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Rolling Out “Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs” (CLASIC) Tool

(EPA National Priorities Grant #836173)



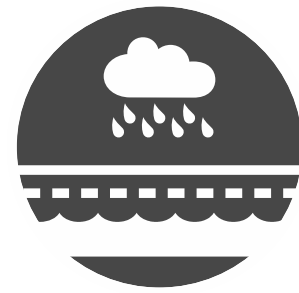
Agenda



- Acknowledgement
- Brief Overview of Stormwater and Green Infrastructure Program at WRF
- CLASIC Tool Features and Demo
- Questions and Answers



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Brief Overview of Stormwater and Green Infrastructure Program at WRF

Harry Zhang, PhD, PE
Program Director – Integrated Water & Stormwater
The Water Research Foundation



Summary of Stormwater & Green Infrastructure Program



Performance Information

- * Stormwater BMP Database
- * Add Stream Restoration Module to BMP Database
- * Algorithm Development

Maintenance Information

- * Template to compare Green vs Gray Maintenance Costs
- * Update BMP Whole Life Cost Tool

Co-Benefit Analysis

- * Workshop and Template for Co-Benefit Analysis
- * Subsequent Data Development and Sharing of Co-Benefit Values

Permitting Guidance

- * TCR for Stream Restoration as a BMP

**Stream Restoration
Crediting Guidance**

Stormwater Harvesting

**Flood Management
/ Resiliency**

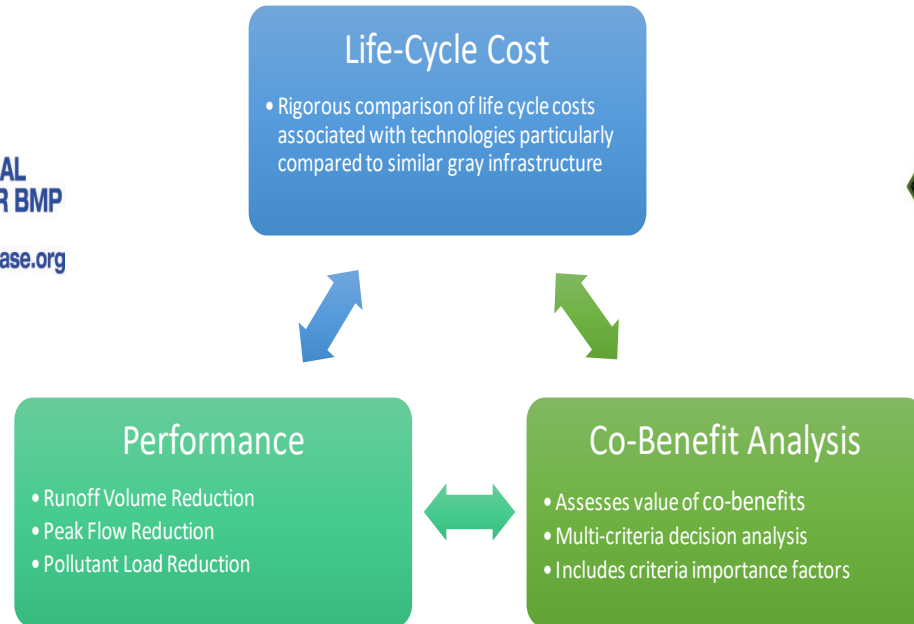


Integrated Decision Support System:
Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC)
(EPA National Priorities Grant #836173)

Integrated Stormwater Management: Life Cycle Cost; Co-Benefits and BMP Database



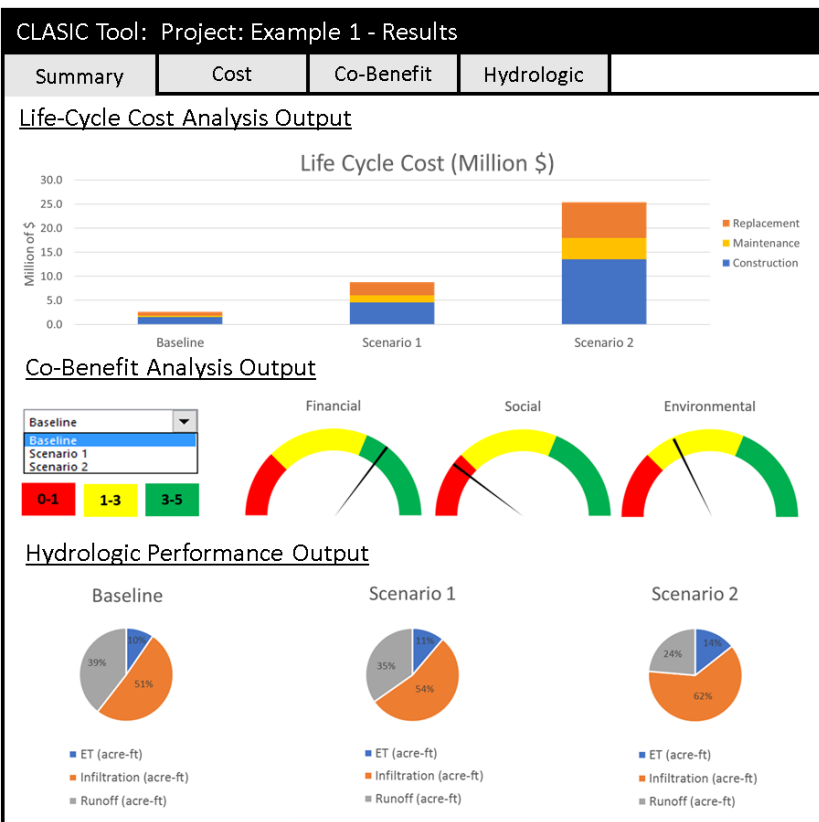
INTERNATIONAL
STORMWATER BMP
DATABASE
www.bmpdatabase.org



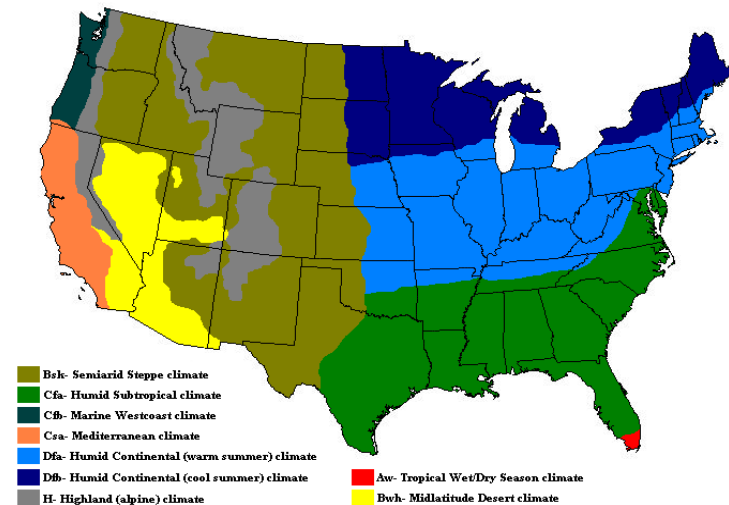
Stormwater Infrastructure (Green & Gray):
- Life Cycle Cost and Co-Benefits of Green Infrastructure

Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC)

- EPA National Priorities Grant #836173



Climate Zones of the Contiguous United States

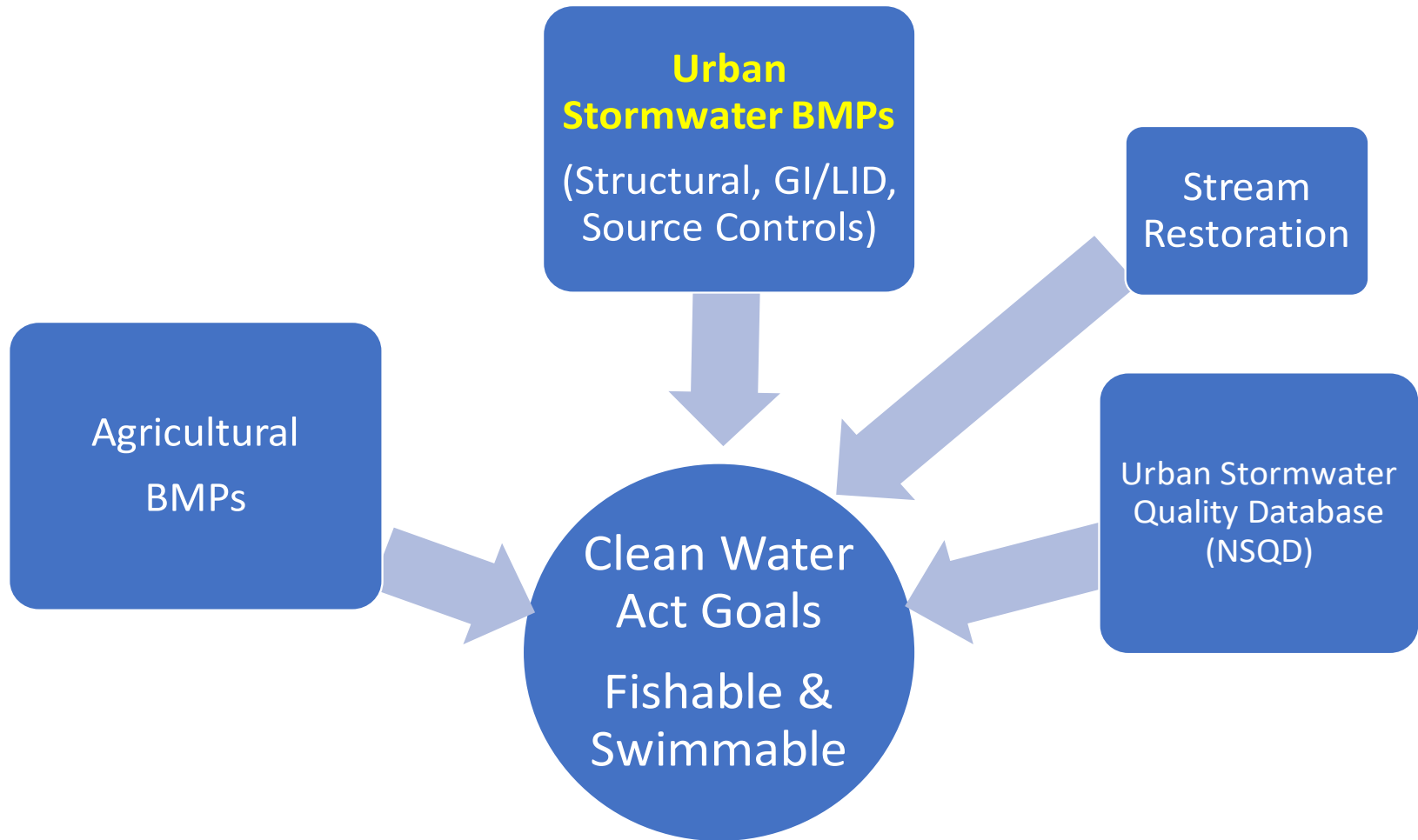


- **Project Duration:** 4 Years (2016-2020);
- **Funding:** \$2M from USEPA (plus \$0.5M matching funds from WRF);
- **Team:** 7 organizations plus national collaborating partners (e.g. WEF; ASCE; American Rivers);
- **Community Engagement** for Municipalities & Utilities (in all 10 EPA Regions)

International Stormwater BMP Database

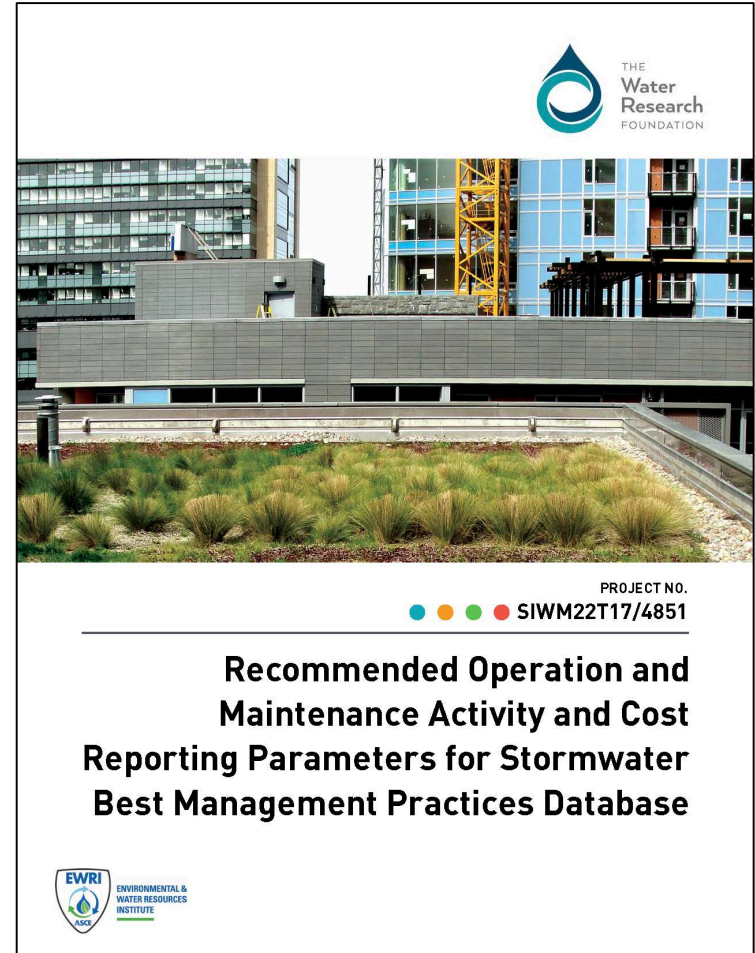


INTERNATIONAL
STORMWATER BMP
DATABASE
www.bmpdatabase.org



Stormwater O&M Cost Tracking Protocol

- Operation & Maintenance (O&M) cost as part of lifecycle cost
 - Develop a protocol to improve tracking cost data for cross comparison



*Funded by ASCE/EWRI (a matching project
for EPA National Priorities Grant #836173)*

Framework and Tools for Quantifying Green Infrastructure Co-Benefits and Linking with Triple Bottom Line Analysis



Social

- ✓ Reduced urban heat stress and associated health benefits
- ✓ Greater flood protection
- ✓ Increased property values
- ✓ Improved recreational opportunities
- ✓ Green job creation

Financial

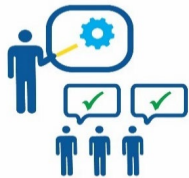
- ✓ Avoided infrastructure costs
- ✓ Asset life extension
- ✓ Energy savings

Environmental

- ✓ Improved air and water quality
- ✓ Groundwater recharge
- ✓ Improved habitat/ecosystem benefits (wetlands)
- ✓ Decreased GHG emissions

Leaders Innovation Forum for Technology (LIFT) Program

- Focus Group on Stormwater & Green Infrastructure



Utility Peer Network



Technology Scans



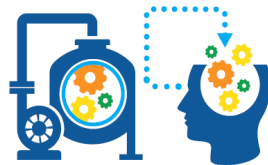
LIFT Link



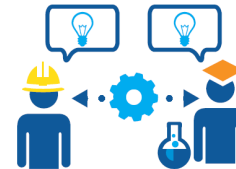
FAST Water Network



Technology Survey



SEE IT



University-Utility Partnership



Hubs, Partners, and Affiliates



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Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC) - Tool Features and Demo

(EPA National Priorities Grant #836173)





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Primary Team Members

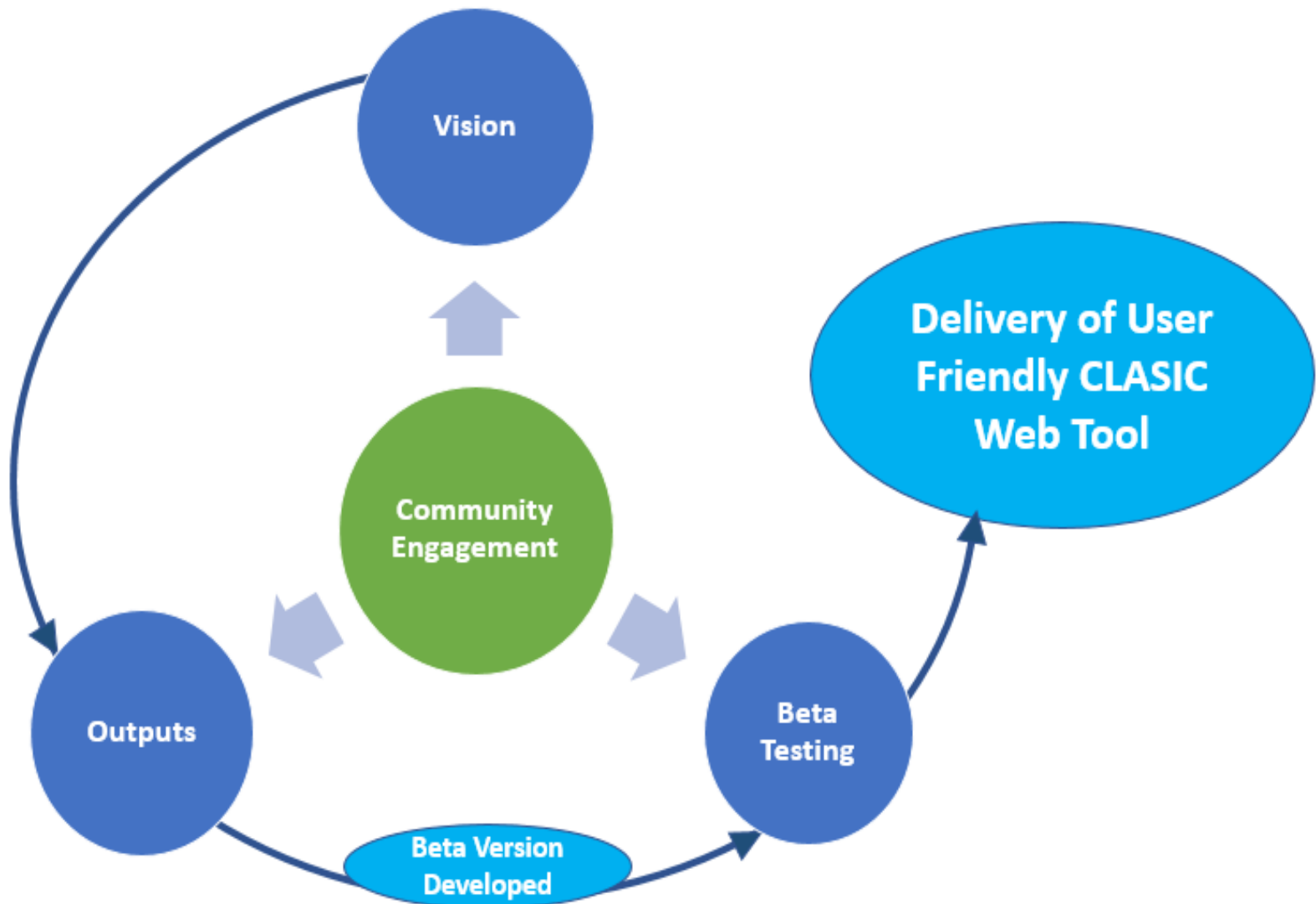
- Sybil Sharvelle, Tyler Dell, Mostafa Razzaghmanesh - CSU
 - Jennifer Cotting, Jennifer Egan – UMD EFC
 - Christine Pomeroy – UU
 - Michele Pugh - WSU
-
- Dan Pankani – Geosyntec Consultants Inc.
 - Jane Clary – Wright Water Engineers

Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs

CLASIC Vision

The CLASIC tool is a user-informed screening tool which utilizes a lifecycle cost framework to support stormwater infrastructure decisions on extent and combinations of green, hybrid green-gray and gray infrastructure practices.





Questions the CLASIC Tool Seeks to Answer

- How do various scenarios of stormwater infrastructure compare in terms of:
 - Lifecycle cost
 - Runoff volume reduction
 - Pollutant removal
 - Social benefits
 - Environmental benefits
- How does climate change and land use change effect future performance of scenarios of green and gray infrastructure?
- How do maintenance and long-run costs compare for user selected scenarios?

CLASIC will enable users to

- Assess scenarios of stormwater infrastructure via functional unit analysis for robust decision making based on preferences to evaluate:
 - Regulatory compliance
 - Runoff volume reduction
 - Water quality
 - Social and environmental benefits
 - Lifecycle cost
- Couple financial decision with holistic consideration of benefits (primary and secondary)
- Conduct analysis from neighborhood to watershed scale

Analyses not included in CLASIC

- Site specific design of stormwater infrastructure
- Comparison of spatial distribution of infrastructure within sub-unit or subcatchment
- Algorithms for optimization of design

CLASIC vs. Stormwater Calculator (SWC): *Hydrologic Simulation*



CLASIC

- Web based GIS tool
- Designed for flexibility in study area size (neighborhood to watershed)
 - Enables variation of parameters within study area subunits
 - Outputs for multiple sub-units within study area at once
- Accesses national database on land use and imperviousness to inform hydrologic model
- Includes a more comprehensive set of technologies (12 total)
 - 5 additional: sand filter, grass swales, storage vault, extended detention basins, wet ponds
- Includes water quality projections
- Considers more advanced climate change scenarios (CMIP5 datasets), including flexibility in assessing multiple climate scenarios
- Horton infiltration method

Stormwater Calculator



- Desktop and mobile-web based
- Designed for site level design and scale of analysis is limited
 - Desktop version (50 acres max)
 - Web version (12 acres max)
- User enters land use data
- More flexibility in LID design specs
- No water quality projections
- Uses older climate change scenarios (CMIP3 datasets)
- Green-Ampt infiltration method

CLASIC vs. Stormwater Calculator (SWC): *Cost Approach (1)*



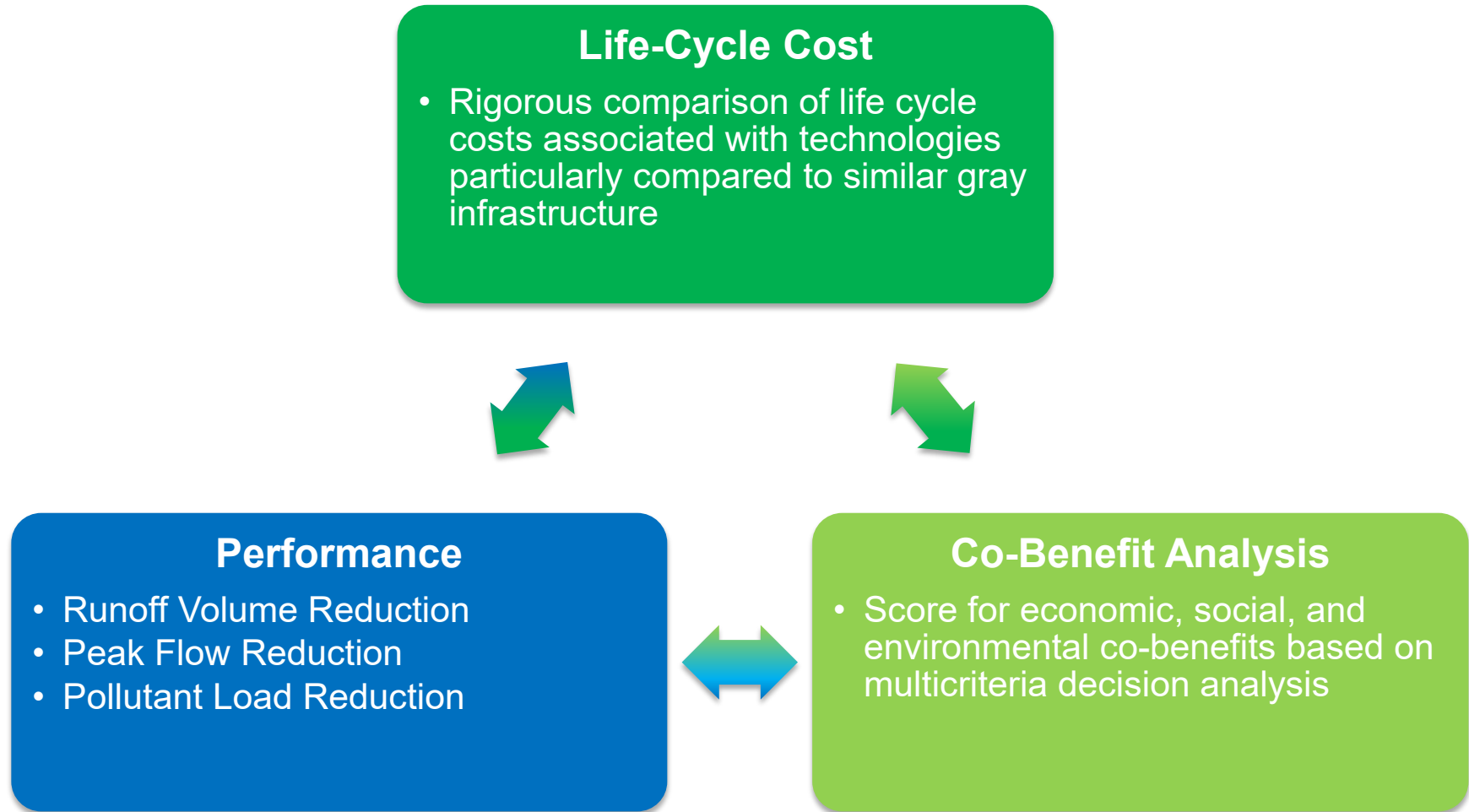
- Similarities between CLASIC and SWC:
 - Both tools will use a line item cost buildup approach for capital costs;
 - Costs will be reported in ranges;
 - CLASIC uses the SWC approach to regional cost factors, utilizing U.S. Bureau of Labor Statistics (BLS) regional centers across the country;
 - CLASIC uses the SWC approach to inflation factors, utilizing BLS data.

CLASIC vs. Stormwater Calculator (SWC): *Cost Approach (2)*



- Differences between CLASIC and SWC:
 - CLASIC tool allows a user to choose from fixed design parameters (e.g., underdrain, liner, etc.) that are used to calculate BMP cost;
 - BMP costs will be developed for the finite number of designs possibilities for each BMP type;
 - Unit costs for capital cost line items are obtained from DOT bid tab data from states across the USA;
 - Maintenance costs in CLASIC are based on regional recommendations for activities and frequencies rather than equations;
 - Regionalization of maintenance costs based on climate data will be available for certain parameters where applicable;
 - CLASIC will have multiple normalized output units for users to view such as:
 - Cost per surface area of LID control
 - Cost per area treated
 - Cost per unit flow treated
 - Cost per unit volume treated
 - Cost per unit volume of LID control

Three Basic Outputs for User Allows for Integrated Assessment



Output	Included in CLASIC tool
Pollutant Load Reduction	<ul style="list-style-type: none"> · TSS · TN · TP · FIB (?)
Hydrologic	<ul style="list-style-type: none"> · Runoff Volume · Volume Infiltrated · Volume Evapo-transpired · Number of runoff events
LCC	<ul style="list-style-type: none"> · Net Present Value <ul style="list-style-type: none"> ○ Construction ○ Maintenance ○ Replacement · Average Annual Cost Over Design Life · Per unit cost for scenario comparison
Co-Benefits	<ul style="list-style-type: none"> · Score of economic, environmental, social performance based on user selected importance factors and performance output

CLASIC Tool: Project: Example 1 - Results

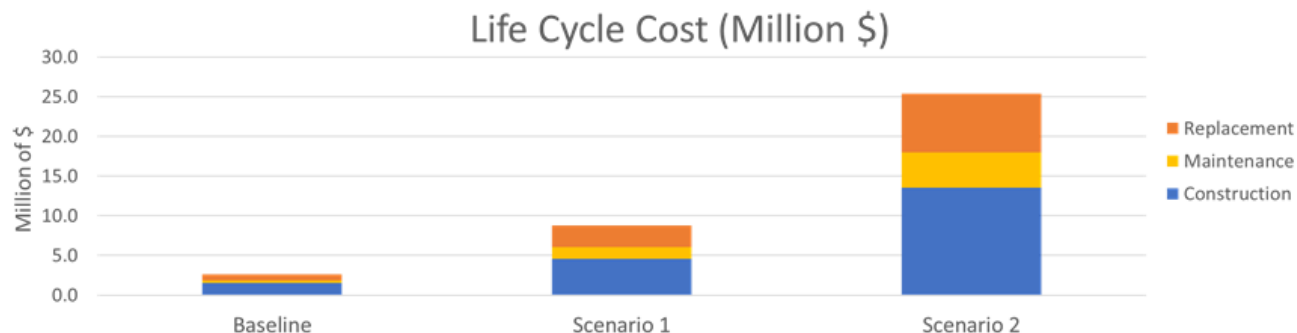
Summary

Cost

Co-Benefit

Hydrologic

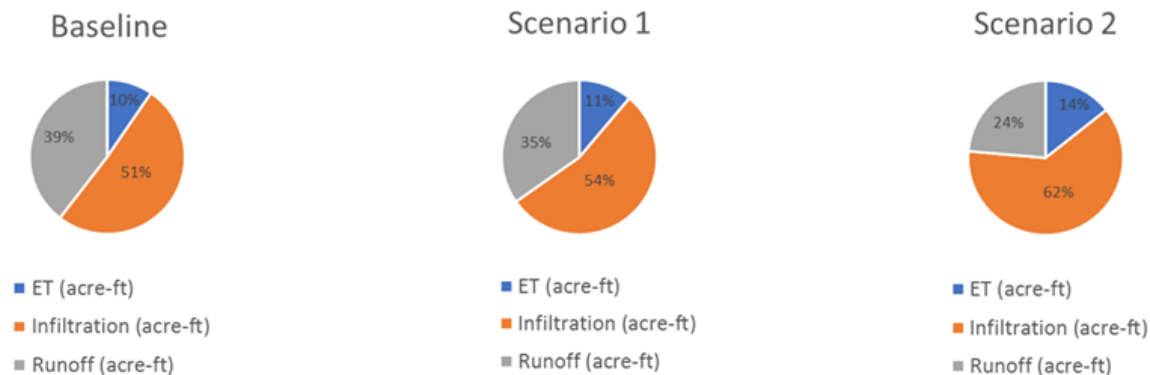
Life-Cycle Cost Analysis Output



Co-Benefit Analysis Output



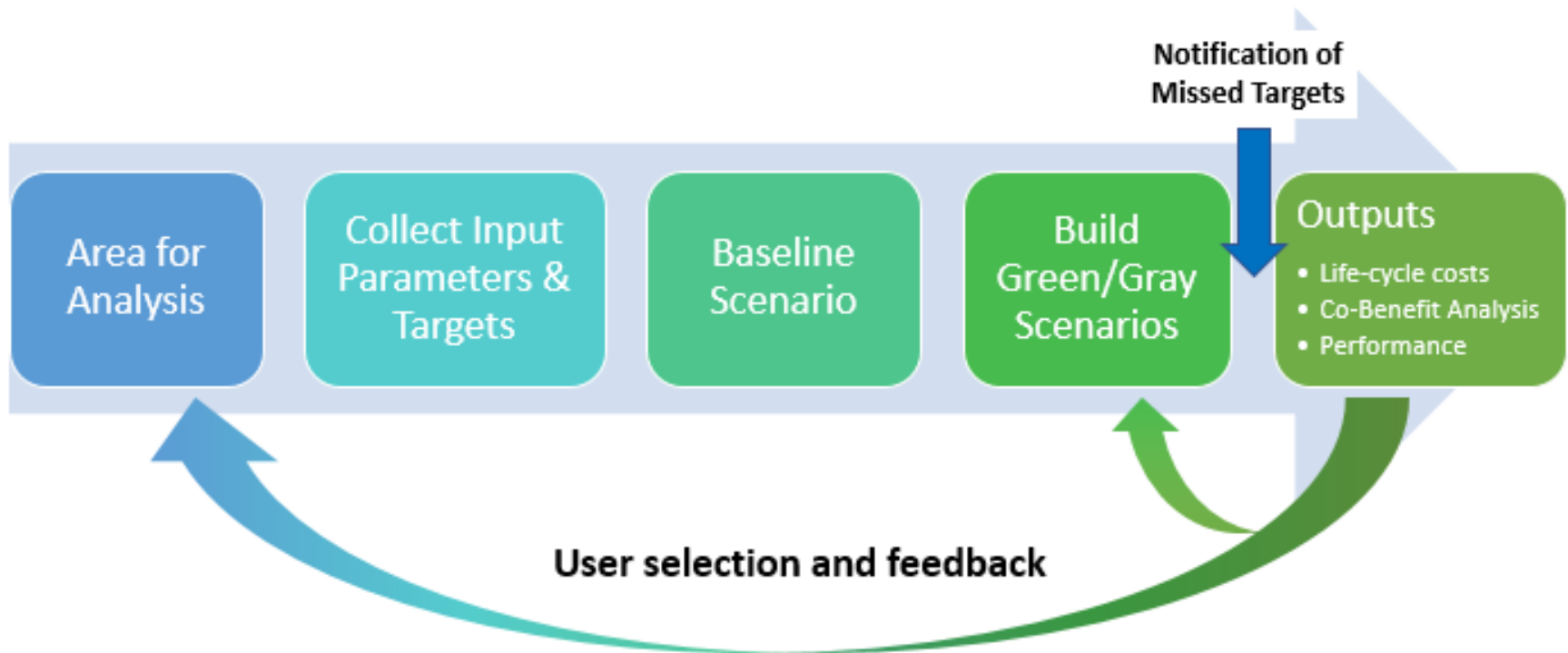
Hydrologic Performance Output



Technology Categories

- Rain Gardens
- Sand Filter
- Infiltration Trench
- Permeable Pavement
- Green Roofs
- Disconnection
- Grass Swales
- Extended Detention Basins
- Wet Pond
- Stormwater Harvesting
- Storage Tunnel/Vault
- Stream Restoration

CLASIC Tool Interface Progression



Web-based Geospatial Tool

- Web-based platform developed at Colorado State University
 - Interface
 - Input Parameters
 - Outputs
- Deployed using the Environmental Resource Assessment and Management System (eRAMS)





Define Project



Define a Project



Create, Import, or Select Project



Create Project



Specify Project Extent



Method



Known Boundaries



Type of Boundary



Cities



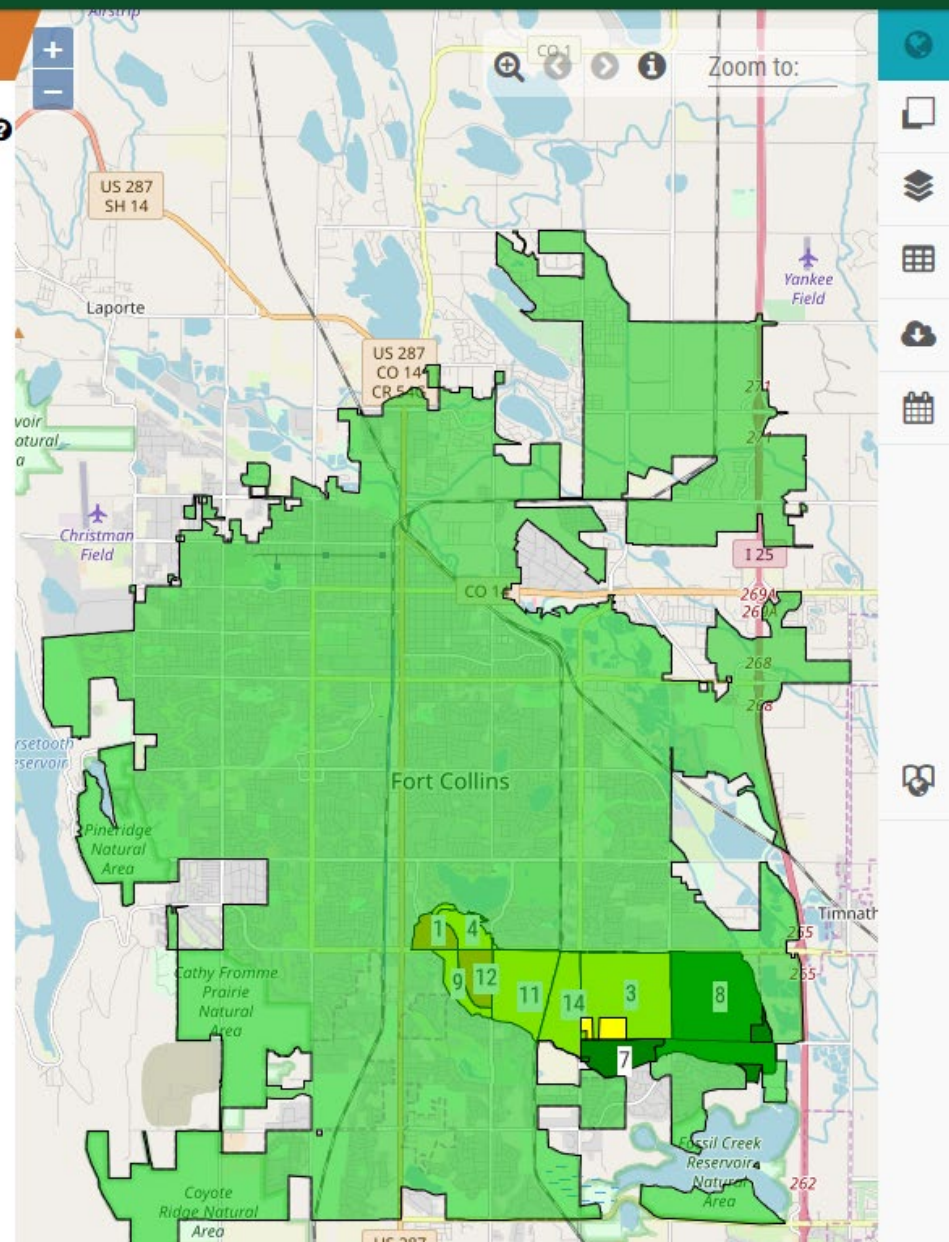
Boundary



Fort Collins

BACK

NEXT

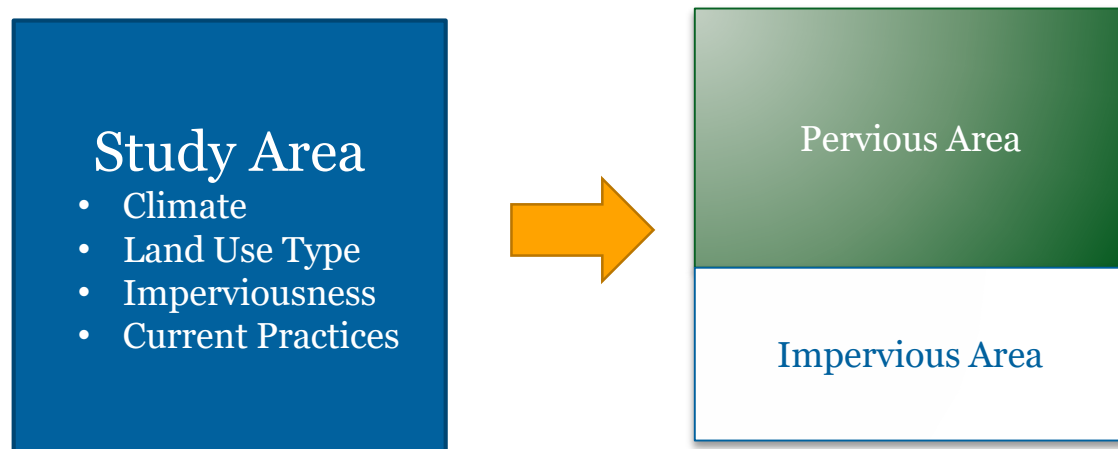


Collect Input Parameters & Targets

- Soil Datasets (SSURGO/STATSGO)
 - Soil Type
- National Digital Elevation Model (DEM)
 - Slope
- Land Use/Land Cover (NLCD)
 - % Open, Low, Medium, High, and Other
 - Water Quality (TSS, TP, TN)
 - Overland Flow Length
- Imperviousness (NLCD)
- Climate
 - Precipitation (NOAA – Stormwater Calculator)
 - Evaporation (NOAA – Stormwater Calculator)

Baseline Scenario Development

- Split each area/subunit into to directly connected impervious area (DCIA) and separate pervious area (SPA)
- Does not consider conveyance system



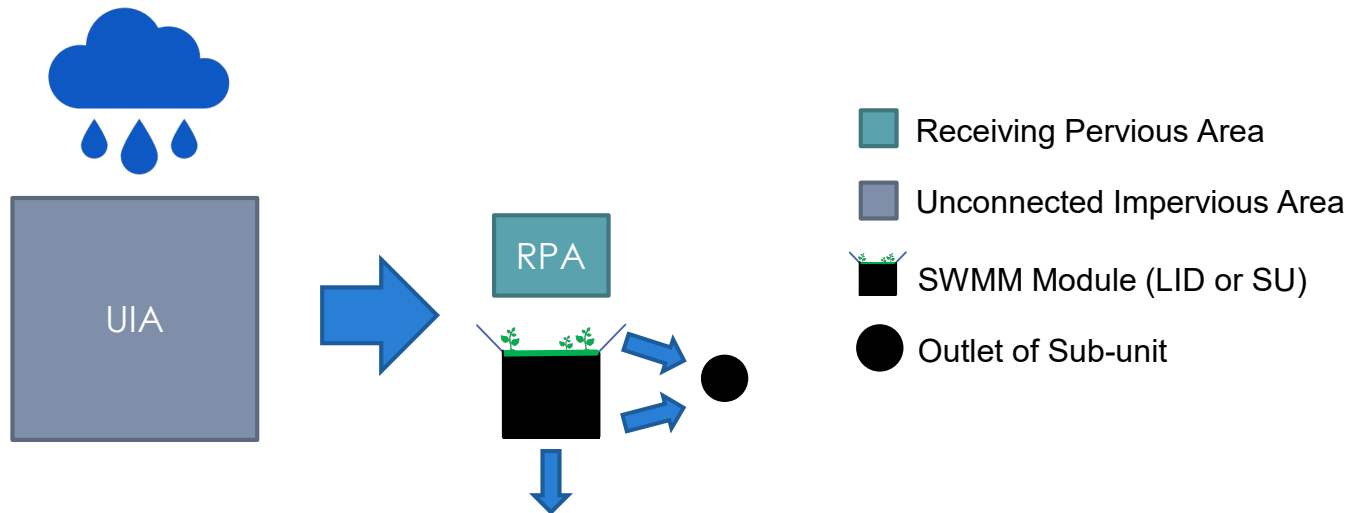
Adding Stormwater Infrastructure

- Current Stormwater Infrastructure
 - Preliminary cost/budget for maintaining traditional stormwater system
 - Types of stormwater technologies
 - Level of implementation of technologies based on current practice



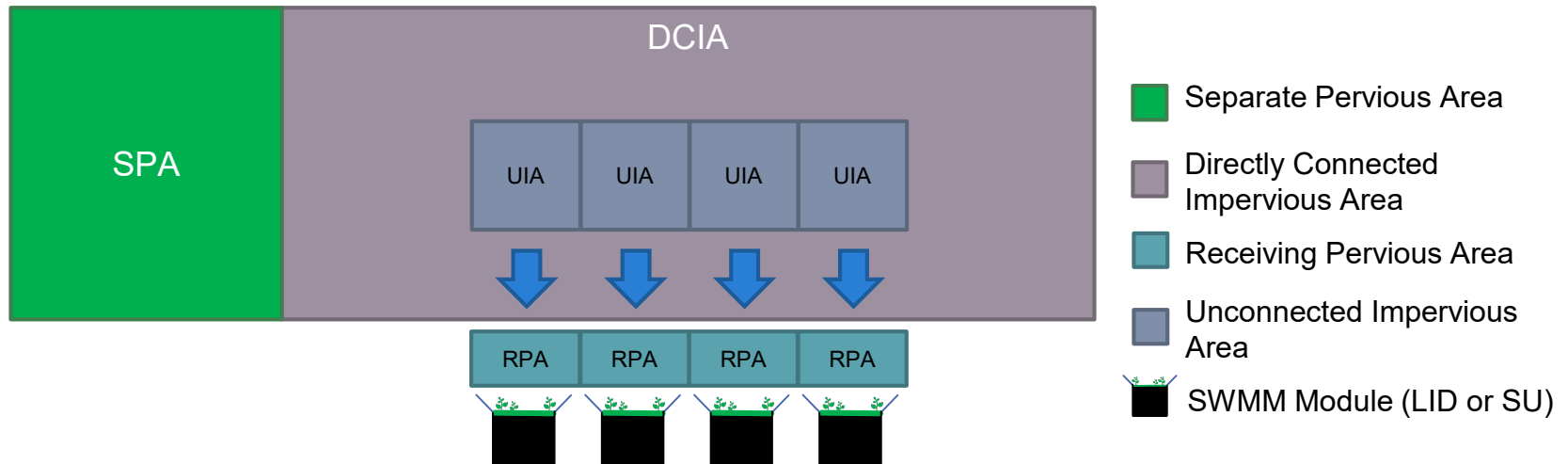
Adding Stormwater Infrastructure

A technology unit treats a certain area or volume that has been pre-set within the CLASIC tool. Technologies may vary in terms of size and design parameters.



Adding Stormwater Infrastructure

Technology units are sized to capture a particular volume or area. The user then specifies a total volume or area that should be captured and the number of technology units are selected to accomplish the level of capture.



Rain Gardens-00



Rain Garden
Size
Medium ▼



Surface Area: 1,000 ft²
Media Thickness: 24"



Impermeable Liner Used



Has Underdrain



Has Vegetation



% DCIA:

25%



Depth to Capture (in.)

0.5

Inch



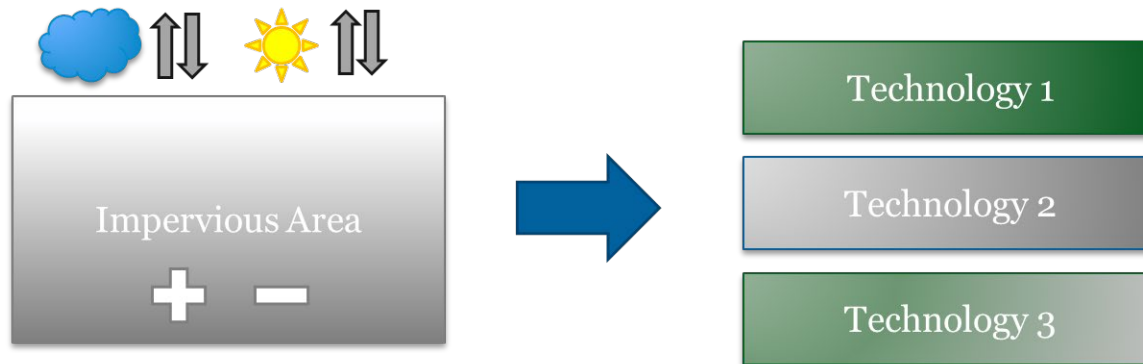
BMP Area

Pervious ▼



Scenario Development

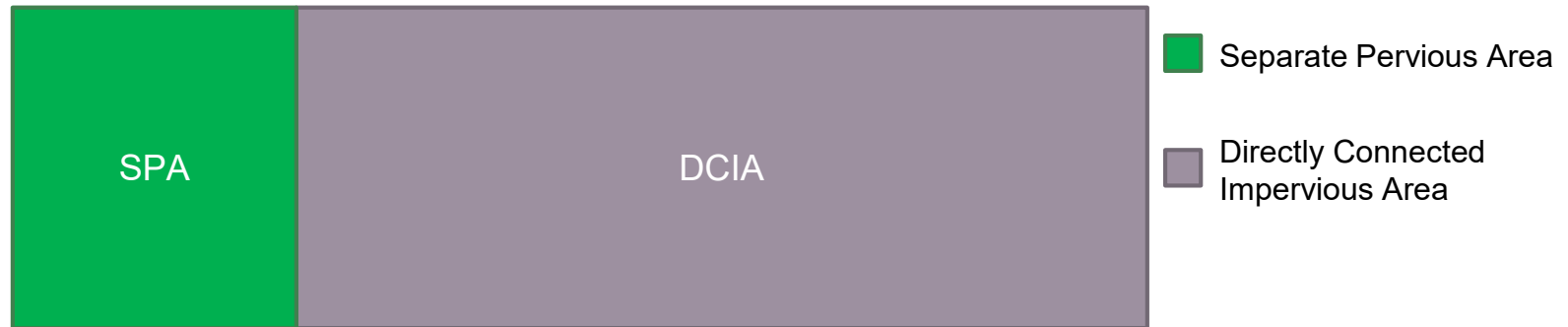
- Create scenarios to evaluate changes of:
 - Stormwater infrastructure adoption
 - Land development pattern
 - Increased impervious area
 - Climate (precipitation/temperature)



A simple example...

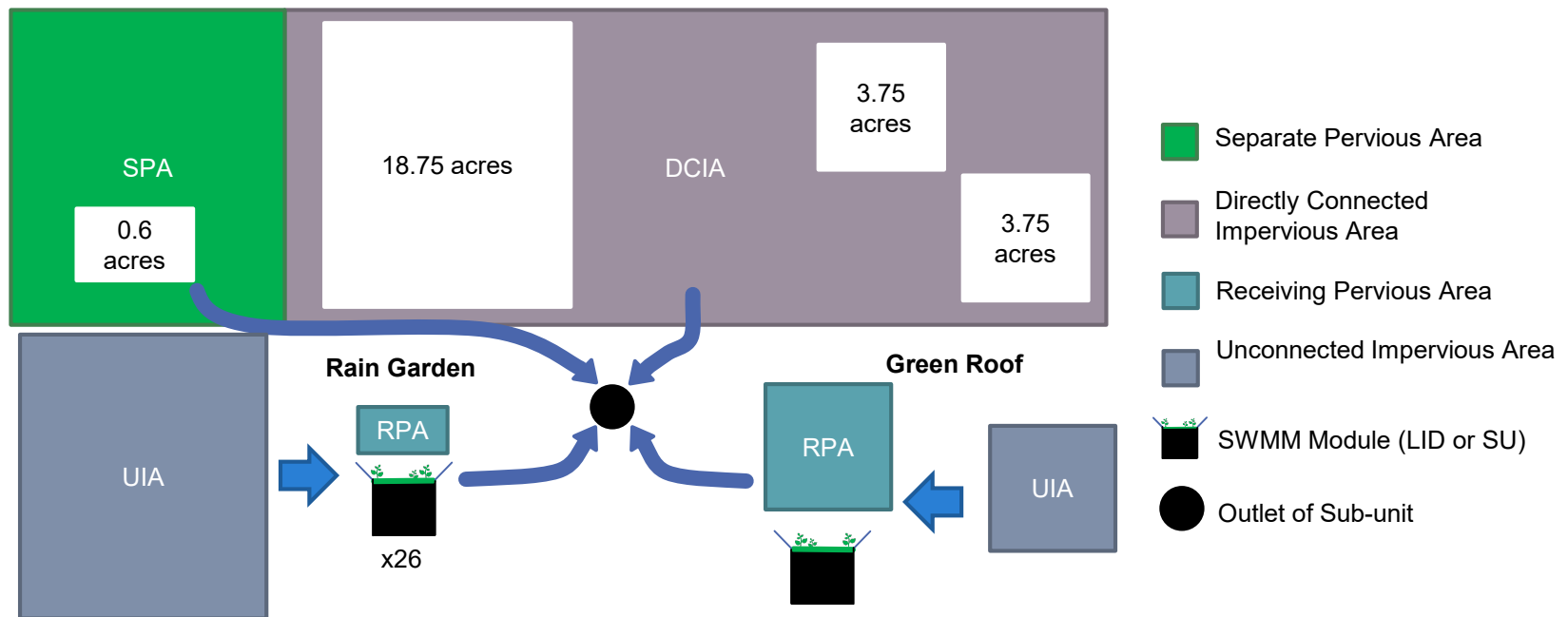
A user-defined subcatchment with 75% impervious and total area of 100 acres.

(75 acres of impervious area and 25 acres of pervious area)

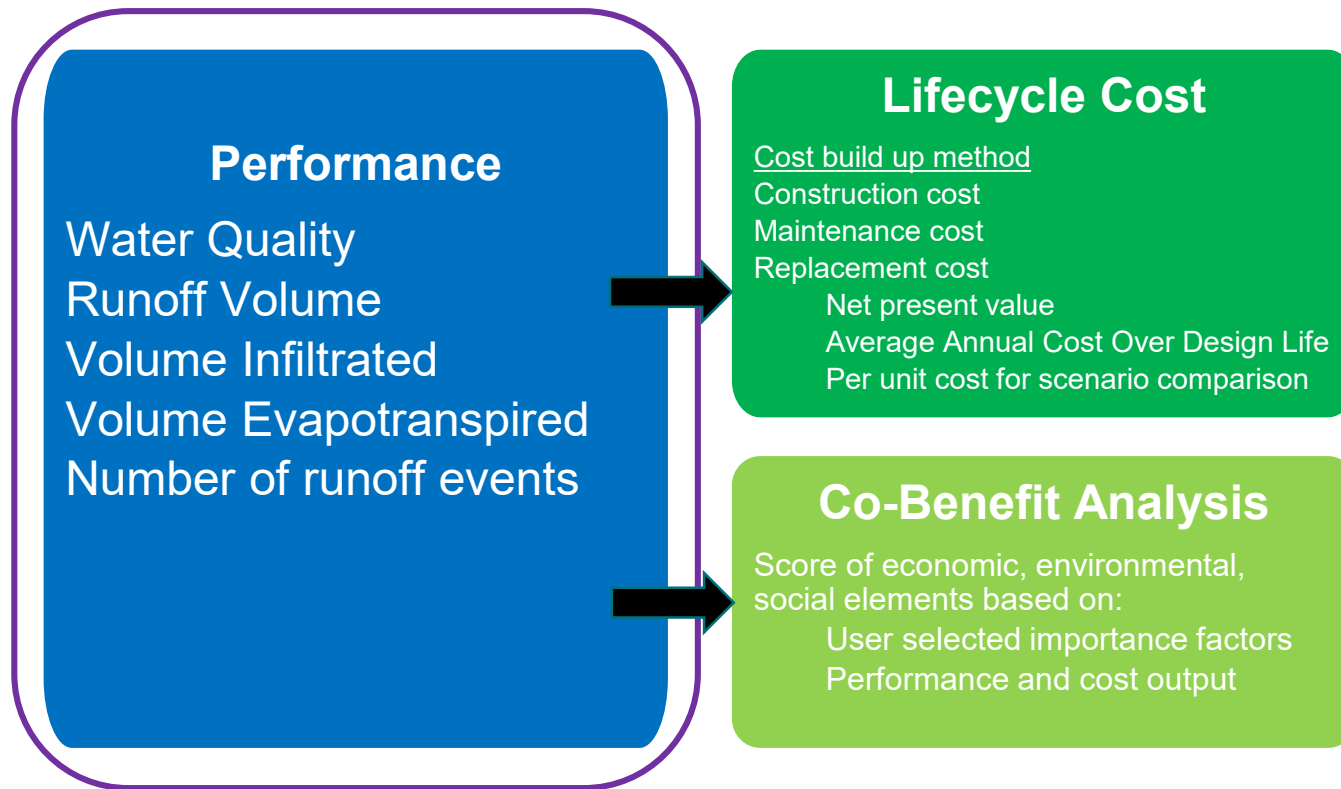


A simple example...

The user-specified impervious capture areas are removed from DCIA, and the BMP area is removed from either the SPA (rain garden) or from the impervious capture area (green roof).



Three Basic Outputs



CLASIC Tool: Project: Example 1 - Results

Summary

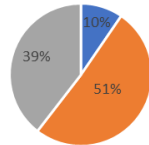
Cost

Co-Benefit

Performance

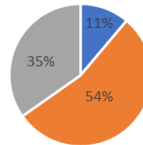
Hydrologic Performance Output

Baseline



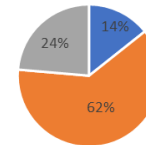
■ ET (acre-ft)
■ Infiltration (acre-ft)
■ Runoff (acre-ft)

Scenario 1



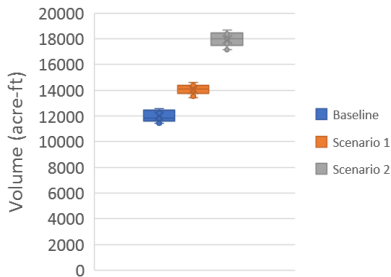
■ ET (acre-ft)
■ Infiltration (acre-ft)
■ Runoff (acre-ft)

Scenario 2

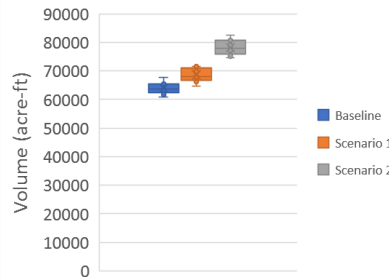


■ ET (acre-ft)
■ Infiltration (acre-ft)
■ Runoff (acre-ft)

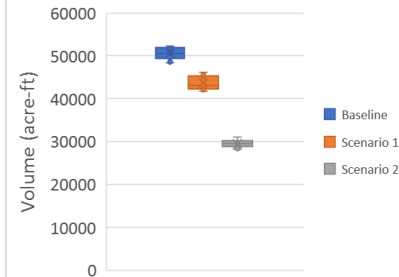
Evapotranspiration



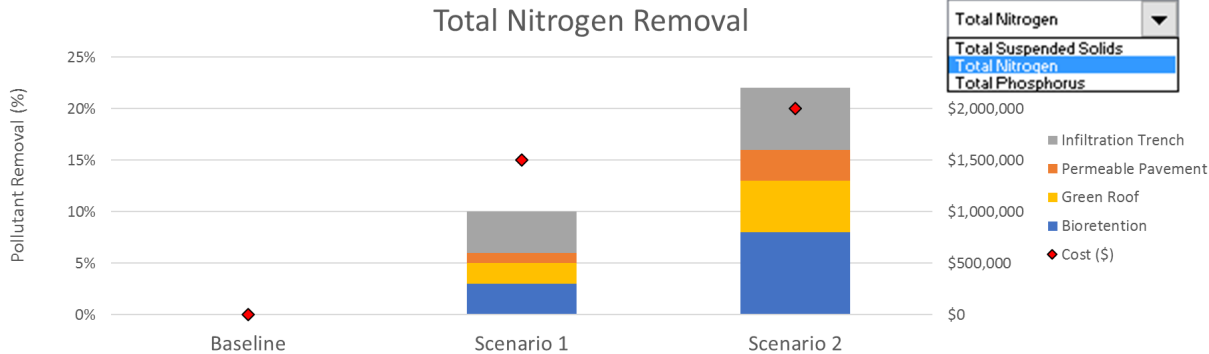
Infiltration



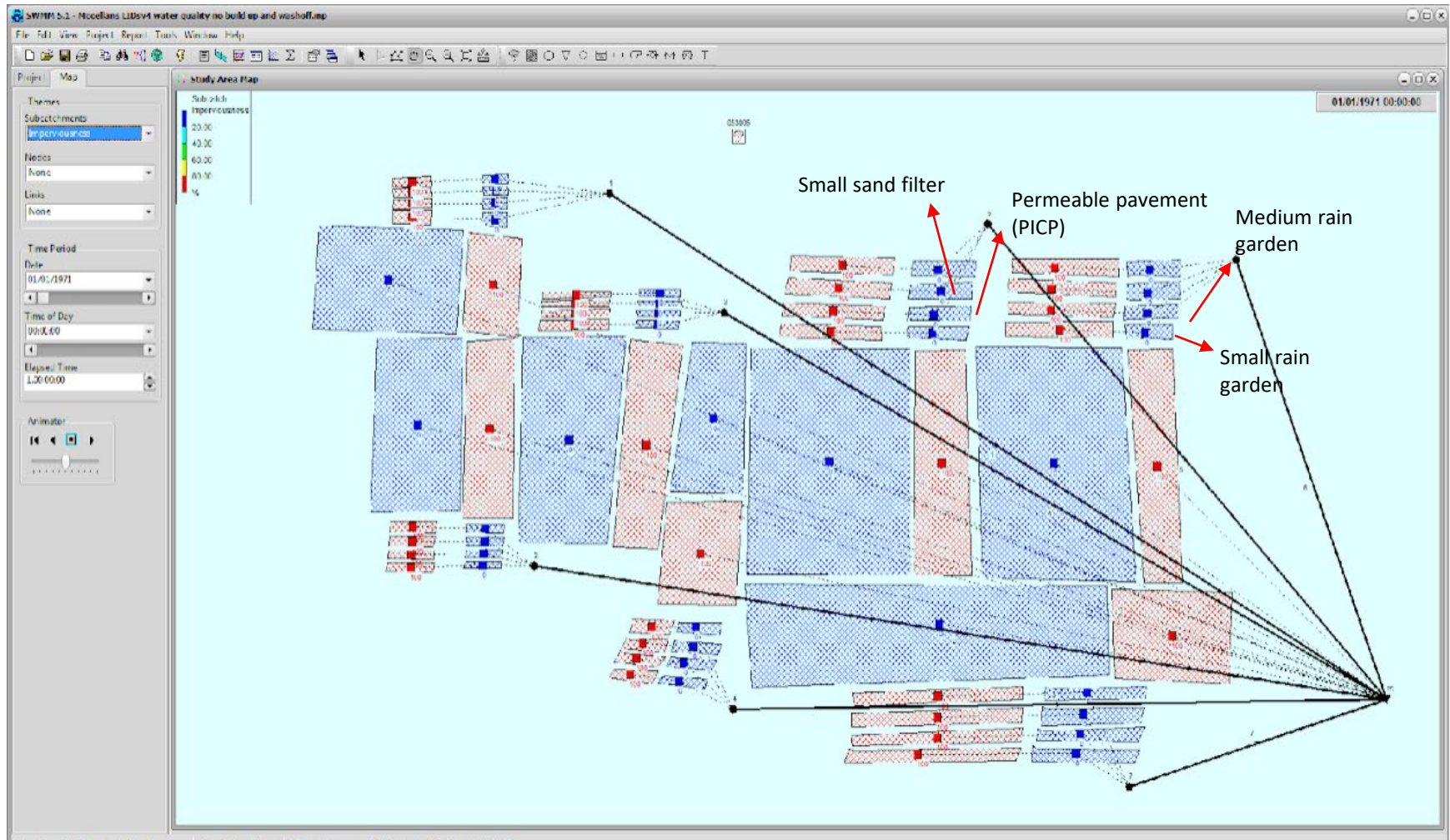
Runoff



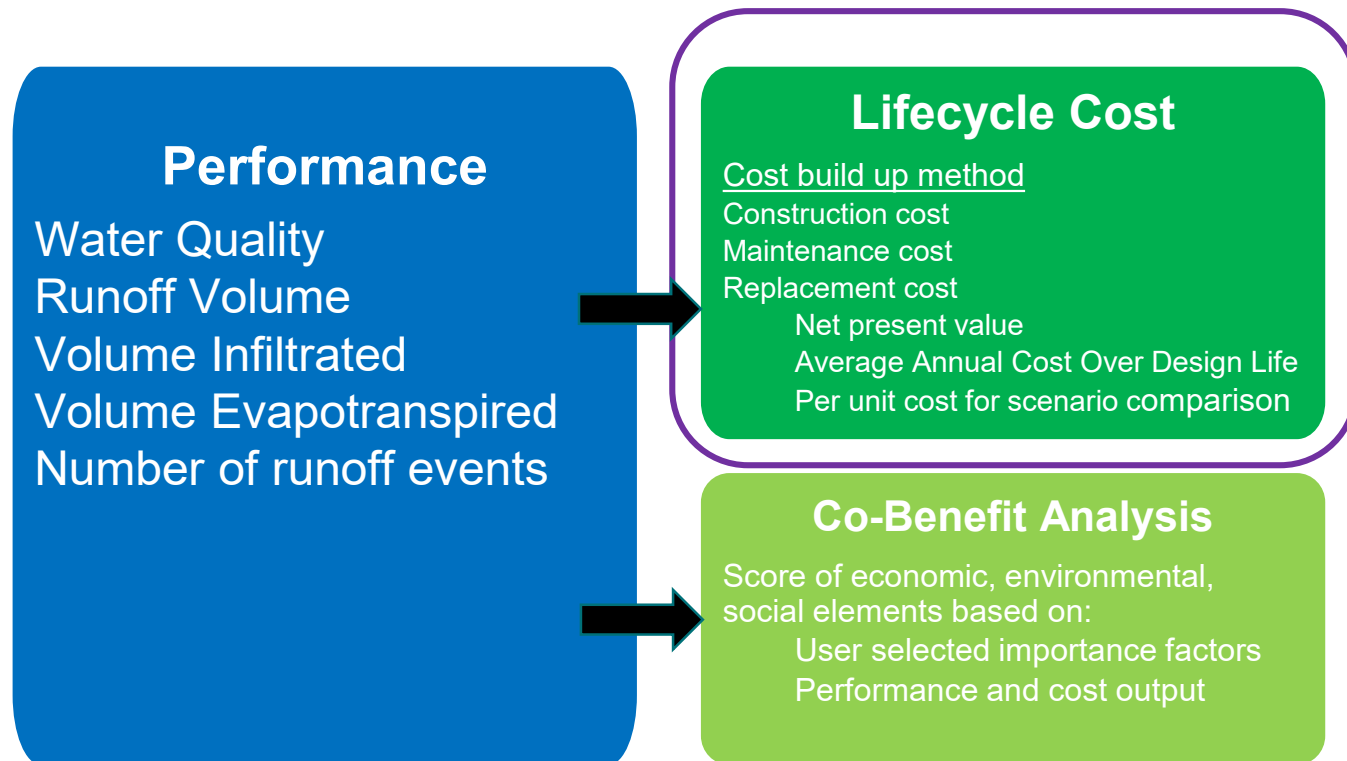
Total Nitrogen Removal



Model developed in SWMM



Three Basic Outputs

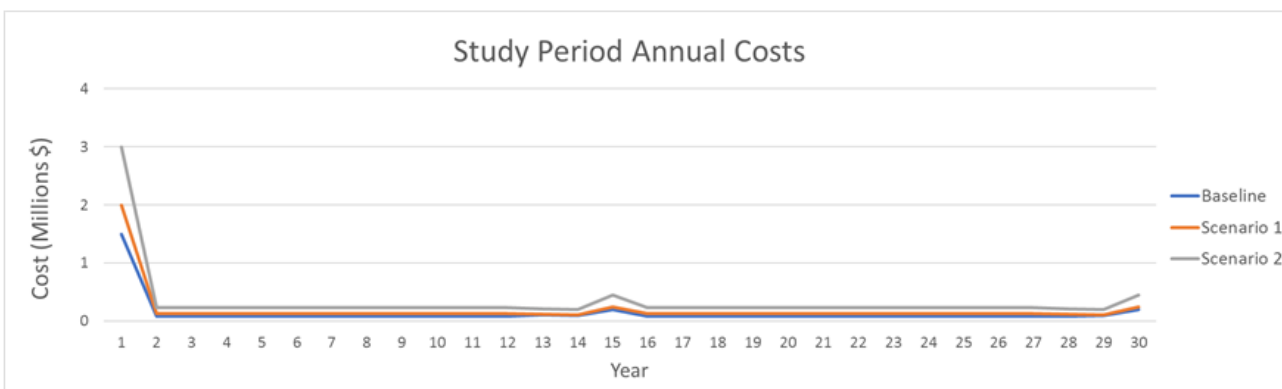
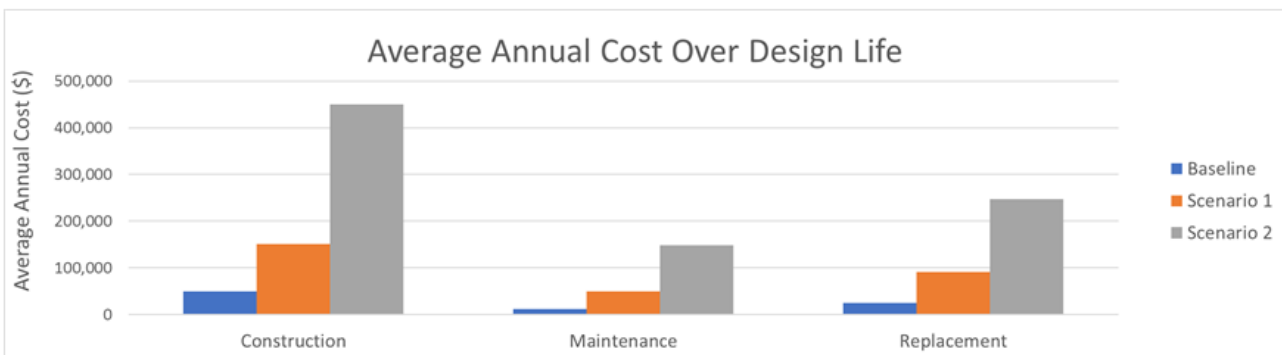
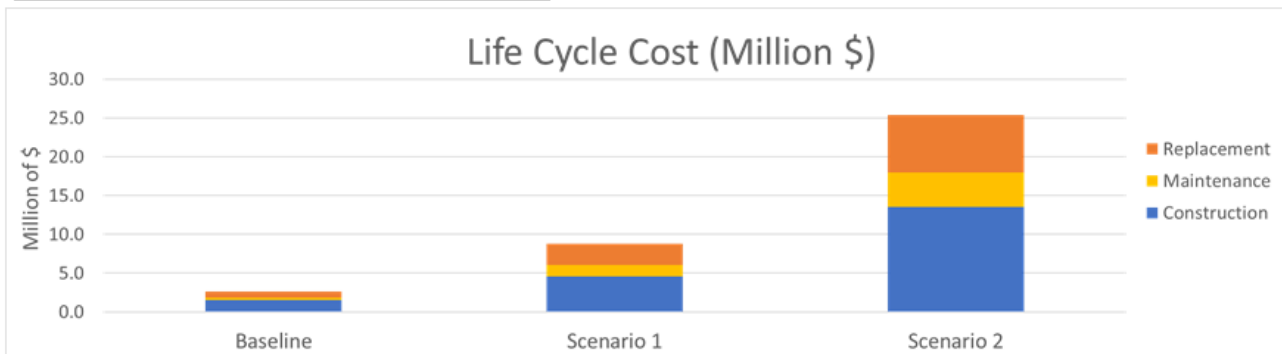


Summary

Cost

Co-Benefit

Hydrologic

Life-Cycle Cost Analysis Output

Lifecycle Cost

Following NIST, 1996; USACE/EPA, 2000; USEPA, 2008

$$LCC = C_0 + \left[\sum_{t=1}^T M_t + \sum_{t=1}^T C_r \right]$$

LCC = life cycle cost

C_0 = initial construction costs

M_t = routine and periodic maintenance costs

C_r = rehabilitation (major) costs

T = study period

LCC Inputs, Assumptions

- Costs include regional adjustments
- Current dollar value includes “escalation” and/or “discount”
- Study period is user specified: 10, 20, 30, 50 years
- No added discount rate (current dollar value throughout study periods)
- Rehabilitation value = portion of initial construction cost dependent on maintenance

Initial Construction Cost

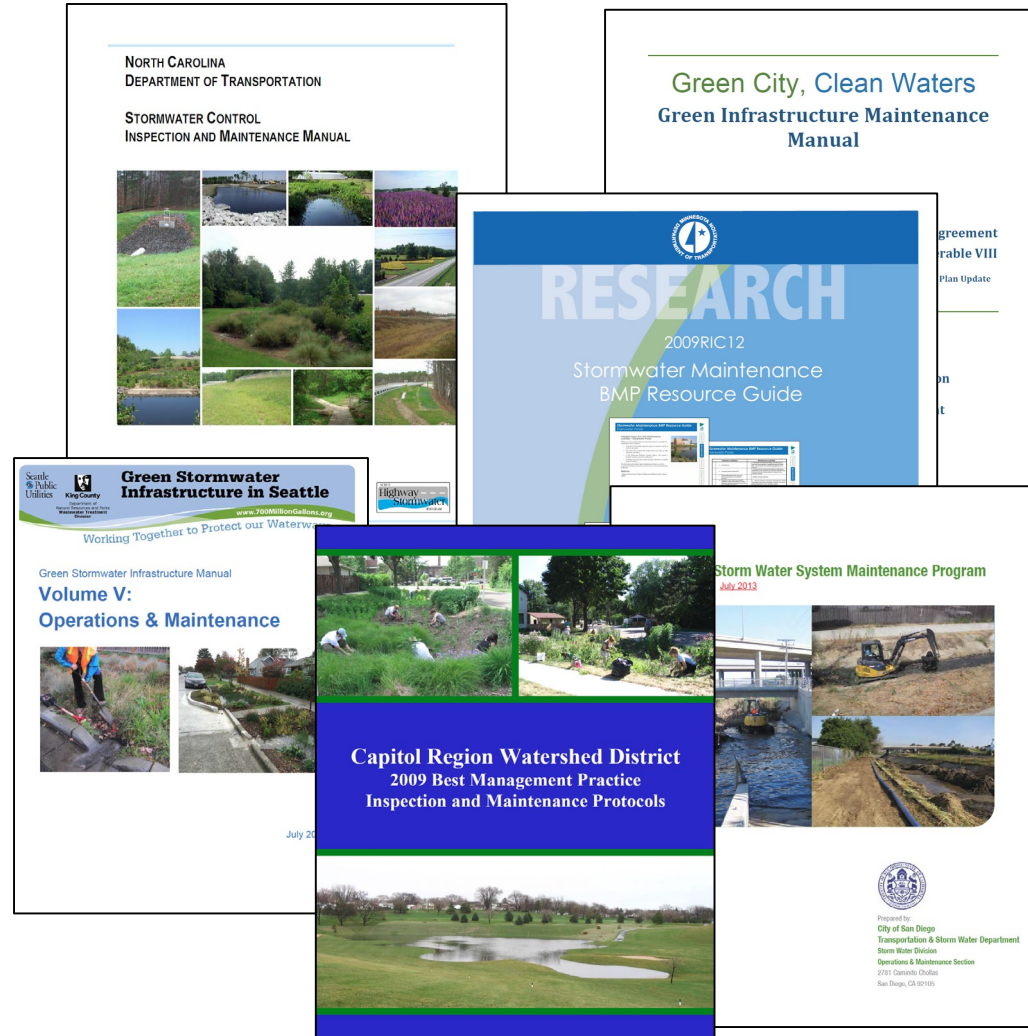
- Line item build up for each technology
- Replacement cost calculated as a subset of initial construction line items counting salvage of select components
- Unit costs from DOT bid tabs
- Bid tab unit costs compared to RSMeans for validation
- Fixed combination of designs for each technology including small, medium and large sizes along with additional select parameters

Design Parameters Affecting Cost: Rain Gardens

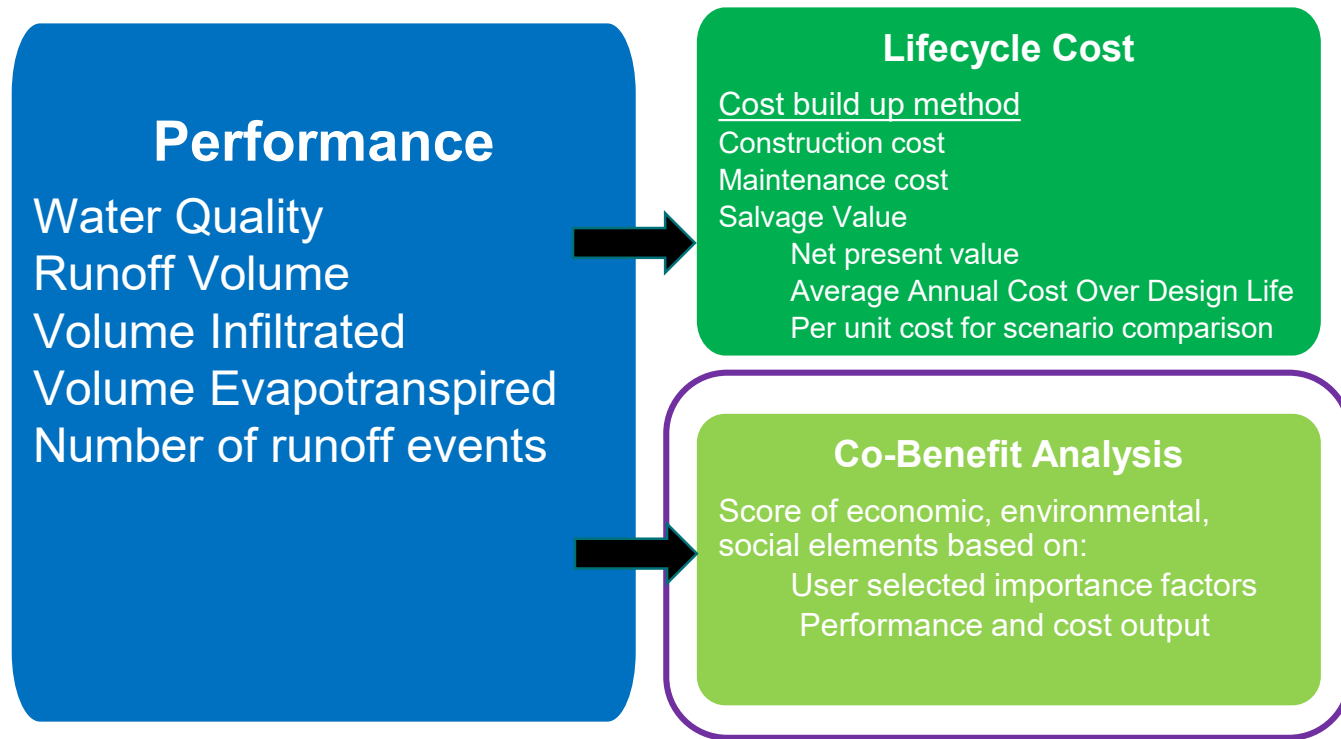
Design Parameter	Small	Medium	Large
Surface Area (sq.ft)	100	1,000	10,000
Total Volume To Capture (cu.ft)	166	1656	16555
Ponding Depth (inches)	12	12	12
Filter Media Depth (inches)	18	18	18
Liner	Yes or No	Yes or No	Yes or No
Underdrain	Yes or No	Yes or No	Yes or No
Vegetation	Yes or No	Yes or No	Yes or No

Maintenance Cost

- Line item build up based on recommended maintenance activities for each technology
- Routine & periodic activities
- Maintenance manuals from agencies across USA reviewed for recommended activities and frequency
- Regional adjustments for climate influenced activities such as mowing and vacuuming of permeable pavement



3 Basic Outputs



CLASIC Tool: Project: Example 1 - Results

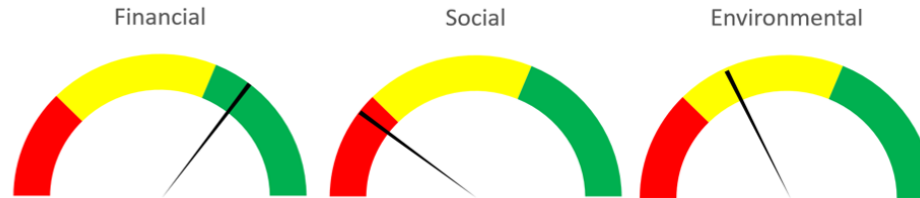
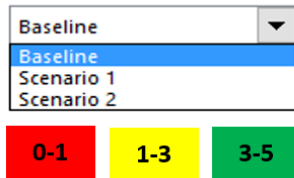
Summary

Cost

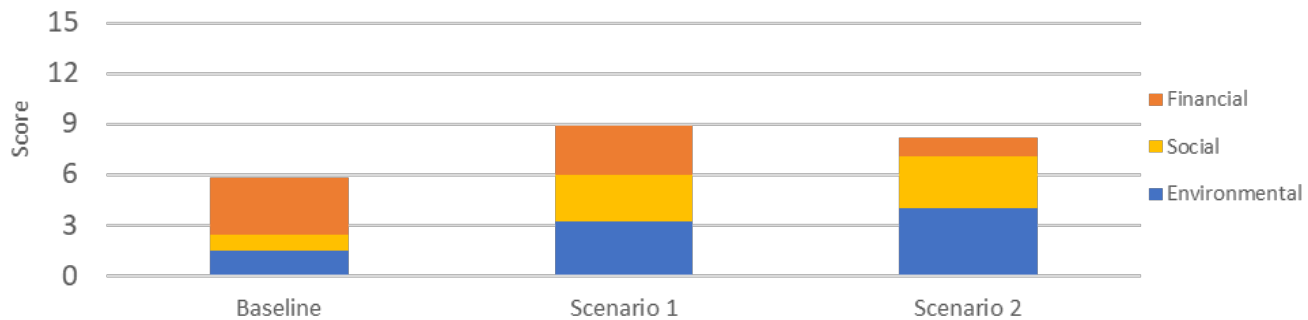
Co-Benefit

Performance

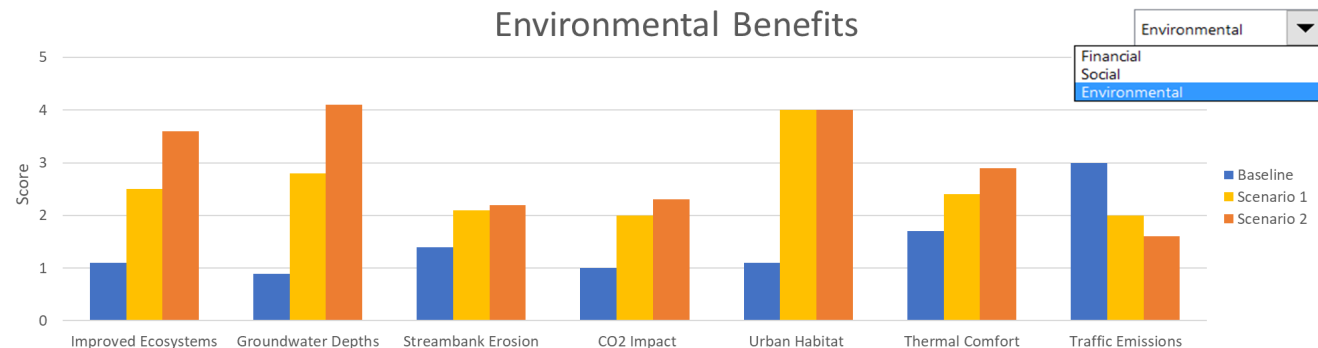
Co-Benefit Analysis Output: (Scores of 0-5 with 5 being highest score)



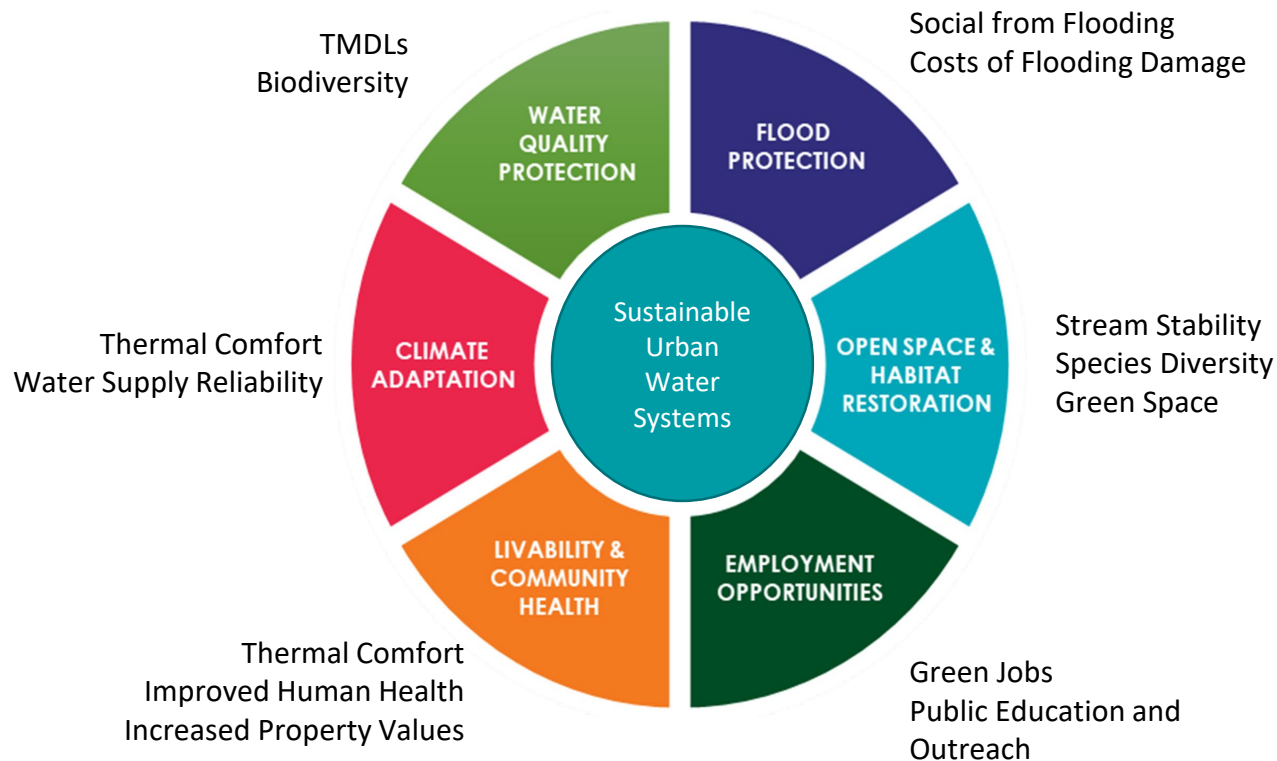
Co-Benefit Analysis



Environmental Benefits



Co-Benefits Analysis



Economic



Overall Importance



Avoided Flood Damage



Avoided Water Treatment



Building Energy Eff.



Costs from Illness



Green Jobs Income



Property Values



Recreation Revenue



Social



Environmental

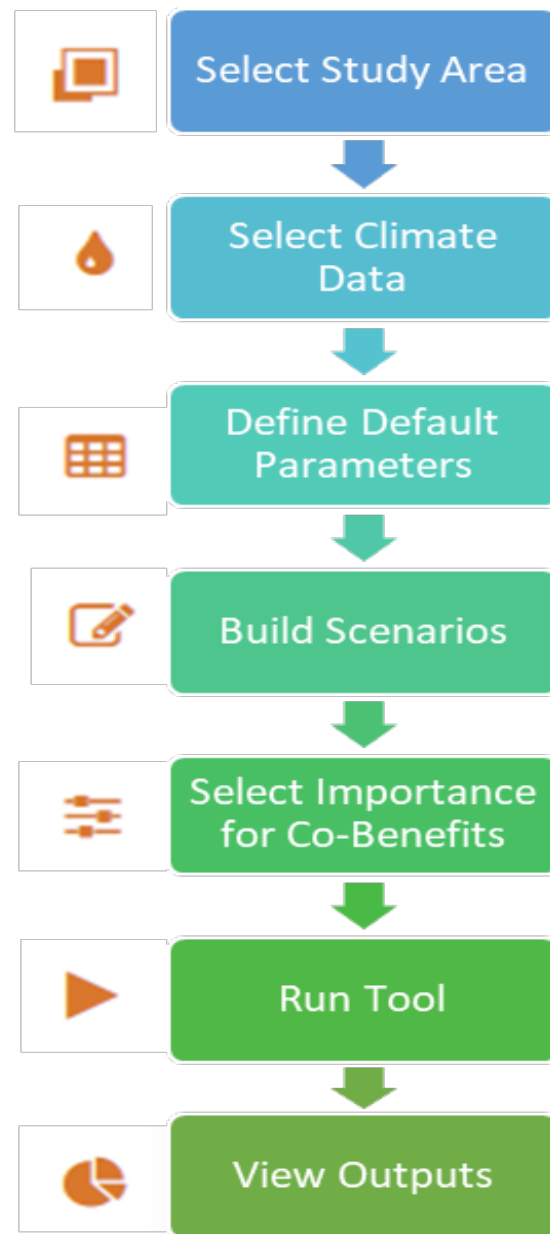


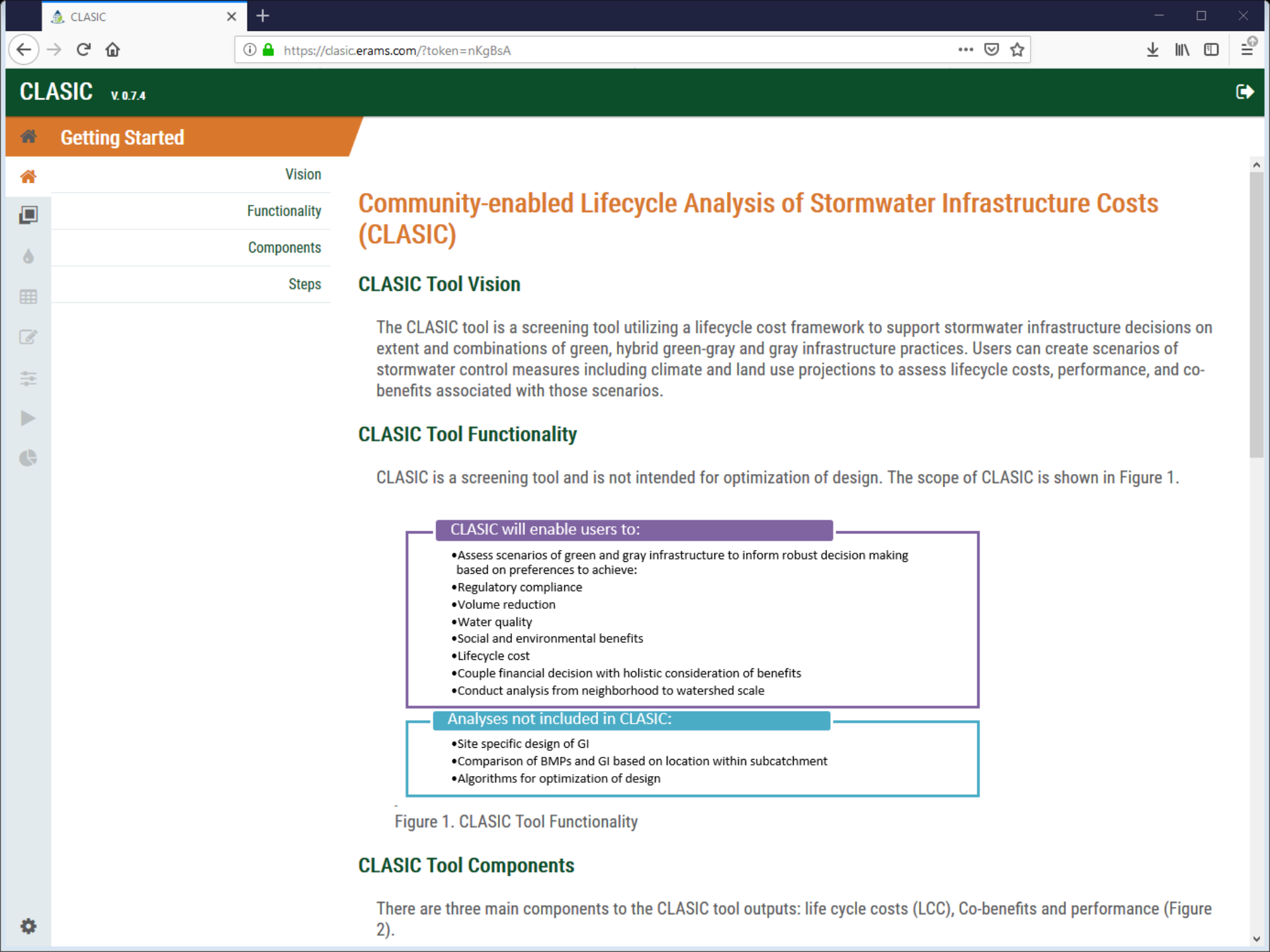
Indicator	CLASIC Output	Min/Max
Economic		
Revenue from water recreation	Pollutant load (TSS, TN, TP)	Min
Property Values	Pollutant load (TSS, TN, TP)	Min
	Area of added green space	Max
Avoided costs for illness resulting from air quality improvements	Area of added green space	Max
Building energy efficiency	Area of green roofs	Max
Avoided costs for water treatment due to reduced municipal water demand	Volume water harvested used	Max

Schedule for CLASIC Release

- Beta Testing: April 2019 – May 2019
CLASIC tool refinement: August 2019
- CLASIC tool final testing and case studies:
September 2019 – October 2019
- CLASIC Tool Delivered: December 2019

CLASIC Tool Steps





Define Project

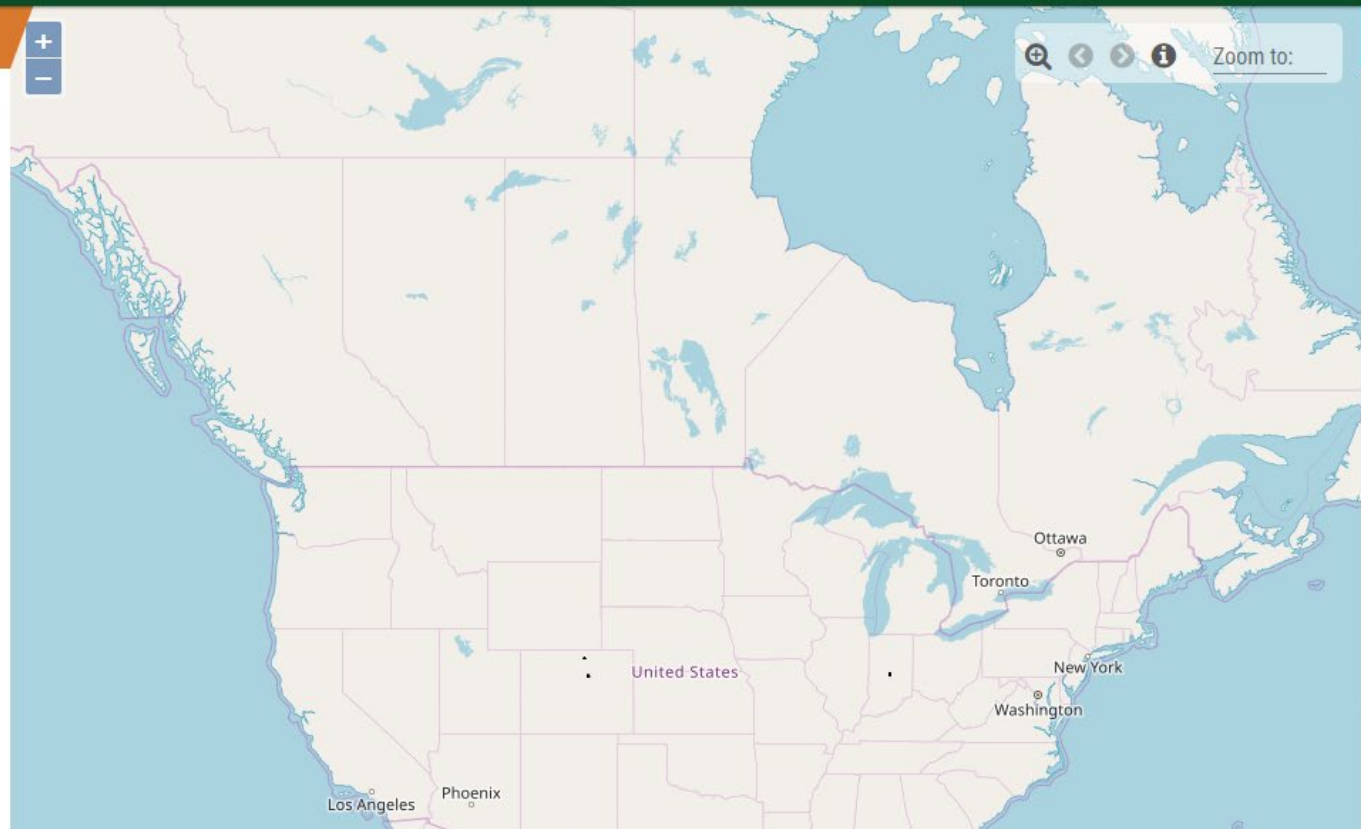
Define a Project

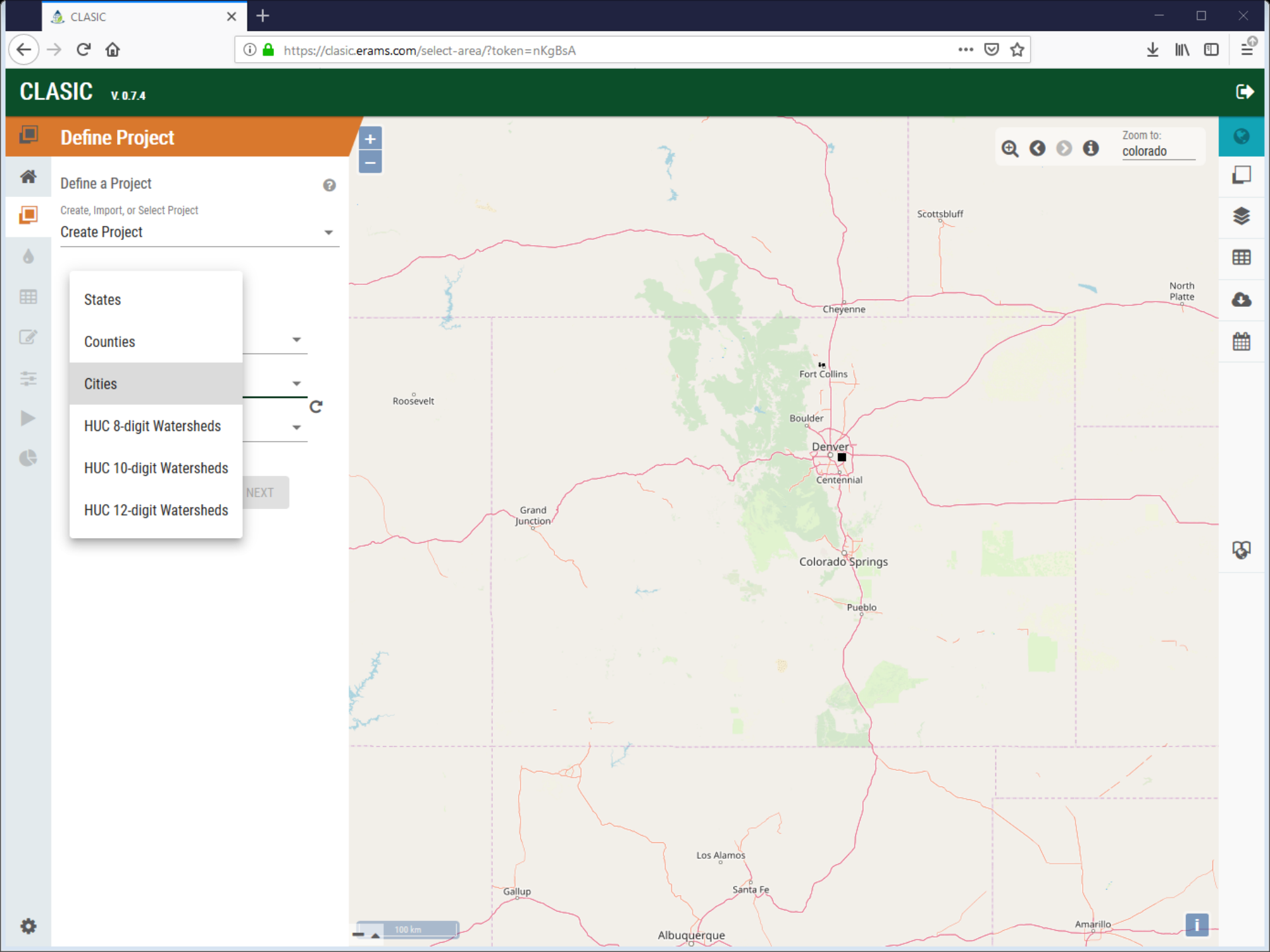
Create, Import, or Select Project

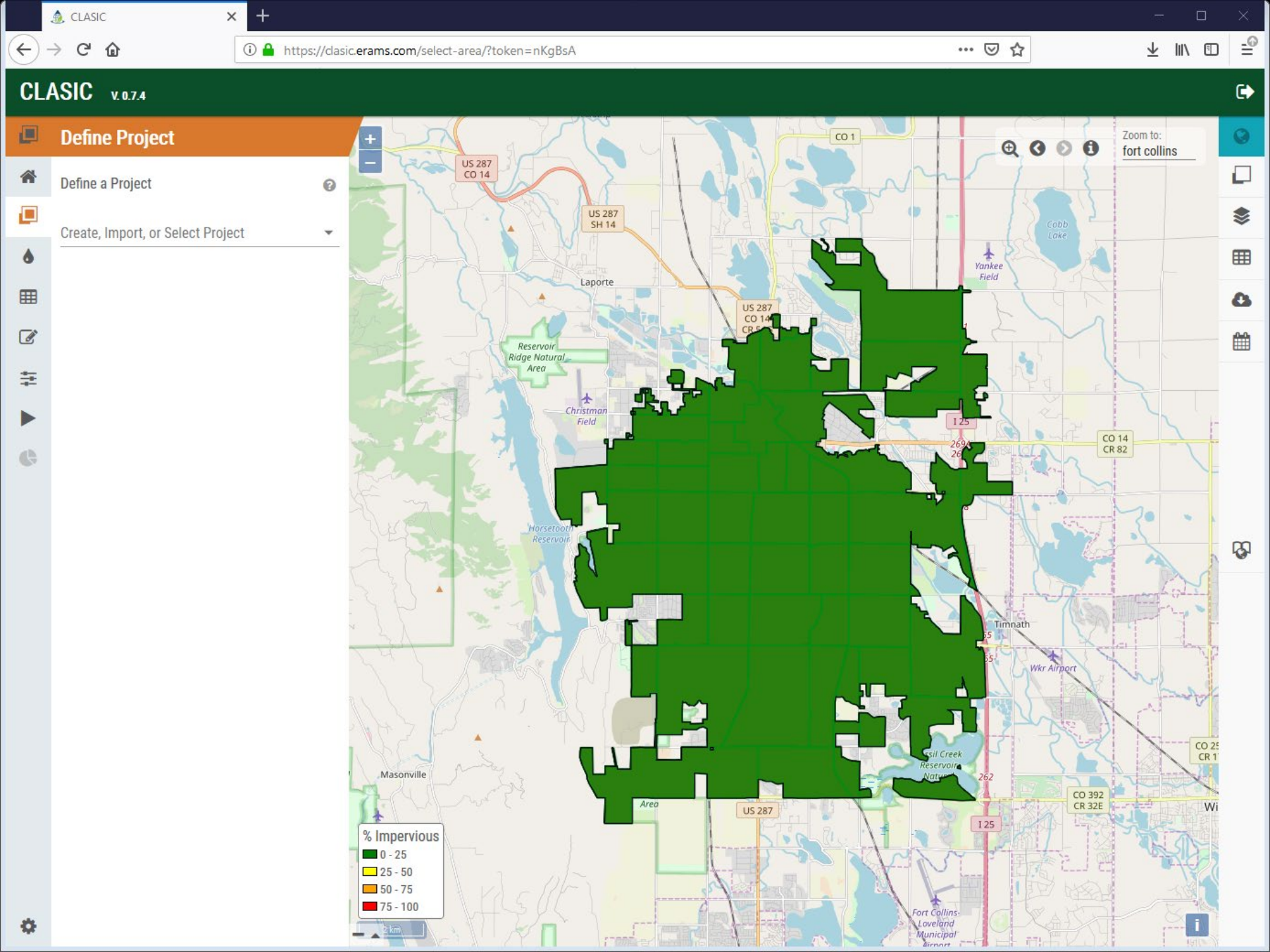
Create Project

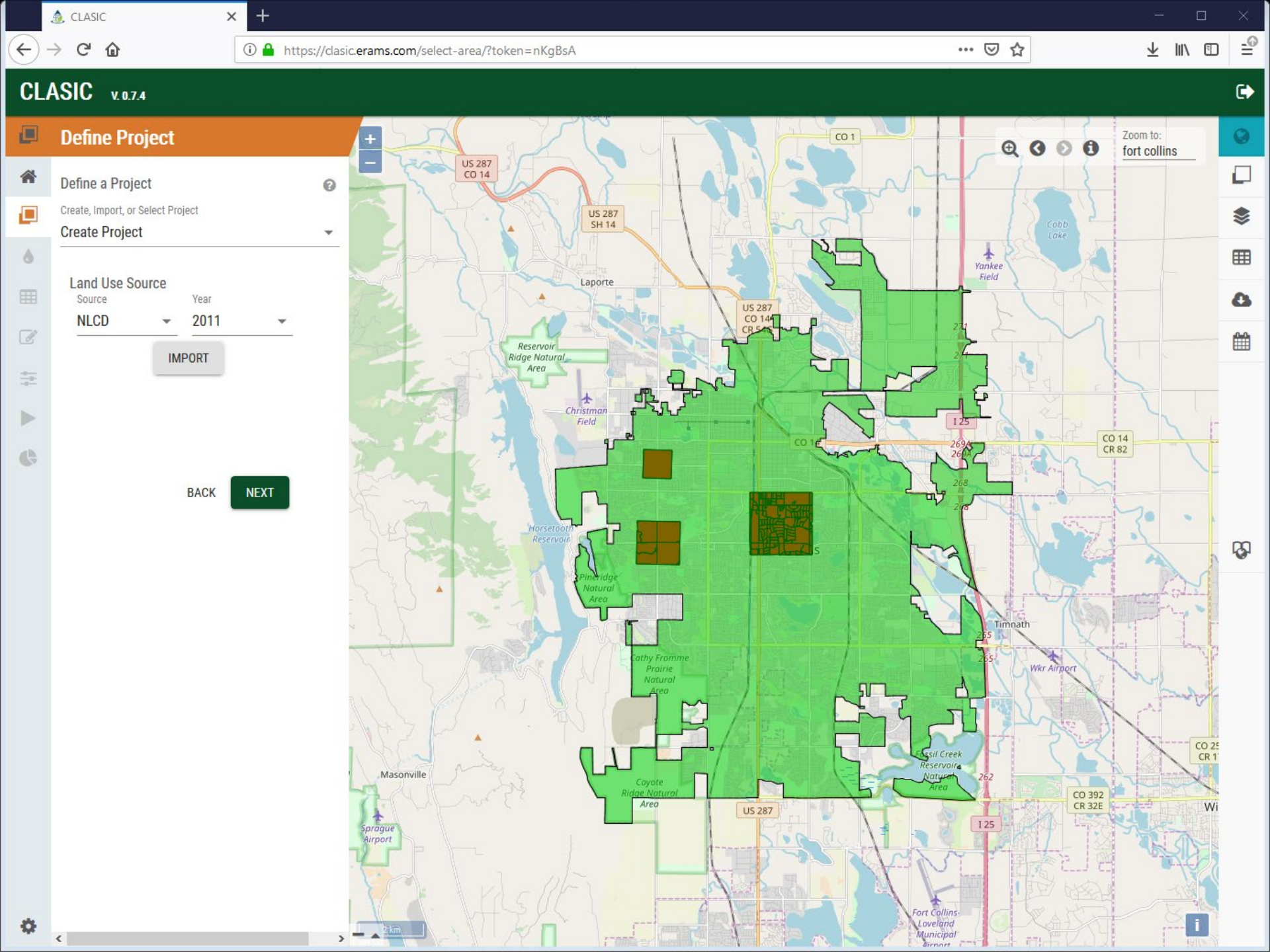
Specify Project Extent

- Draw a Point
- Draw a Line
- Draw a Polygon
- Draw a Rectangle
- Draw a Circle
- Known Boundaries
- User-Supplied Layer









CLASIC V.0.7.5

Climate Data

Select Climate Data

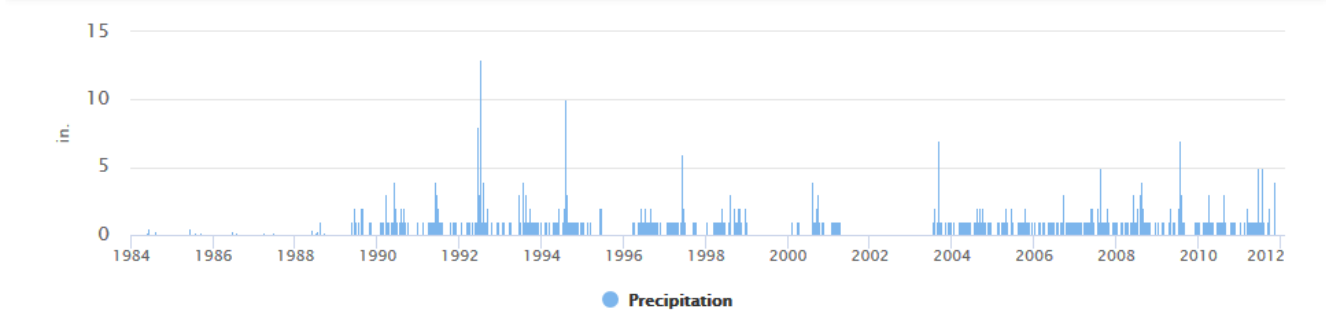
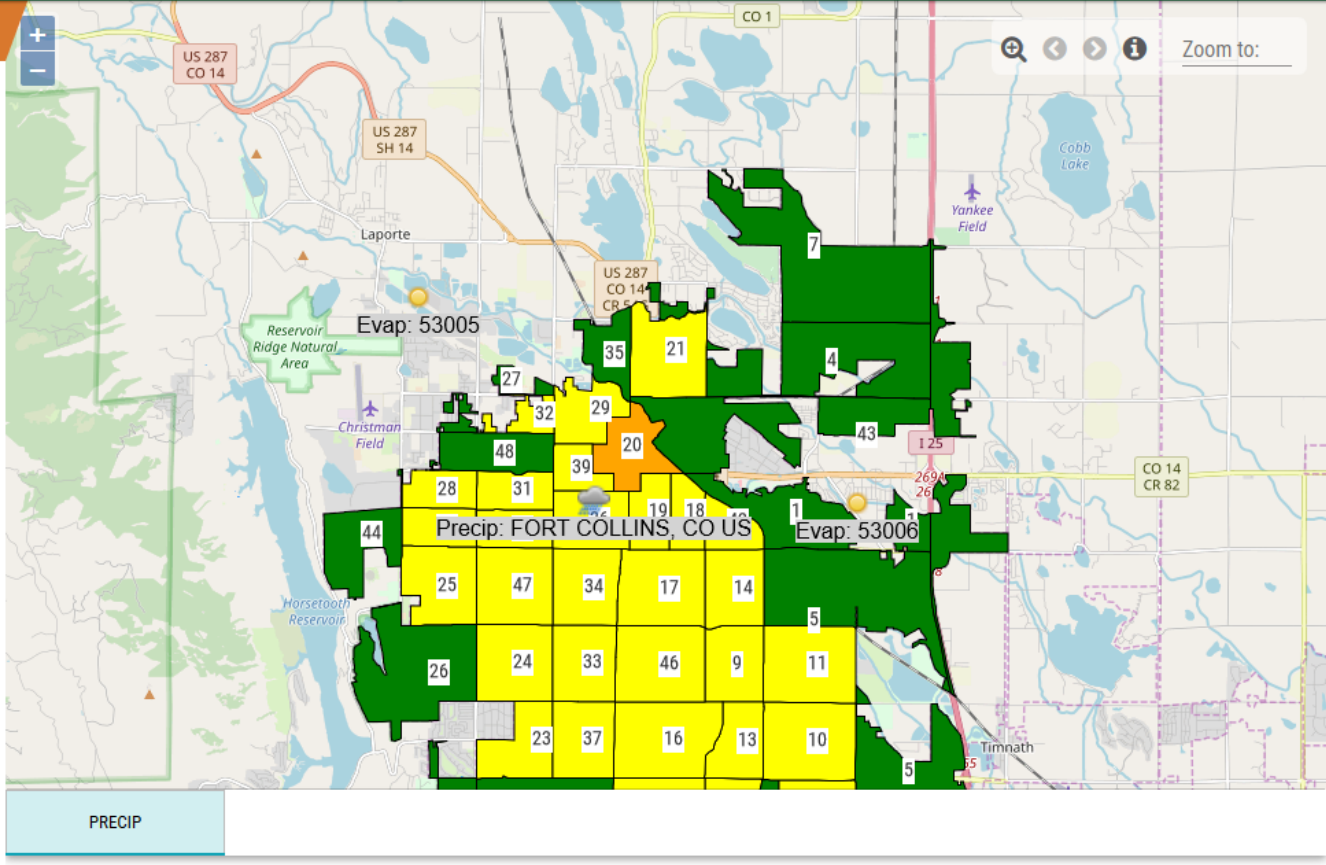
UPDATE CLIMATE

Select Precip Station

FORT COLLINS, CO US

on Station

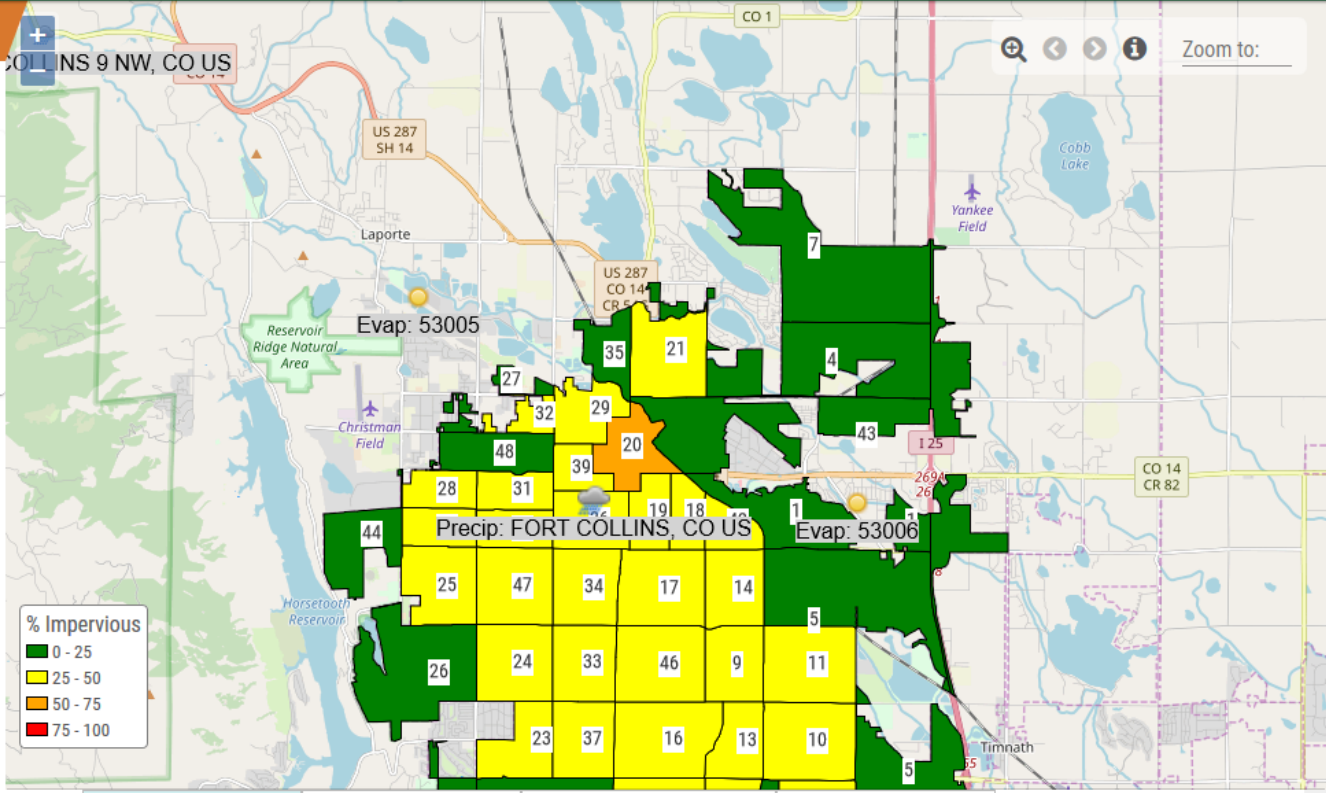
- 53006
- 53005
- 58839
- 51060
- 530070



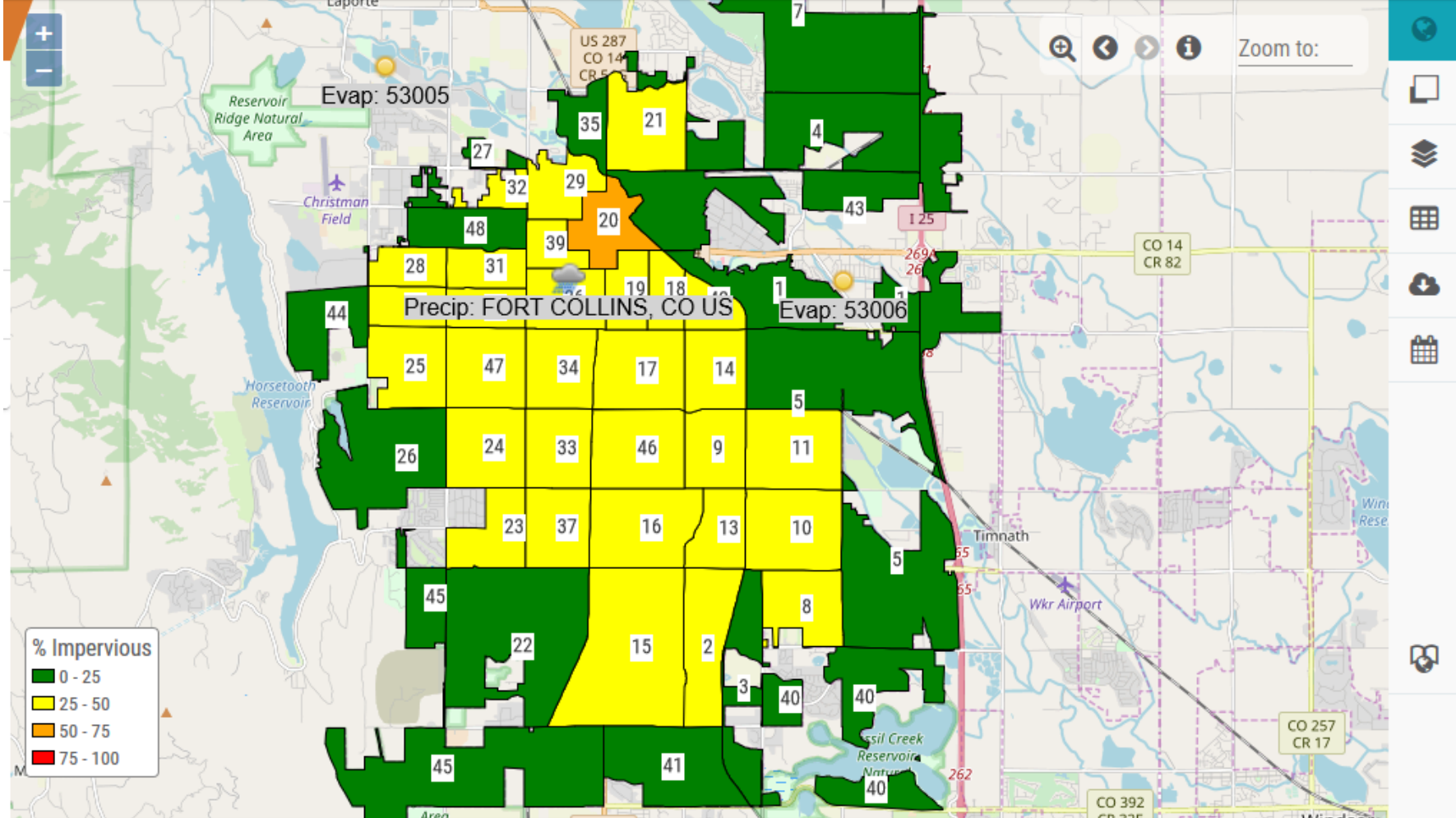
CLASIC V.0.7.5

- Model Defaults
- Review and Modify Default Parameters
- Subunits
- Water Quality
- Overland Flow Length
- Infiltration

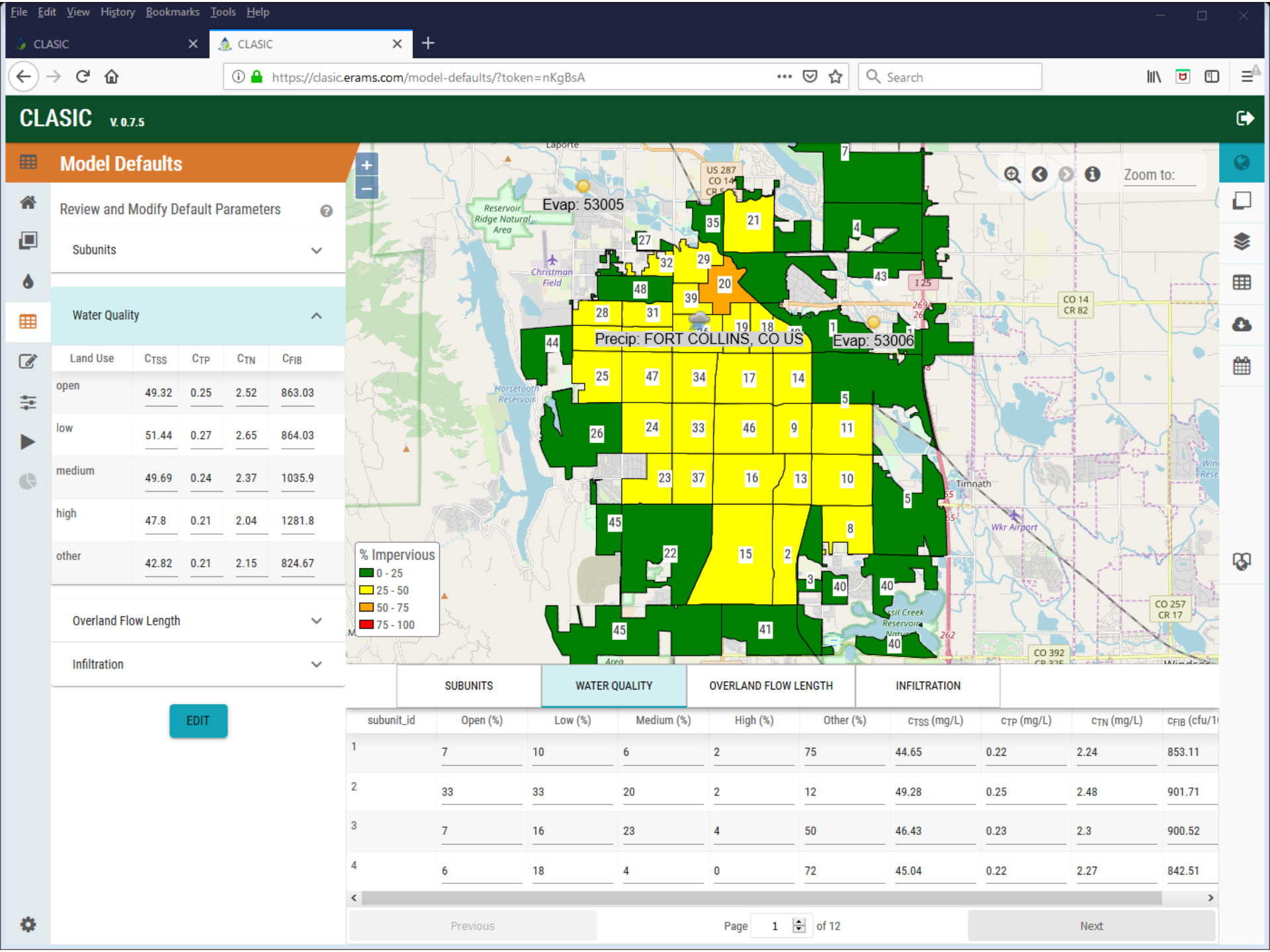
EDIT



SUBUNITS		WATER QUALITY		OVERLAND FLOW LENGTH		INFILTRATION			
subunit_id	Area (Ac)	Impervious (%)	Slope (%)	Open (%)	Low (%)	Medium (%)	High (%)	Other (%)	Length
1	1592.68	9	2.00	7	10	6	2	75	186
2	1239.86	28	7.00	33	33	20	2	12	160.5
3	941.98	24	4.00	7	16	23	4	50	163
4	2423.72	9	1.00	6	18	4	0	72	187
5	5062.02	14	2.00	9	11	10	3	66	178
6	1396.35	10	2.00	7	10	8	1	74	185.5



SUBUNITS		WATER QUALITY		OVERLAND FLOW LENGTH		INFILTRATION			
subunit_id	Area (Ac)	Impervious (%)	Slope (%)	Open (%)	Low (%)	Medium (%)	High (%)	Other (%)	Length
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3	941.98	24	4.00	7	16	23	4	50	163
4	2423.72	9	1.00	6	18	4	0	72	187



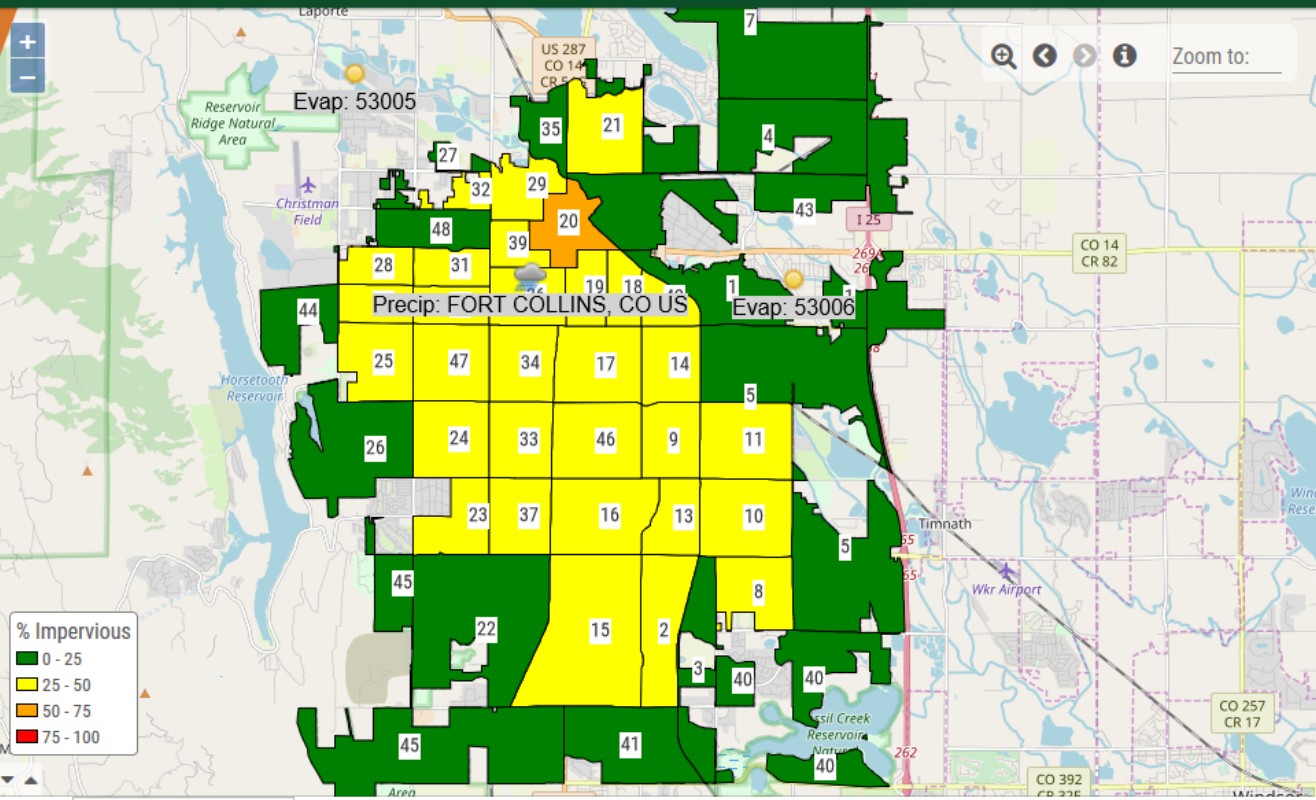
CLASIC V.0.7.5

Scenario Development

Green infrastructure (GI) scenario development

Scenarios

Baseline



SCENARIO SUMMARY

CLASIC V.0.7.5

Scenario Development

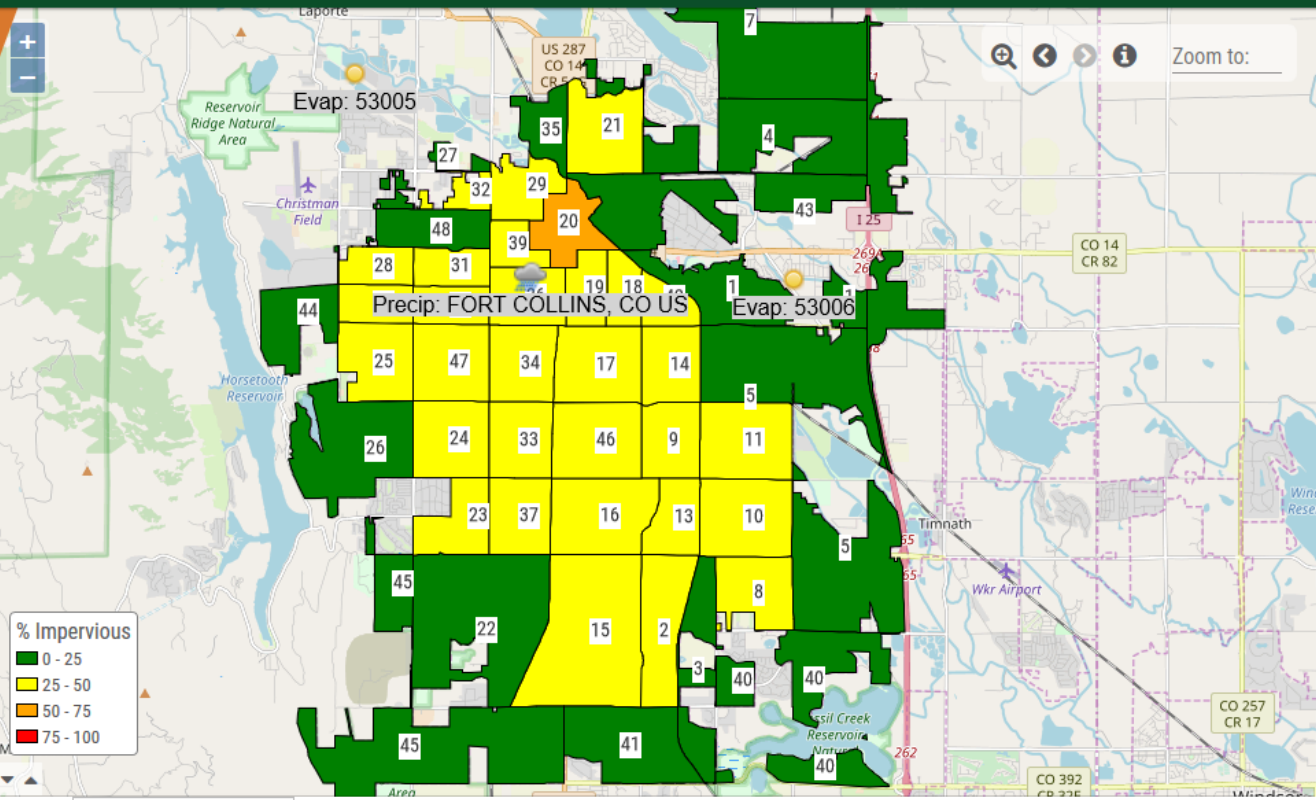
Green infrastructure (GI) scenario development

Scenarios

Baseline

Rain Gardens

RG + SF



SCENARIO SUMMARY

development

?

☒ Impermeable Liner
Used

☒ Has Underdrain

☒ Has Vegetation

?

Depth to Capture

0.5 Inch

BMP Placement

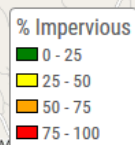
Surrounding Pervious ▾

Select Subunits

?

ALL NONE TOGGLE

<None>



CLIMATE

LANDUSE

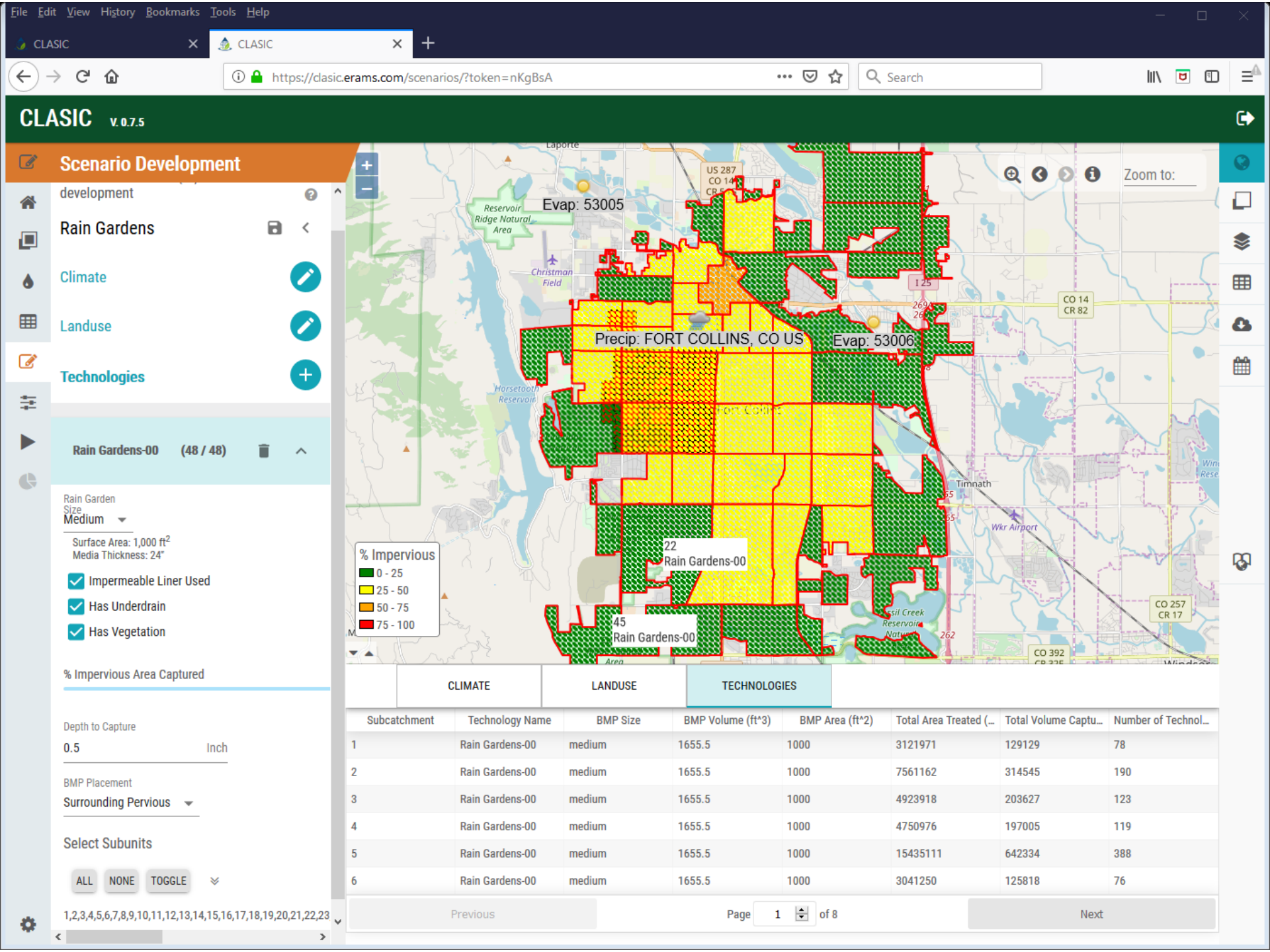
TECHNOLOGIES

Subcatchment	Technology Name	BMP Size	BMP Volume (ft^3)	BMP Area (ft^2)	Total Area Treated (...)	Total Volume Captured (...)	Number of Technologies
			No rows found				

[Previous](#)

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Scenario Development

- Climate
- Landuse
- Technologies

Rain Gardens-00 (5 / 48)

Rain Garden Size Medium

- Surface Area: 1,000 ft²
- Media Thickness: 24"
- ☒ Impermeable Liner Used
- ☒ Has Underdrain
- ☒ Has Vegetation

% Impervious Area Captured 50%

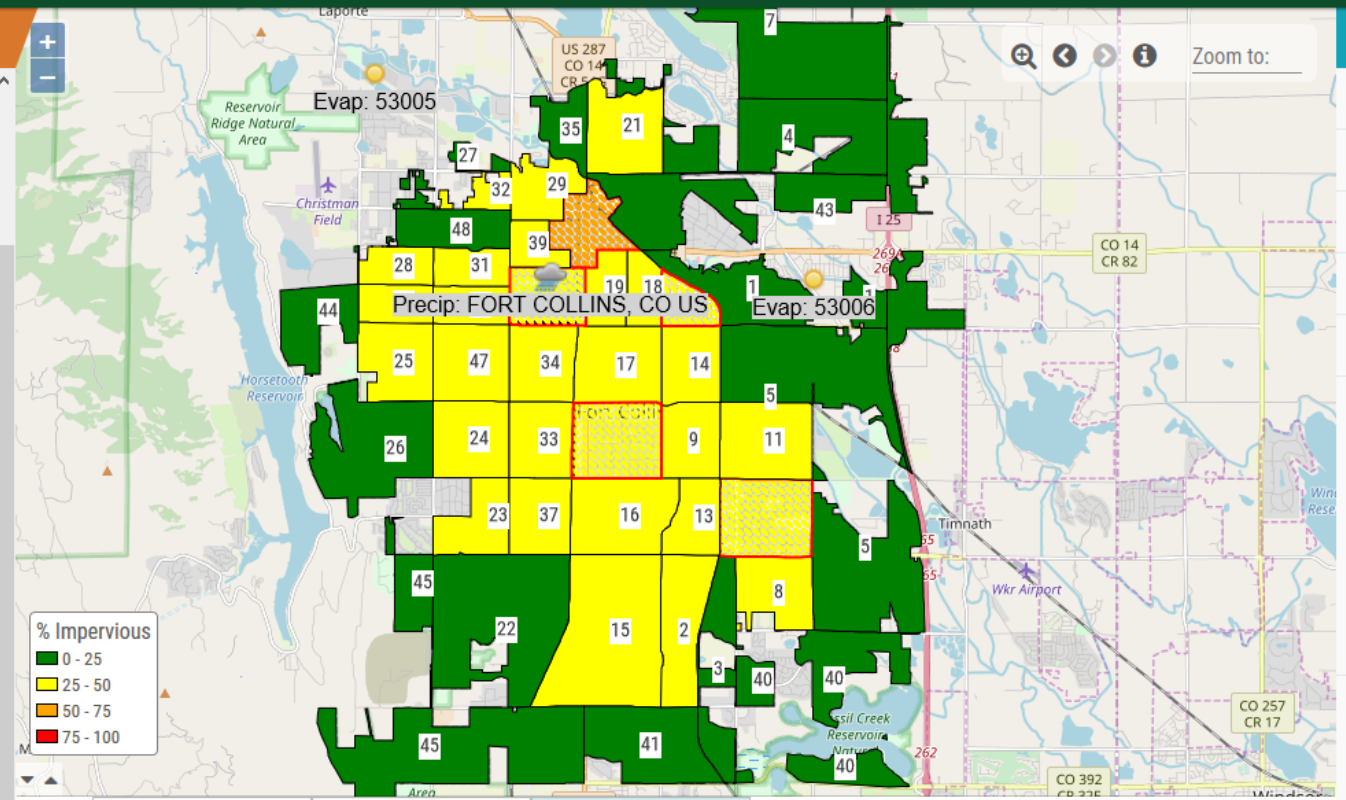
Depth to Capture 0.5 Inch

BMP Placement Surrounding Pervious

Select Subunits

Assign this technology to subunits where

impervious >= 40



CLIMATE		LANDUSE		TECHNOLOGIES			
Subcatchment	Technology Name	BMP Size	BMP Volume (ft ³)	BMP Area (ft ²)	Total Area Treated (...)	Total Volume Captu...	Number of Technol...
10	Rain Gardens-00	medium	1655.5	1000	12851857	534727	323
20	Rain Gardens-00	medium	1655.5	1000	9323460	387387	234
36	Rain Gardens-00	medium	1655.5	1000	8048067	334411	202
42	Rain Gardens-00	medium	1655.5	1000	4863147	201971	122
46	Rain Gardens-00	medium	1655.5	1000	12741790	529760	320

Scenario Development

Green infrastructure (GI) scenario development

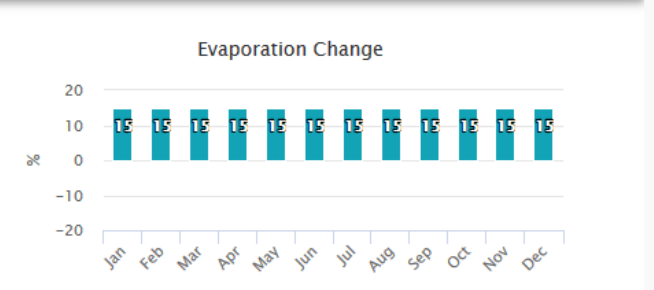
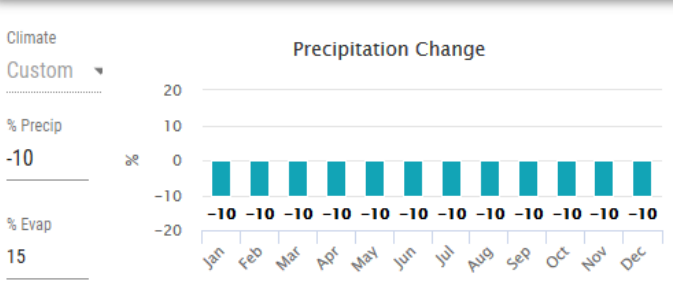
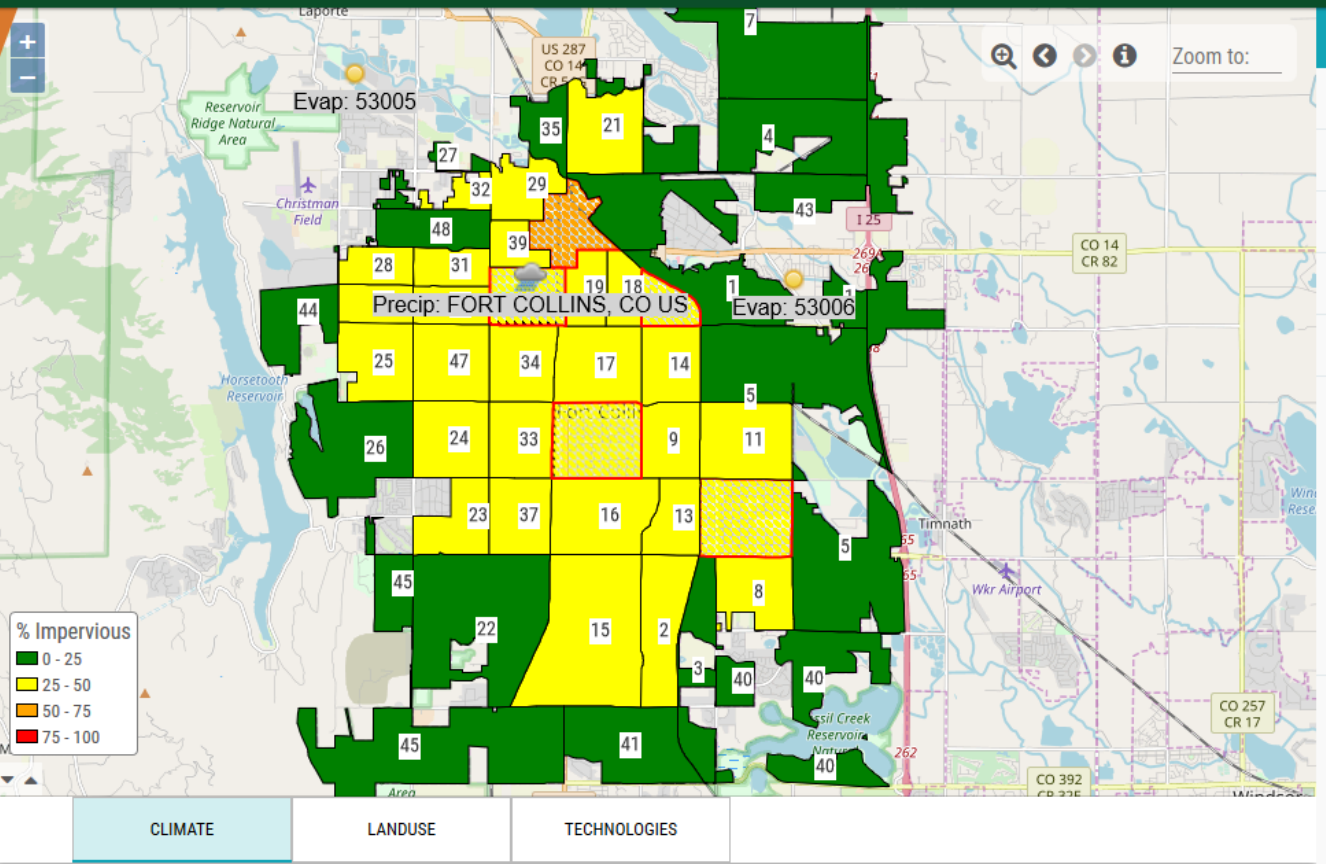
Rain Gardens

Climate

Landuse

Technologies

Rain Gardens-00 (5 / 48)



Scenario Development

Green infrastructure (GI) scenario development

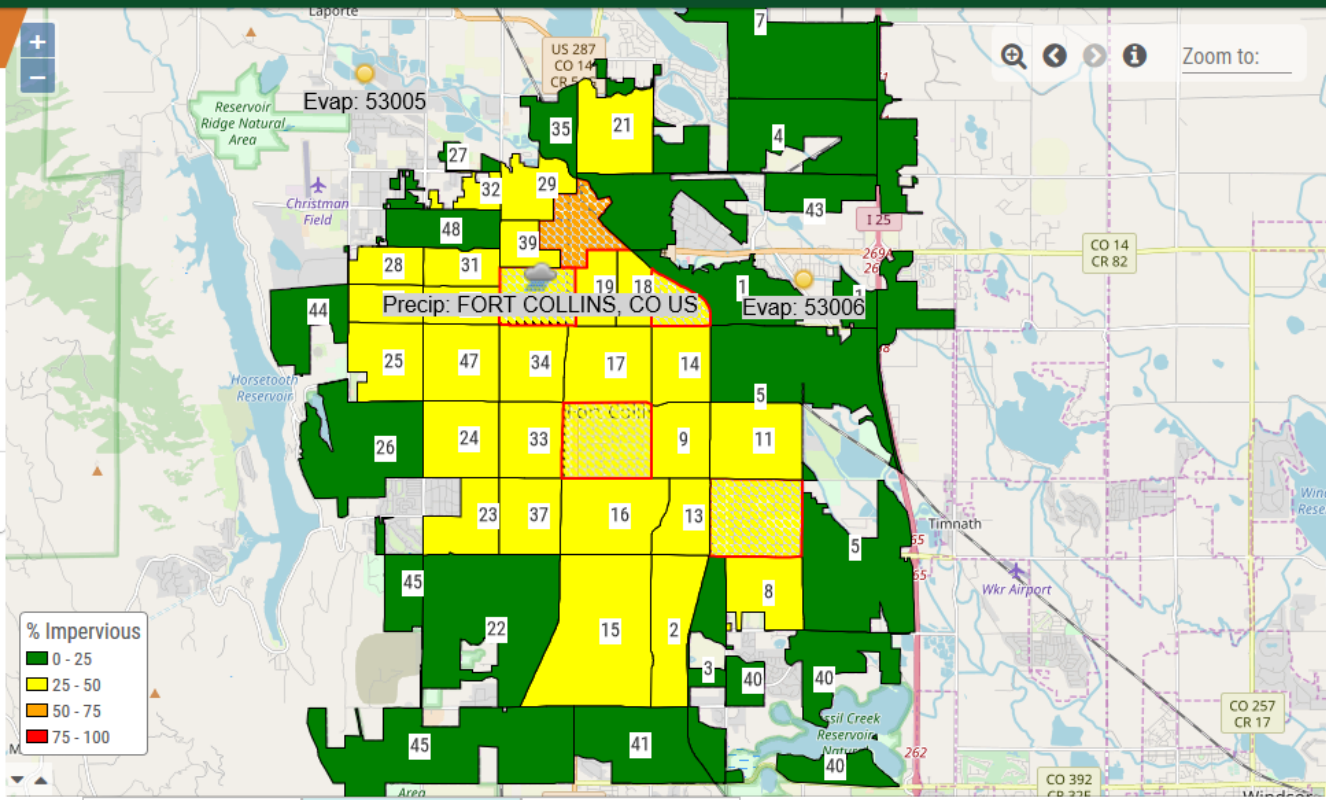
Rain Gardens

Climate

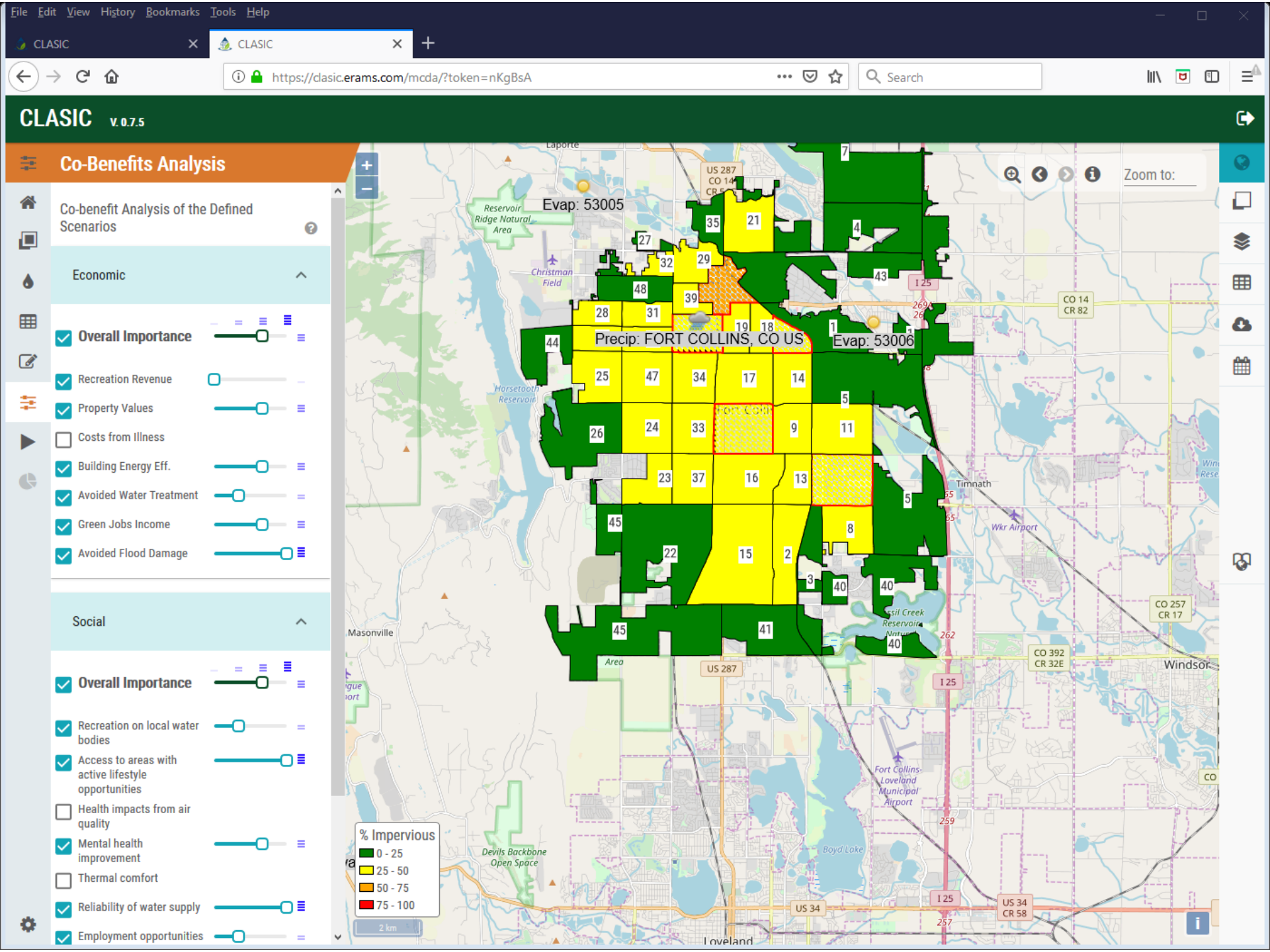
Landuse

Technologies

Rain Gardens-00 (5 / 48)



	CLIMATE	LANDUSE	TECHNOLOGIES				
	subunit_id	Impervious (%)	Open (%)	Low (%)	Medium (%)	High (%)	Other (%)
1	9	7	10	6	2	75	
2	28	33	33	20	2	12	
3	24	7	16	23	4	50	
4	9	6	18	4	0	72	
Previous		Page 1 of 12				Next	



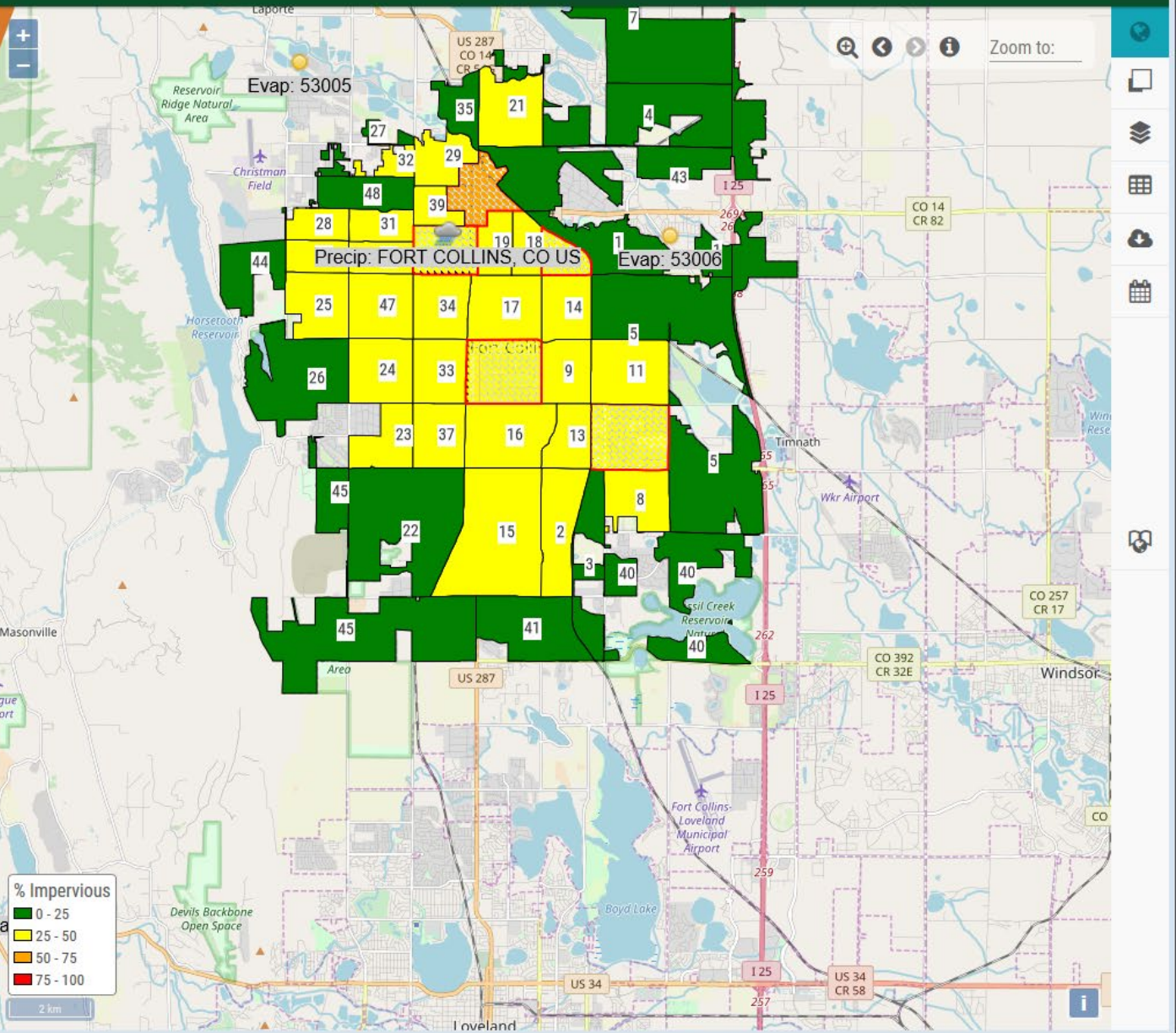
CLASIC V.0.7.5

Run CLASIC

Select Scenarios to Run

- ☒ Baseline
- ☒ Rain Gardens
- ☒ RG + SF

RUN



CLASIC Tool: Project: Example 1 - Results

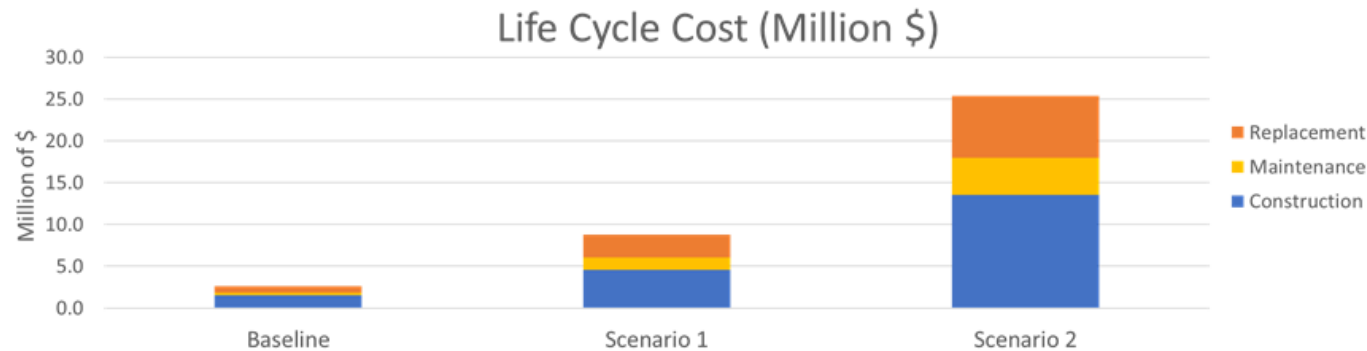
Summary

Cost

Co-Benefit

Hydrologic

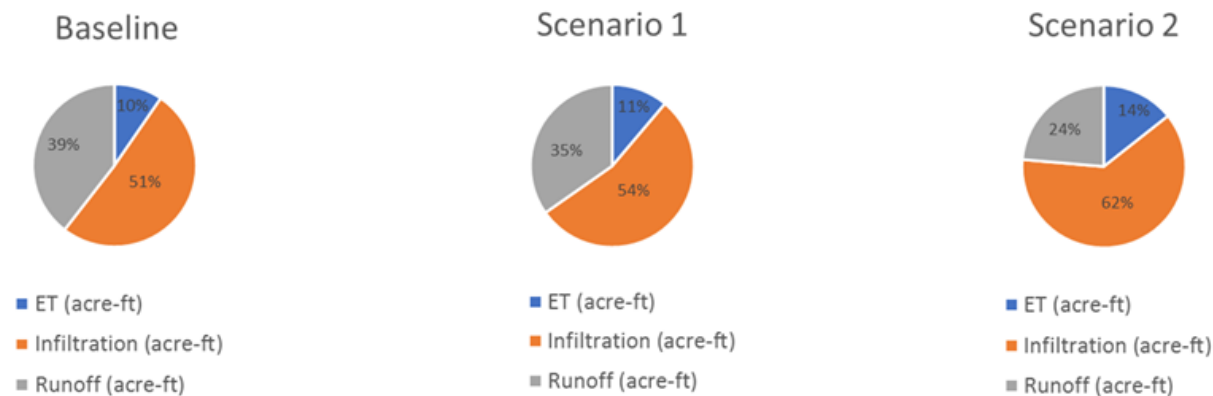
Life-Cycle Cost Analysis Output



Co-Benefit Analysis Output



Hydrologic Performance Output





THE
**Water
Research**
FOUNDATION

Thank you!

