for consideration:
  - Location
  - Regulatory context
  - Stormwater Credit Currency

National Urban and Community Forestry Challenge Cost-Share Grant Program

USDA

FOREST SERVICE U S DEPARTMENT AGRICULTURE

CENTER FOR WATERSHED PROTECTION

Tree Crediting Methods

- Applies to trees planted in the urban environment
- Two types credits:
  - Performance-based Credit for State Stormwater Programs (event or design-storm)
  - Annual Pollutant Load Reduction Credit for Tree Planting (TMDL) Chesapeake Bay
- Final version posted January 3, 2018

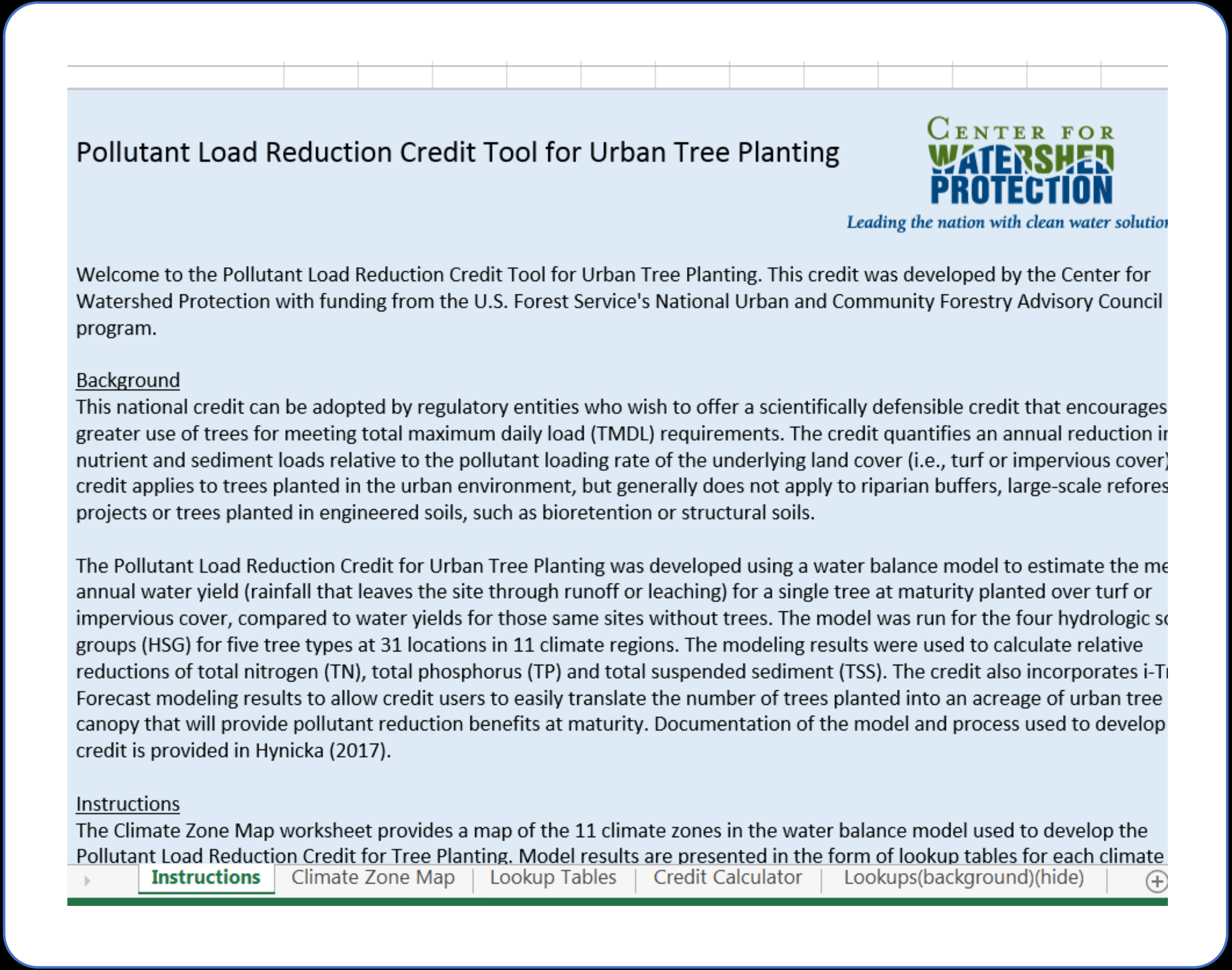
  https://www.cwp.org/making-urban-trees-count/

Making Urban Trees Count: A Stormwater Credit Framework for Urban Tree Planting

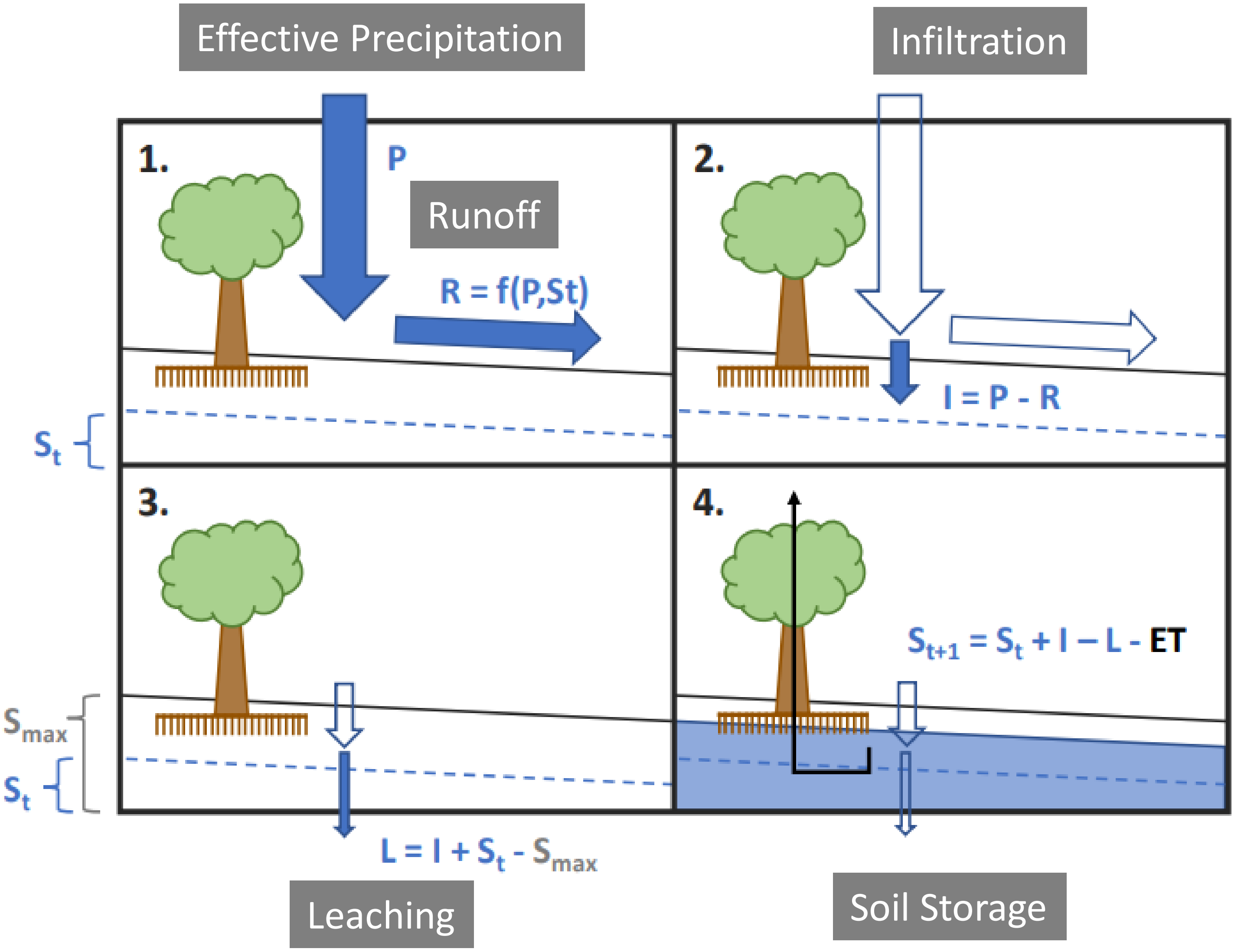
Center for Watershed Protection

Spreadsheet Tool Calculator

- Credit is calculated as the difference in land use loading rates *with and without trees* planted
- *Relative* runoff reduction
- Absolute values for N, P and Sediment
- Use of Look-up Tables based on water balance model output



Water Balance Modeling Approach



Future Research & Next Steps

- Direct measurement of urban tree performance
  - Collecting field data to develop urban tree water balance (University of Maryland)
    - Tree over turf grass
    - Trees in small cluster w/ turf grass
    - Trees with understory leaf litter
  - Developing an Urban Forest Typology (Virginia Tech)
    - Better understand the relative benefits of these types forests
    - Distribution, management, protection, etc.
  - Accounting for leaf litter on impervious surfaces

Summary and link to reports and documentation

About the Center | Training & Services | News & Publications | OWL | Membership | Career Center

‹ Previous Next ›

Search by keyword...

Search ...

Or, search by category:

All Categories

Submit

Making Urban Trees Count

The use of trees as a stormwater best management practice (BMP) has been limited by the uncertainty of how to "credit" trees for runoff and pollutant reduction to meet water quality requirements. In 2014, the Center for Watershed Protection (the Center) began a study to address this gap by developing a science-based crediting system for urban tree planting. The project was funded through a grant from the U.S. Forest Service's National Urban and Community Forestry Advisory Council.

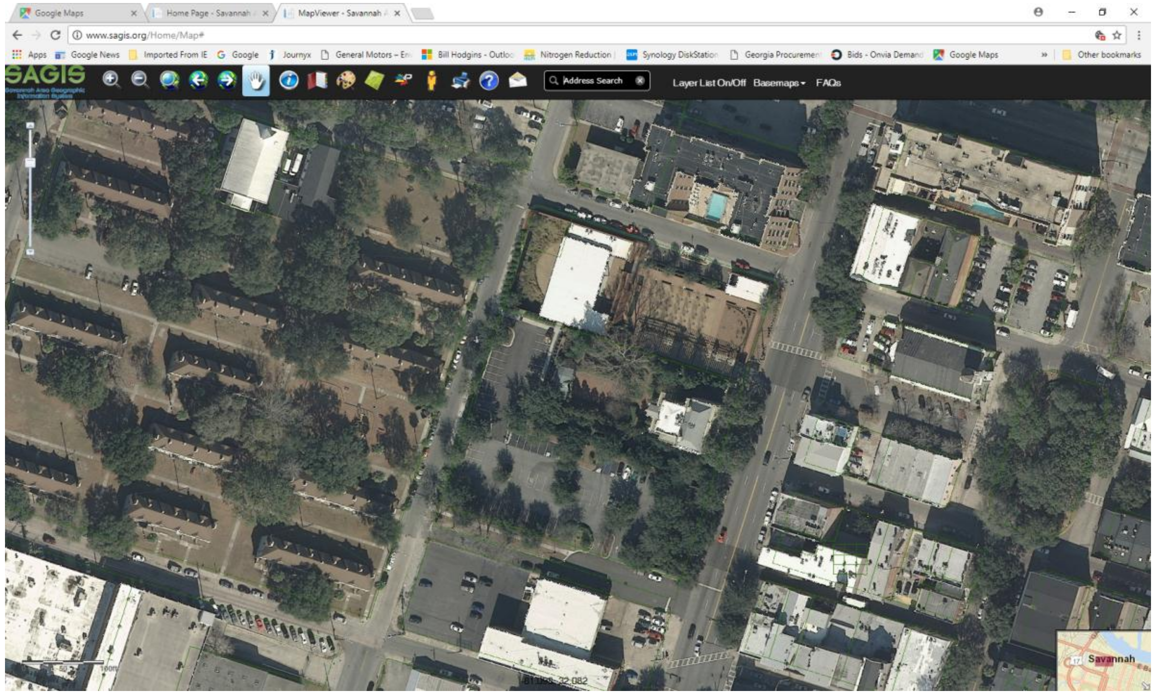
As a first step, the Center reviewed 159 publications to help answer the question "What is the effectiveness of urban tree planting for reducing runoff, nutrients and sediment?" Our literature review found that only a limited number of studies directly address the water quality benefits of urban trees, and the available studies are highly variable in their methods, scale, and results given the numerous processes involved (Figure 1) and factors that affect them (e.g., tree characteristics, storm event characteristics, meteorological factors). As a result, the project team developed a water balance model to provide an improved method for quantifying the stormwater benefits of urban tree canopy. An early version of this model was used by the Chesapeake Bay Program in their Urban Tree Canopy Expansion BMP crediting protocol adopted in 2016.

https://www.cwp.org/making-urban-trees-count/

Bill Hodgins

wh@cwp.org

https://www.cwp.org/2019-national-conference/



Example tree lawn

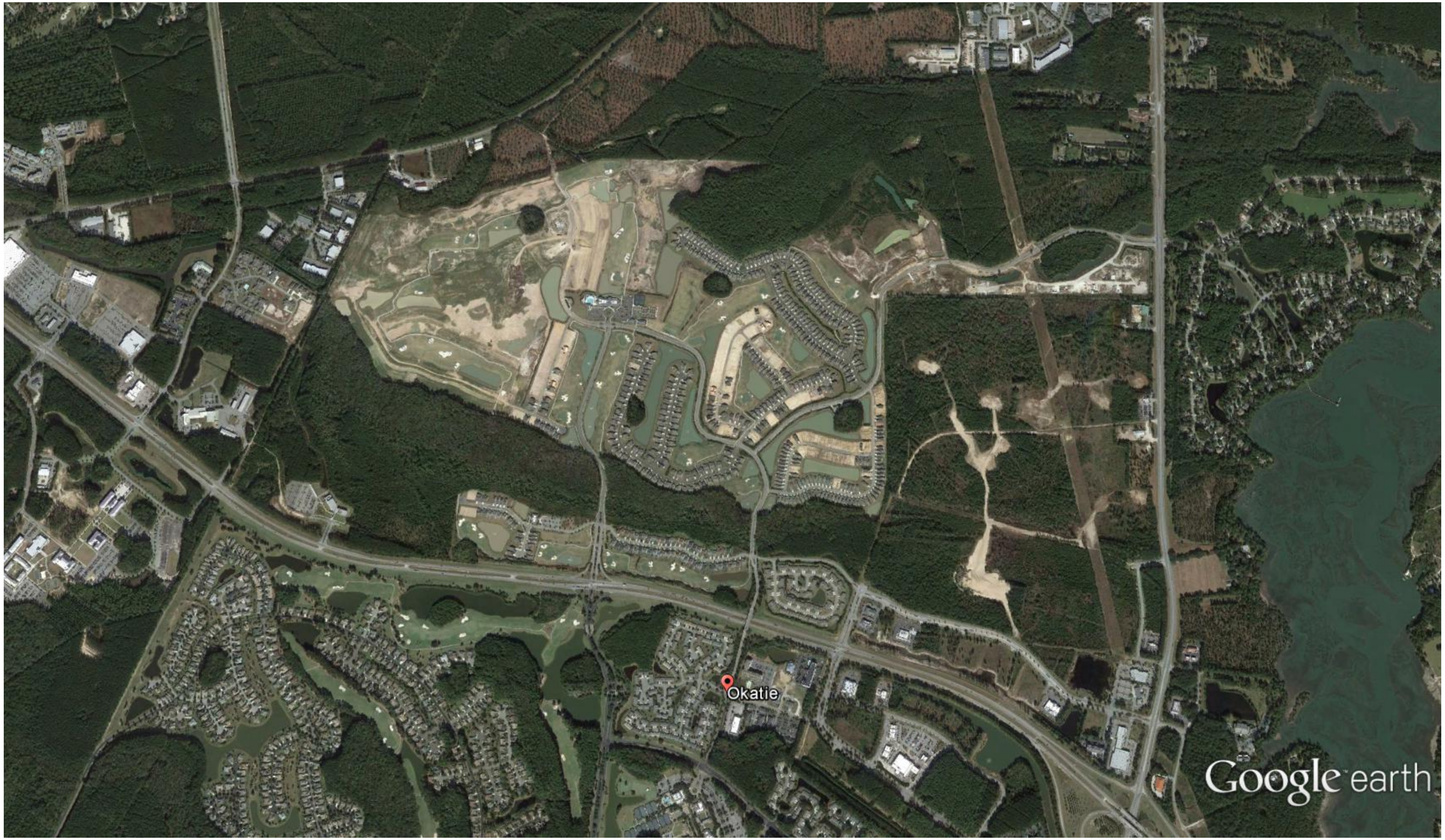
PROTECTION

TR-55 input

- Tree area = 4150 sf
- B type soil
- Use CN = 61
- Site sf = 38,039 sf
- 24 trees with assumed dbh of 6”

Center for Watershed Protection

Center for Watershed Protection


Okatie
Google earth


Okatie
Google earth

Center for Watershed Protection