i-Tree Hydro: Applying the Model in Urban Forest and Land Use Planning

2019 Ohio Stormwater Conference

Will Ayersman, GISP
Davey Resource Group, Inc.
5/10/2019

i-Tree is a Cooperative Initiative among these

Presenter Information – Will Ayersman

- Certified Geospatial Professional (2014)
- Bachelors (2008) and Masters (2010) in Forestry from West Virginia University
- Worked as a GIS Analyst at the Natural Resource Analysis Center in Morgantown, WV
- Summer Field Technician for US Forest Service
- Came to Davey Resource Group, Inc in 2011
- Responsible for project coordination of all GIS project work for municipal and vegetation management clients
- Applying i-Tree applications for approximately 6-7 years

Outline

- What is i-Tree Hydro and what does it provide users?
  - Urban vs. natural hydrology
  - Conceptual model used in this tool
- Hydro model options
  - Topography in reality and in the model
  - Weather data
  - Land cover
    - Green Infrastructure
  - Soil parameters and auto-calibration using streamflow data
- Hydro model uses
  - Base and alternative case scenarios
  - Real world examples
  - Recommendations for new users – where to start?
- Use Cases
- Future Developments

The 2019 i-Tree Suite of Tools

Web-based, run in your browser

- i-Tree Landscape
- i-Tree Canopy
- i-Tree Design

Installed on a Windows desktop or laptop

- i-Tree Eco
- i-Tree Streets
- i-Tree Hydro

i-Tree

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DAVEY

Arbor Day Foundation

sma Society of Municipal Arborists

ISA

Casey Trees

ESF State University of New York College of Environmental Science and Forestry

Motivation for i-Tree Hydro

- Motivation: Improve human wellbeing and biodiversity.
- Problem: Urbanization leads to stormwater quantity and quality management problems.
- Goal: Sustainably use tree cover to deliver ecosystem services to urban populations.

Model History for i-Tree Hydro

- Origins from discussions between
  SUNY ESF (Dr. Ted Endreny)
  &
  USDA FS (Dr. David Nowak)

- Wanted to replace curve number based runoff models with a **processed based hydrological model**

St. Elizabeth Hosp. D.C. 2006-2011
Casey Trees

- TOPMODEL -> OBJTOP -> UFORE -> i-Tree Hydro

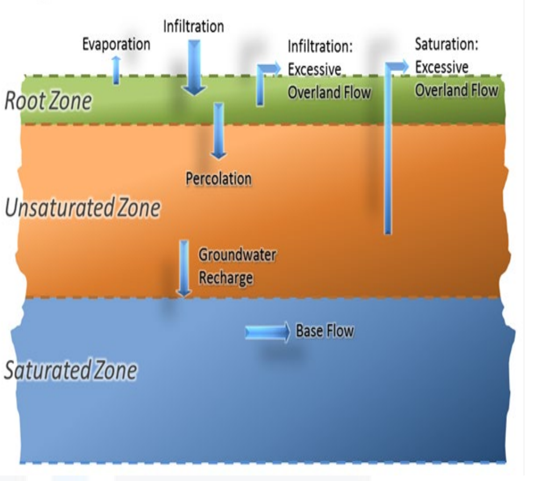
- Designed to be a First Order hydrology model to quantify benefits

- First release was a watershed-only model

i-Tree Hydro User Focused Tool

Watershed scale 1st level analyses

- vegetation and impervious cover effects on hydrology
- Increase/decrease TC
- Increase/decrease IC
- Increase/decrease other landcover/veg. types



Hydro quantifies hourly and total changes

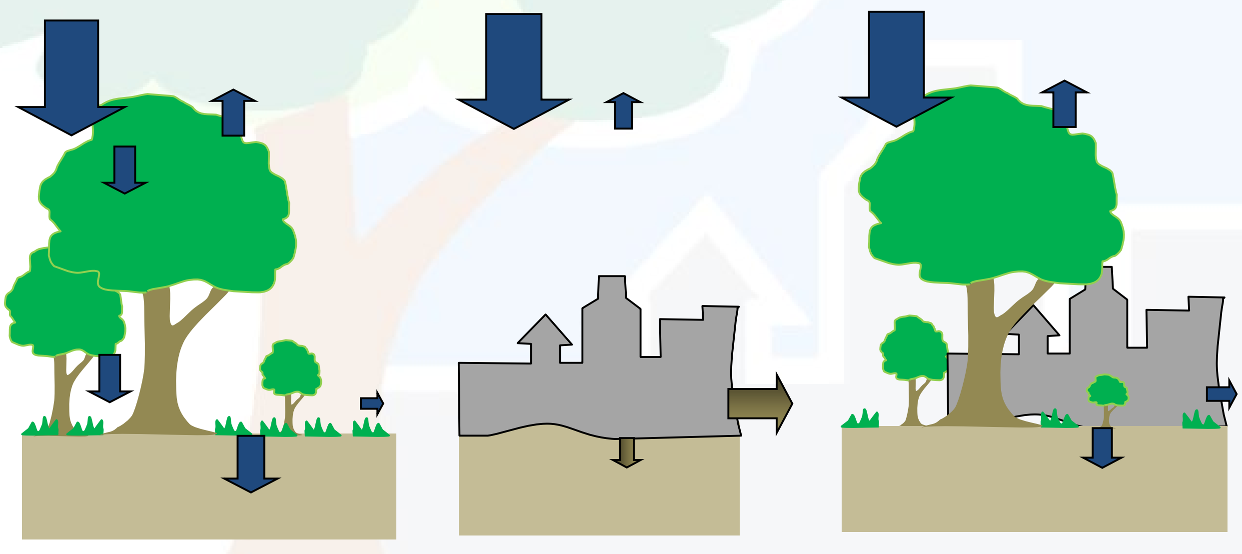
- stream flow, water quality

Great for modeling runoff change from tree canopy levels; water quality data not completely user friendly at this point

i-Tree Hydro

The Basics: Urban vs. Natural Hydrology – Part 1

- Urban areas
  - Less vegetation
  - More directly connected impervious surfaces
  - More soil compaction
- Natural areas
  - More vegetation
  - Less impervious surfaces
  - Less compacted soils higher in organic matter



i-Tree Hydro

The Basics: Urban vs. Natural Hydrology – Part 2

Imagine a rain drop falling into your community,

what might it land on and where would it go next?

Water, tree canopy, pavement, …

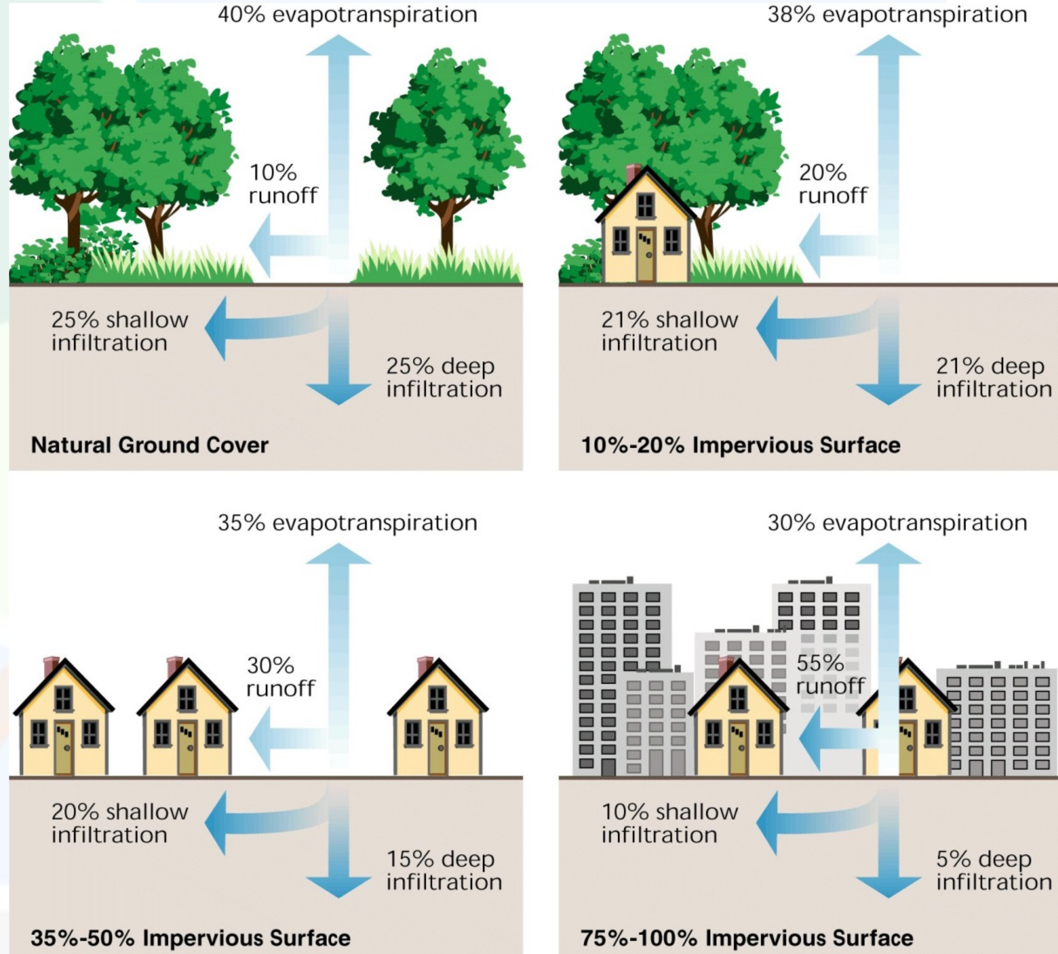


Fig. 3.21 -- Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

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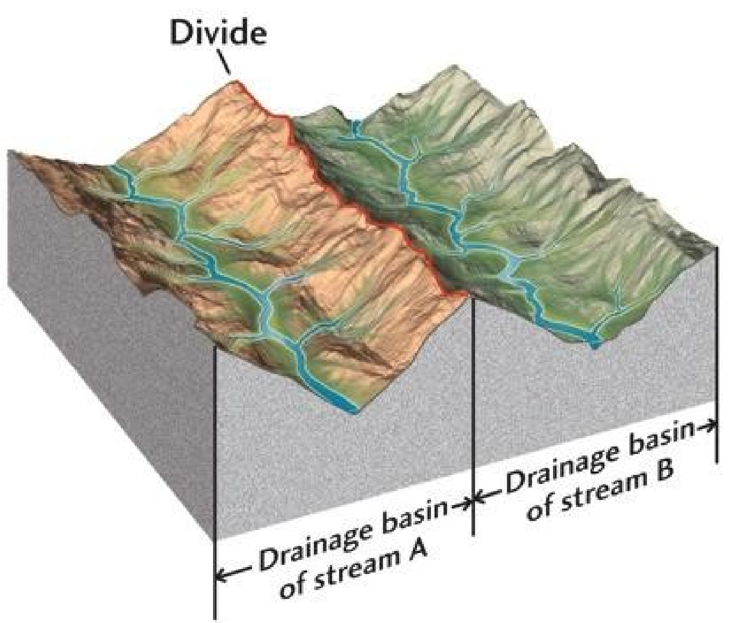
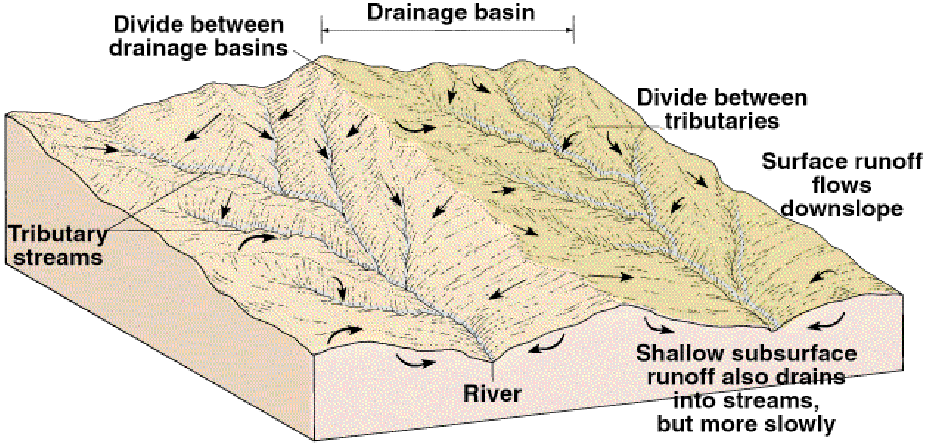
i-Tree Hydro

The Basics: Watersheds

- "A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place."

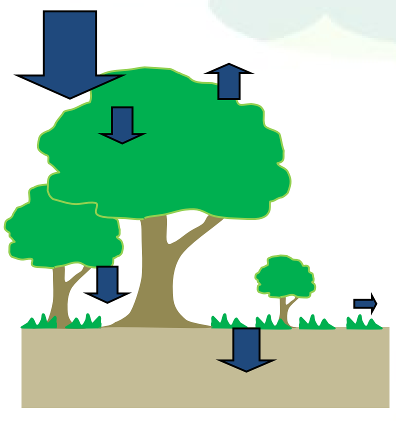


Streams and their Drainage Basins



i-Tree Hydro *Conceptual Model – Basics*

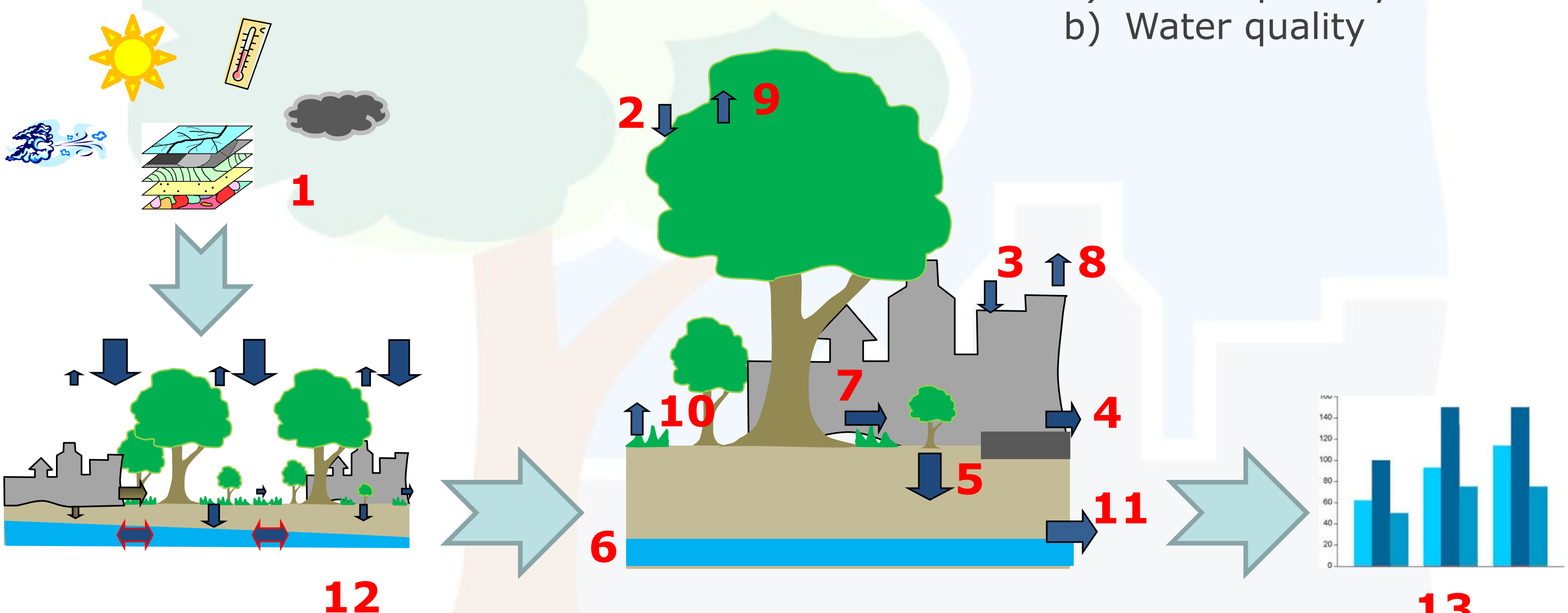
- Rainfall – Runoff model
  - Transformation of rainfall into runoff
    - Effective precipitation -> infiltration -> runoff generation
    - Runoff partitioning - baseflow, overland flow, shallow subsurface flow, impervious runoff, etc.
  - Routing of runoff through watershed / to the outlet
    - Building of the hydrograph, timing of flow arrival



i-Tree Hydro *Conceptual Model – Processes*

1 Inputs
   a) Location
   b) Weather
   c) Land Cover
   d) Topography
   e) Hydrology & Soil

2 Canopy Interception
3 Depression Storage
4 Impervious Runoff
5 Infiltration
6 Soil Moisture
7 Pervious Runoff
8 Surface Evaporation
9 Veg Evaporation
10 Evapo-transpiration
11 Subsurface Runoff
12 Semi-Spatial Distribution
13 Outputs
   a) Water quantity
   b) Water quality



R based on Topographic Index

TOPMODEL Concepts (Beven & Kirby, 1979)

$$q_i = P_w \cdot a_i$$

$$q_i = T_i \cdot tan\beta_i$$

$$T_i = T_o \cdot exp\left({}^{-S_i}/_{m}\right)$$

$$S_i = m\left[ln\left({}^{R}/_{T_o}\right) + ln\left({}^{a_i}/_{tan\beta_i}\right)\right]$$

$$TI_i = ln\left({}^{a_i}/_{tan\beta_i}\right)$$

$$\overline{S} = -m \cdot ln\,{}^{R}/_{T_o} - m \cdot \overline{TI}$$

$$Q_{sub} = T_o \cdot exp(-\overline{TI}) \cdot exp\left(-{}^{\overline{S}}/_{m}\right)$$

- q_i is subsurface discharge (m^2/hr)
- i is pixel element
- P_w is precipitation as recharge (m/hr)
- a_i is local basin area per unit width (m)
- T_i is local transmissivity (m^2/hr)
- $tan\beta_i$ is local tangent of hillslope angle
- T_o is local saturated transmissivity (m^2/hr)
- S_i is local soil moisture deficit (m)
- m is a scaling parameter
- TI is topographic index
- $\overline{S}$, $\overline{TI}$ is basin average values
- Q_{sub} is subsurface flow (m^3/hr)

References for i-Tree Hydro Theory

- Rutter et al. (1975) canopy interception
- Dijk & Bruijnzeel (2001) throughfall
- Huber & Dickinson (1992) depression storage
- Beven (1984), Wang et al. (2006) infiltration
- Noilhan & Planton (1989) canopy evaporation
- Shuttleworth (1993) potential evaporation
- Valeo & Moin (2000) impervious runoff
- Beven & Kirkby (1979) pervious runoff
- Beven & Kirkby (1979) subsurface runoff
- Wang et al. (2006) & Yang et al. (2011) model overview

i-Tree Hydro *Model Inputs – Topography*

Topography of Actual Terrain

↓

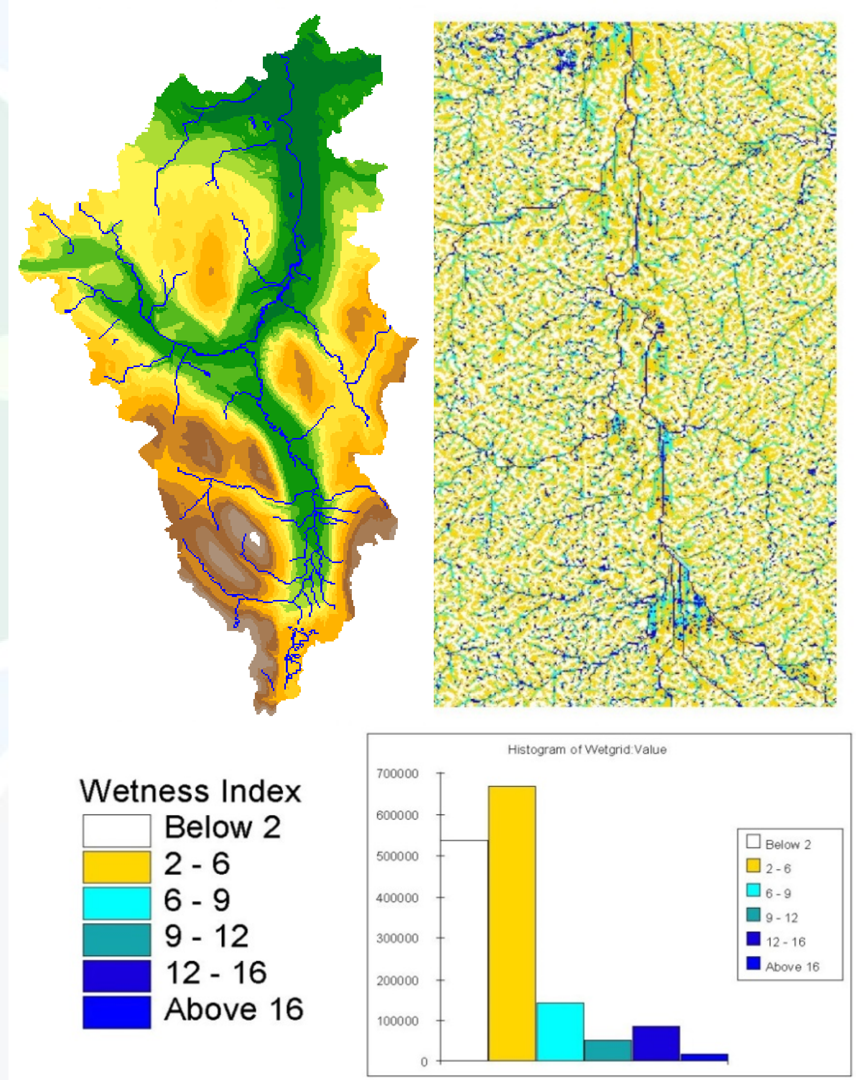
* Digital Elevation Model (DEM)

↓

Topographic Wetness Index (TI)

↓

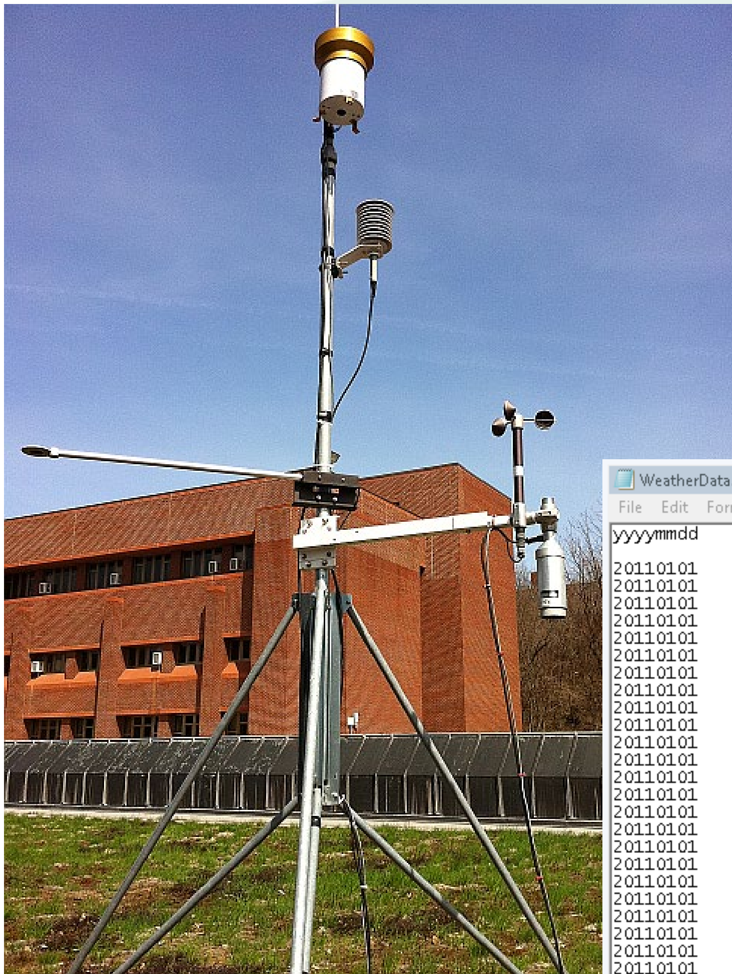
* TI Histogram for Hydro

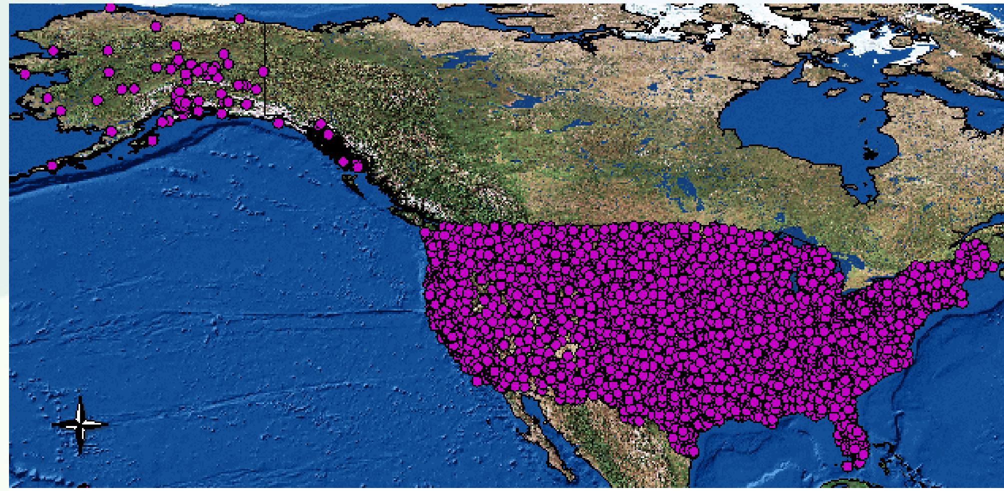


* Input for Hydro topographic data

i-Tree Hydro

Model Inputs – Weather





WeatherData.dat - Notepad

yyyymmdd	Hr:Min:Sec	Tair(F)	Tdew(F)	NetRad(W/m^2)	WndSpd(m/s)	Precip(m/hr)	Snow(m/hr)
20110101	00:00:00	42.70000000	34.90000000	0.00000000	3.44210997	0.00000000	0.00000000
20110101	01:00:00	40.00000000	34.00000000	0.00000000	2.23513634	0.00000000	0.00000000
20110101	02:00:00	42.10000000	34.10000000	0.00000000	3.48681270	0.00000000	0.00000000
20110101	03:00:00	42.90000000	35.00000000	0.00000000	2.68216361	0.00000000	0.00000000
20110101	04:00:00	42.00000000	35.00000000	0.00000000	2.68216361	0.00000000	0.00000000
20110101	05:00:00	36.85000000	36.00000000	0.00000000	0.00000000	0.00025400	0.00000000
20110101	06:00:00	36.76000000	36.00000000	0.00000000	1.01922217	0.00000000	0.00000000
20110101	07:00:00	36.00000000	36.00000000	0.00000000	1.34108181	0.00000000	0.00000000
20110101	08:00:00	35.31578947	35.31578947	12.50021015	0.00000000	0.00000000	0.00000000
20110101	09:00:00	36.00000000	36.00000000	53.31007742	0.44702727	0.00000000	0.00000000
20110101	10:00:00	37.00000000	37.00000000	88.96392811	0.00000000	0.00000000	0.00000000
20110101	11:00:00	47.00000000	41.00000000	180.3095209	2.77156907	0.00000000	0.00000000
20110101	12:00:00	47.20000000	41.10000000	382.4534808	3.48681270	0.00000000	0.00000000
20110101	13:00:00	49.00000000	42.00000000	174.0454807	2.68216361	0.00000000	0.02540000
20110101	14:00:00	49.90000000	42.90000000	131.4296478	3.17389361	0.00000000	0.00000000
20110101	15:00:00	49.00000000	42.00000000	159.7079611	3.71032633	0.00000000	0.00000000
20110101	16:00:00	49.00000000	42.00000000	27.88483690	4.91729996	0.00000000	0.00000000
20110101	17:00:00	46.00000000	41.90000000	0.00000000	3.57621815	0.00000000	0.00000000
20110101	18:00:00	46.30000000	41.10000000	0.00000000	3.63582179	0.00000000	0.00000000
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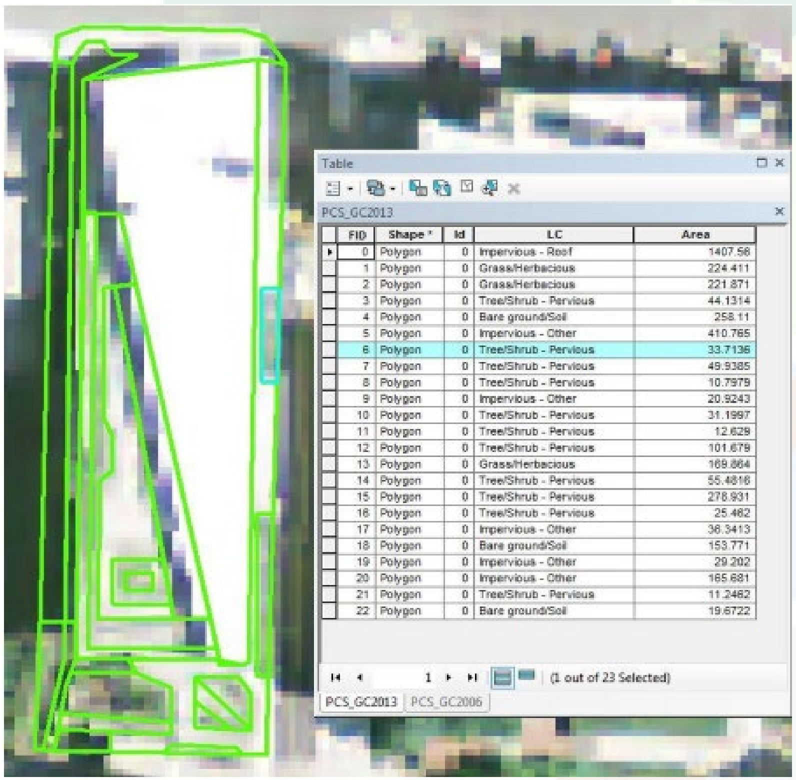
20110101	21:00:00	50.00000000	40.00000000	0.00000000	5.05140814	0.00000000	0.00000000
20110101	22:00:00	50.00000000	40.00000000	0.00000000	6.25838176	0.00000000	0.00000000
20110101	23:00:00	49.00000000	39.00000000	0.00000000	6.79481448	0.00000000	0.00000000
20110102	00:00:00	48.90000000	39.10000000	0.00000000	7.42065266	0.00000000	0.02540000
20110102	01:00:00	48.00000000	40.00000000	0.00000000	5.81135449	0.00000000	0.02540000

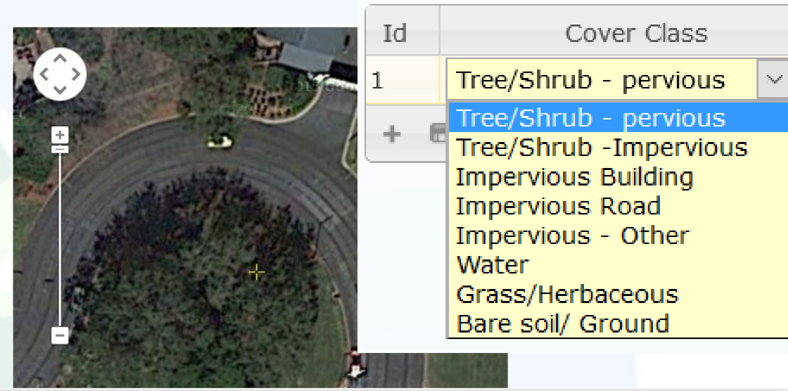
i-Tree Hydro

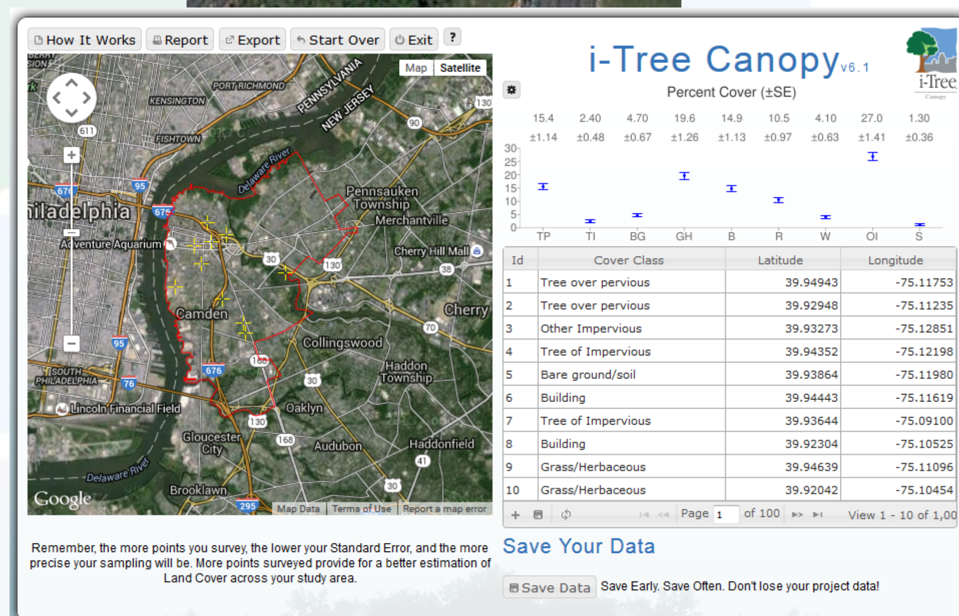
Model Inputs – Land Cover 1 - Sources

GIS, blueprints,
or the most popular approach:
i-Tree Canopy



FID	Shape *	Id	LC	Area
0	Polygon	0	Impervious - Roof	1407.58
1	Polygon	0	Grass/Herbacious	224.411
2	Polygon	0	Grass/Herbacious	221.871
3	Polygon	0	Tree/Shrub - Pervious	44.1314
4	Polygon	0	Bare ground/Soil	258.11
5	Polygon	0	Impervious - Other	410.765
6	Polygon	0	Tree/Shrub - Pervious	33.7136
7	Polygon	0	Tree/Shrub - Pervious	49.9385
8	Polygon	0	Tree/Shrub - Pervious	10.7979
9	Polygon	0	Impervious - Other	20.9243
10	Polygon	0	Tree/Shrub - Pervious	31.1997
11	Polygon	0	Tree/Shrub - Pervious	12.629
12	Polygon	0	Tree/Shrub - Pervious	101.679
13	Polygon	0	Grass/Herbacious	169.864
14	Polygon	0	Tree/Shrub - Pervious	55.4816
15	Polygon	0	Tree/Shrub - Pervious	278.931
16	Polygon	0	Tree/Shrub - Pervious	25.482
17	Polygon	0	Impervious - Other	38.3413
18	Polygon	0	Bare ground/Soil	153.771
19	Polygon	0	Impervious - Other	29.202
20	Polygon	0	Impervious - Other	165.681
21	Polygon	0	Tree/Shrub - Pervious	11.2462
22	Polygon	0	Bare ground/Soil	19.6722





Id	Cover Class	Latitude	Longitude
1	Tree over pervious	39.94943	-75.11753
2	Tree over pervious	39.92948	-75.11235
3	Other Impervious	39.93273	-75.12851
4	Tree of Impervious	39.94352	-75.12198
5	Bare ground/soil	39.93864	-75.11980
6	Building	39.94443	-75.11619
7	Tree of Impervious	39.93644	-75.09100
8	Building	39.92304	-75.10525
9	Grass/Herbaceous	39.94639	-75.11096
10	Grass/Herbaceous	39.92042	-75.10454

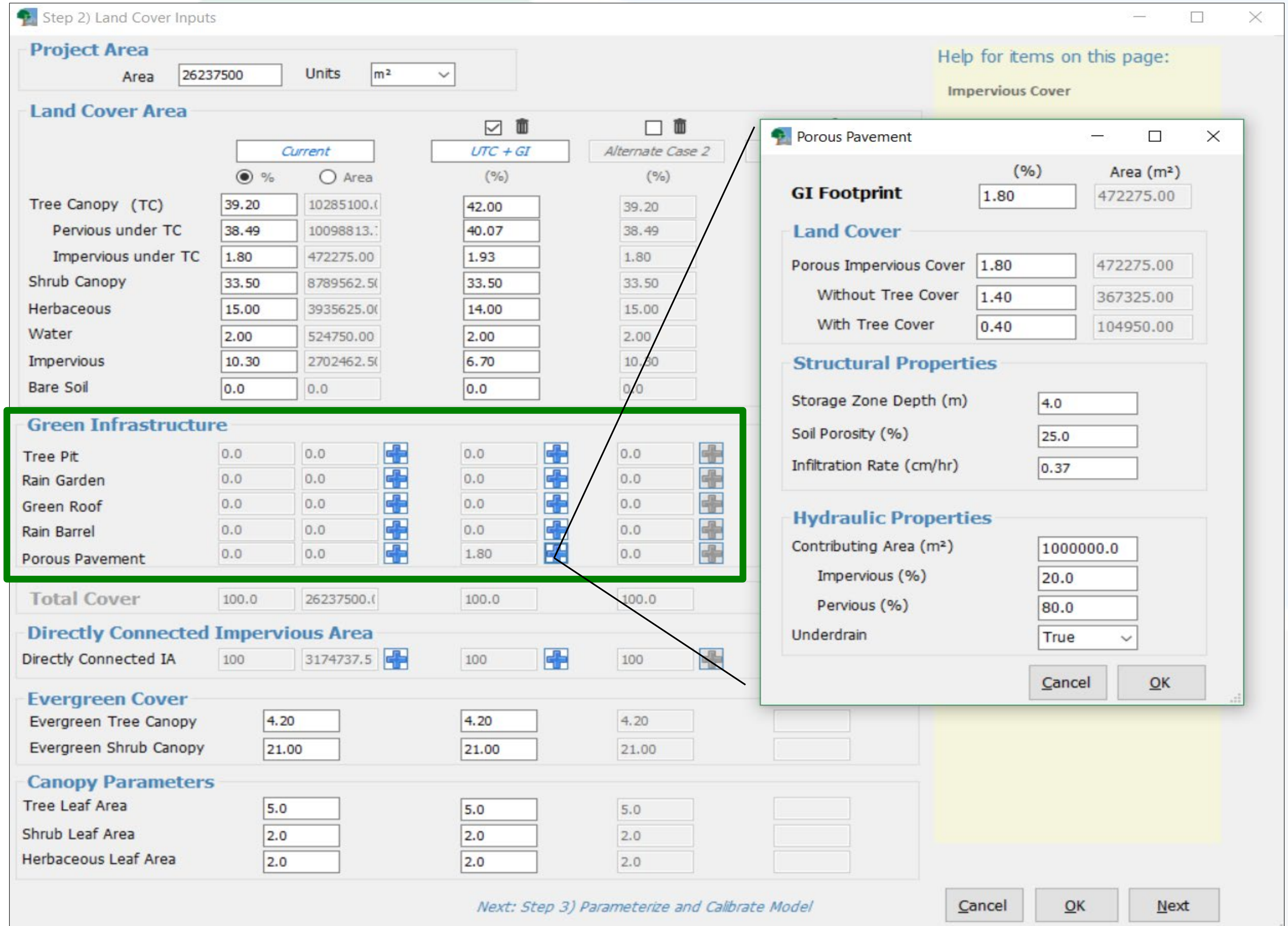
i-Tree Hydro

Model Inputs – Land Cover 2 – Variables

- Land Cover
  - 5 main cover classes
    1. Bare Soil
    2. Shrub/Grass/Herbaceous (Short Vegetation)
    3. Impervious Surface
    4. Tree Cover over Impervious Area
    5. Tree Cover over Pervious Area

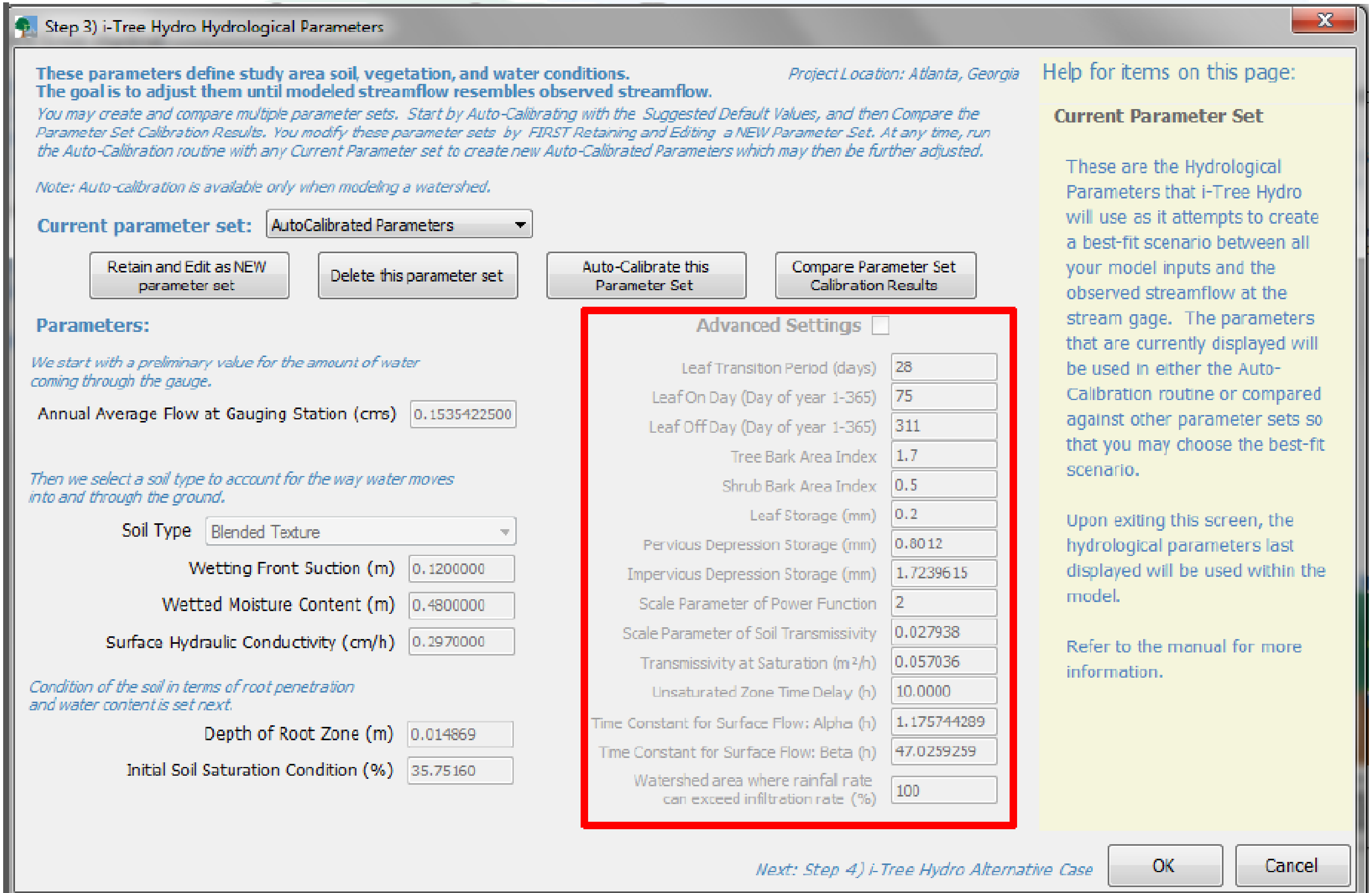
i-Tree Canopy survey
for photo-interpretation of i-Tree Hydro's land cover inputs

i-Tree Hydro *Model Inputs – Green Infrastructure*



i-Tree is a Cooperative Initiative among these

i-Tree Hydro *Model Inputs – Hydrologic Parameters*

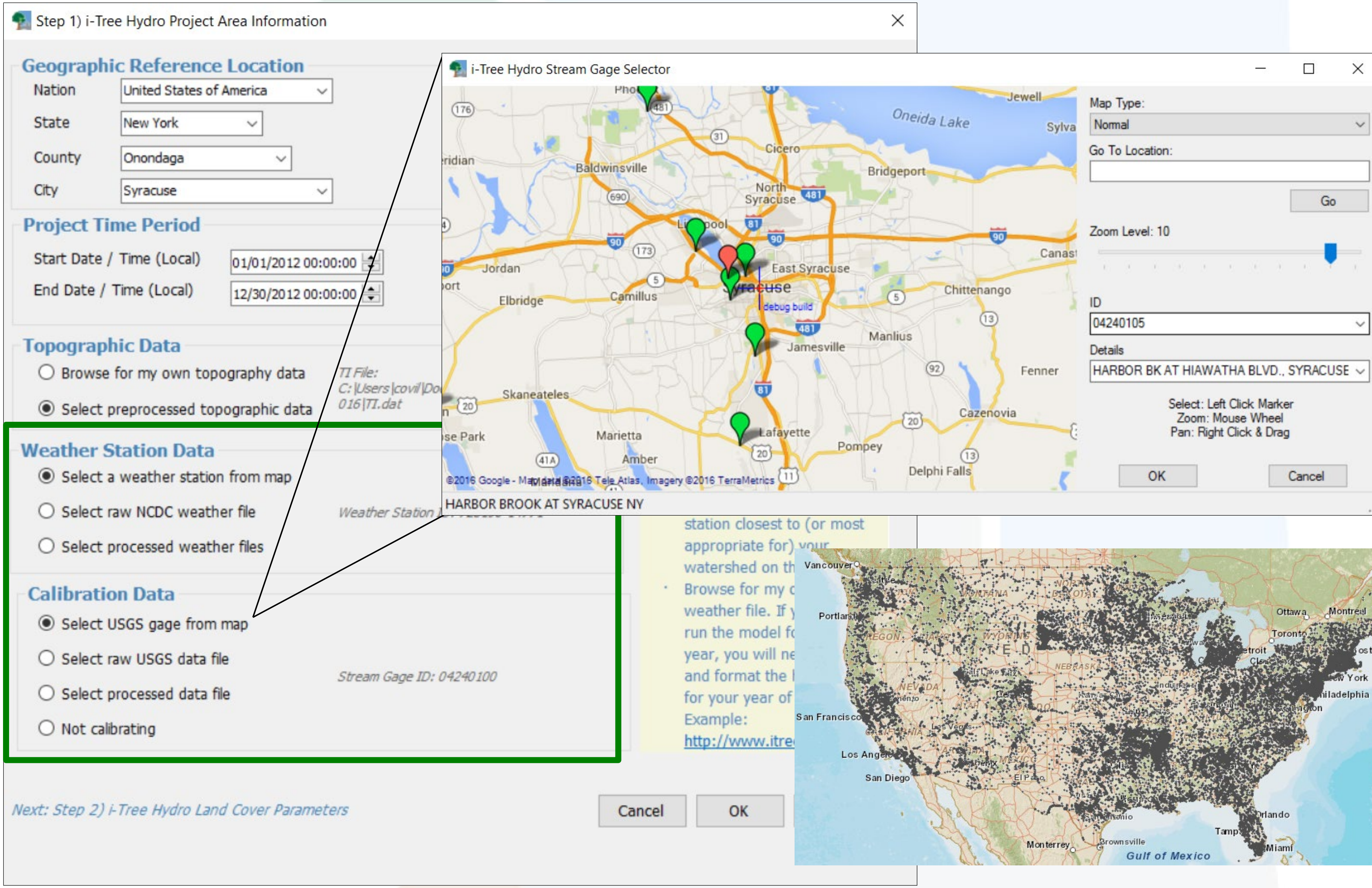


i-Tree is a Cooperative Initiative among these

i-Tree Hydro *Model Inputs – Calibration 1*

- Calibration
  - Purpose:
    - Soil parameters based on accessible field observations
    - Increases accuracy of absolute value estimates
  - Method:
    - Model optimization algorithm
    - Repeated model runs
      Comparing predicted and observed values
    - Maximize goodness-of-fit metrics
  - Problems:
    - Equifinality – Different parameter sets, same optimum
    - Disagreement between field data and model parameters

i-Tree Hydro *Model Inputs – Calibration 2*



i-Tree Hydro *Model Inputs – Calibration 3*

Parameter Calibration Results

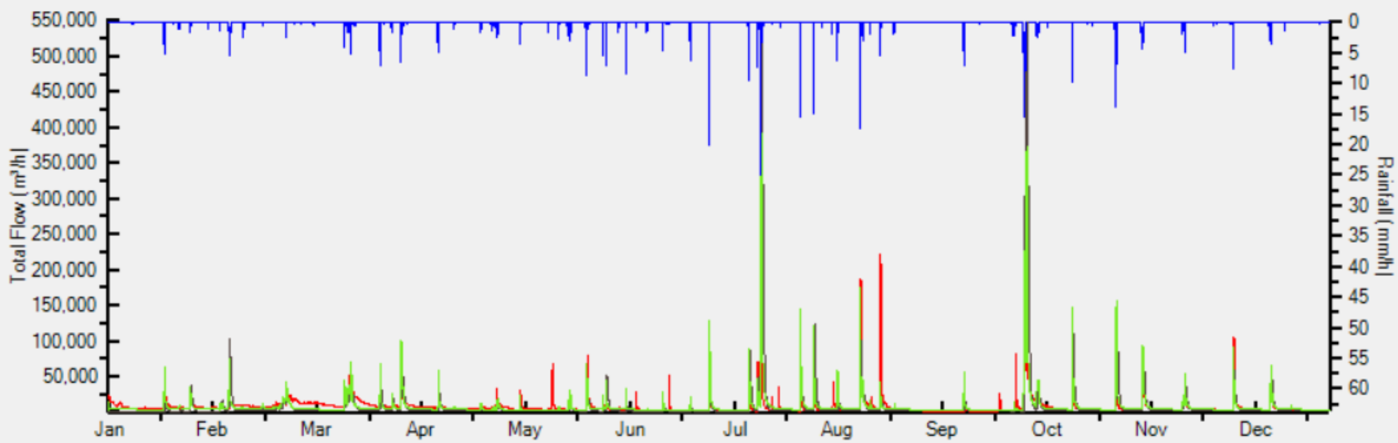
Weekly Model Calibration Results

Enabled	Name	Volumetric Efficiency	Peak Flow Fit	Base Flow Fit	Balanced Flow Fit	Color
☑	Observed Discharge	N/A	N/A	N/A	N/A	(red)
☑	Rainfall	N/A	N/A	N/A	N/A	(blue)
☑	Suggested Default Values	0.314493	-1.58279	-0.247392	-0.451646	(dark brown)
☑	AutoCalibrated Parameters	0.582123	0.211887	0.239605	0.372056	(green)

The Peak Flow, Base Flow, and Balanced Flow calibration metrics are a measure of how well the predicted flow matches the flow observed at the gaging station. These values range from negative infinity to 1.0. A value of 1.0 indicates a perfect match between the predicted and observed streamflow. A value of 0.0 indicates the predictions are no better at matching the observations than using the average observed streamflow. Negative values indicate the predictions are worse than using the average observed streamflow. Typically "good" calibration metrics range from 0.3 to 0.7, with higher values being better. Sources: Peak Flow Metric - Nash and Sutcliffe, 1970; Base Flow Metric - Ye et al., 1997; Balanced Flow Metric

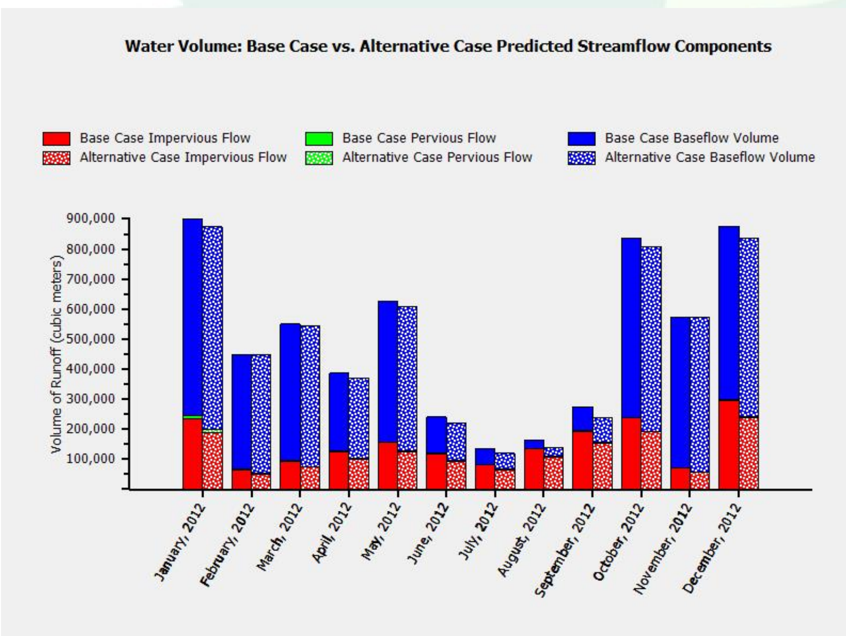
Show Graph

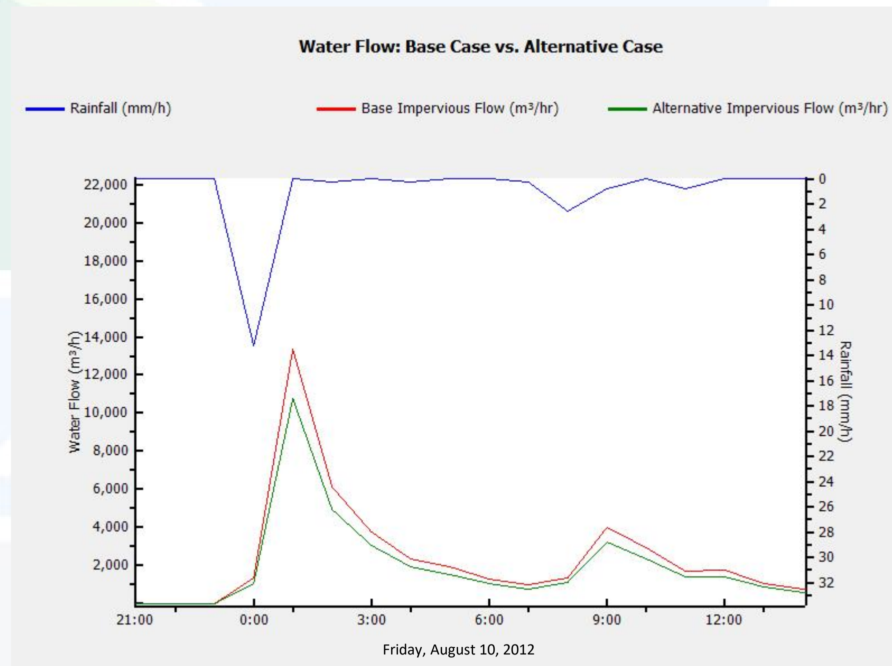
Export JPG



Outputs

- Water Quantity Outputs
  - Predicted streamflow vs. observed (if available)
  - Yearly, monthly, weekly, daily bar-graphs
  - Hourly time-series chart & table with export options



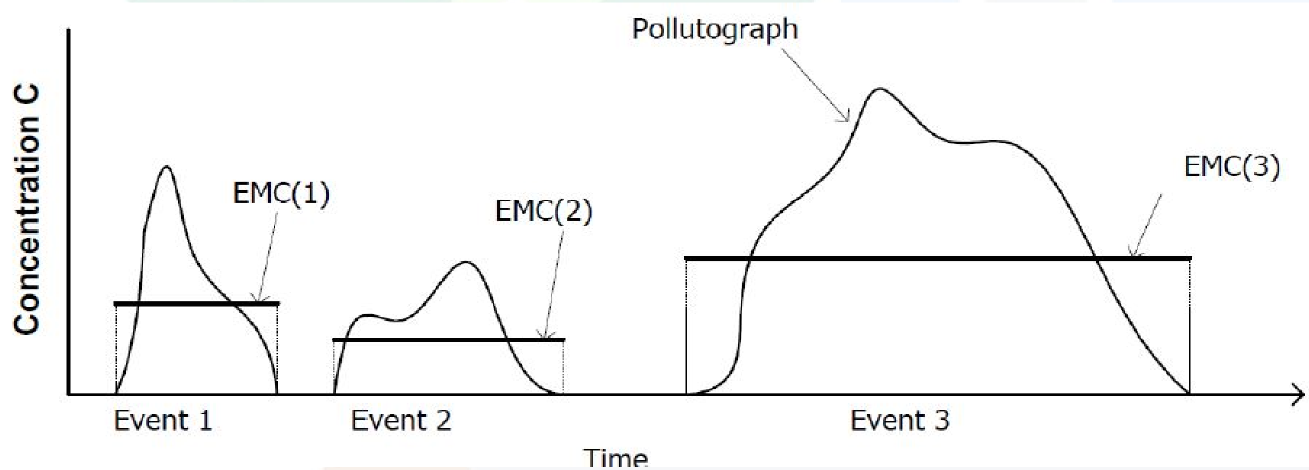


Exported Figures from i-Tree Hydro's Sample Project

i-Tree is a Cooperative Initiative among these

Outputs

- Water Quality Outputs
  - Pollution – Loading estimates
    - Total pollutant mass
    - Based on EMC values
      - nationwide defaults from EPA's NURP data
      - Localized values for TN, TP, and TSS available soon
    - Available in same formats as water quantity outputs



Common Research Questions

- How will that affect our storm water runoff if I increase canopy by/to "X" percent?
- What happens if we lose tree canopy?
- How do these scenarios affect our costs?
- Does it improve our water quality?

Past Projects and Applications

- Current Stormwater Assessment
- Avoided Runoff Modeling
- Stormwater Pollutant Uptake

Previous Projects:

Sacramento, CA	Cleveland, OH	Holyoke, MA
Edmonds, WA	Columbia, MO	Oakland, CA
Tallahassee, FL	East Lansing, MI	Ferndale, MI
Tulsa County, OK	Golden, CO	Lawrenceburg, IN
Louisville, KY	Plano, TX	Patterson, CA
Woodland, CA	Largo, FL	Oklahoma City, OK

i-Tree Hydro Stormwater Report

i-Tree Hydro Executive Summary

Project Location: Woodland, California
Project Time Span: 01/01/2009 - 12/30/2009

Model Parameters

Watershed Area *square kilometers*	Rainfall *millimeters*	Total Runoff *cubic meters*	Stream Gage	Weather Station
38.95	393.70	7,557,632.91	0	724839-93225

Land Cover	Base	Alternative		Base	Alternative	LC beneath Tree Cover	Base	Alternative
Tree Cover %	14.5	0.0	Tree LAI	4.7	4.7	Soil Cover %	95.0	95.0
Shrub Cover %	0.0	0.0	Shrub LAI	2.2	2.2	Impervious Cover %	5.0	5.0
Herbaceous Cover %	7.3	21.1	Herbaceous LAI	1.6	1.6			
Water Cover %	2.7	2.7	Directly Connected Impervious Cover (%)	65.0	65.0			
Impervious Cover %	46.8	47.5						
Soil Cover %	28.7	28.7						

Streamflow Predictions

	Total Runoff		Baseflow		Pervious Flow		Impervious Flow	
	Base	Alternative	Base	Alternative	Base	Alternative	Base	Alternative
Total Flow (cubic meters)	7,557,632.9	7,601,149.1	26,587.9	26,603.4	3,185,669.6	3,224,900.8	4,345,375.5	4,349,644.8
Highest Flow (cubic meters / hour)	306,383.5	306,338.3	4.5	4.5	183,068.5	183,075.5	123,311.9	123,259.7
Lowest Flow (cubic meters / hour)	2.7	2.7	2.7	2.7	0.0	0.0	0.0	0.0
Highest Flow Date	03/03/09	03/03/09	01/01/09	01/01/09	03/03/09	03/03/09	03/03/09	03/03/09
Lowest Flow Date	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09
Median Flow (cubic meters / hour)	3.1	3.1	3.1	3.1	0.0	0.0	0.0	0.0
Number of flow events ABOVE median flow	9.0	9.0	4.0	4.0	13.0	13.0	12.0	12.0
Average length of flow events with flow ABOVE median (hours)	485.6	485.6	1,299.7	1,299.3	204.6	205.6	213.6	213.6
High Flow: Number of flow events ABOVE 1 standard deviation	8.0	8.0	1.0	1.0	6.0	6.0	12.0	12.0
Average length of flow events ABOVE 1 standard deviation (hours)	554.7	554.7	2.0	2.0	271.8	273.7	213.6	213.6
Number of flow events BELOW median flow	8.0	8.0	3.0	3.0	0.0	0.0	0.0	0.0
Average length of events BELOW median (hours)	546.0	546.0	1,456.0	1,456.0	0.0	0.0	0.0	0.0

i-Tree Hydro: Determining Cost Savings Avoided Runoff

i-Tree Hydro Executive Summary

Project Location: Woodland, California
Project Time Span: 01/01/2009 - 12/30/2009

Model Parameters

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38.95	393.70	7,557,632.91	0	724839-93225

Land Cover	*Base*	*Alternative*		*Base*	*Alternative*	LC beneath Tree Cover	*Base*	*Alternative*
Tree Cover %	14.5	0.0	Tree LAI	4.7	4.7	Soil Cover %	95.0	95.0
Shrub Cover %	0.0	0.0	Shrub LAI	2.2	2.2	Impervious Cover %	5.0	5.0
Herbaceous Cover %	7.3	21.1	Herbaceous LAI	1.6	1.6			
Water Cover %	2.7	2.7						
Impervious Cover %	46.8	47.5	Directly Connected Impervious Cover (%)	65.0	65.0			
Soil Cover %	28.7	28.7						

Streamflow Predictions

	Total Runoff		Baseflow		Pervious Flow		Impervious Flow	
	Base	*Alternative*	*Base*	*Alternative*	*Base*	*Alternative*	*Base*	*Alternative*
Total Flow (cubic meters)	7,557,632.9	7,601,149.1	26,587.9	26,603.4	3,185,669.6	3,224,900.8	4,345,375.5	4,349,644.8
Highest Flow (cubic meters / hour)	306,383.5	306,338.3	4.5	4.5	183,068.5	183,075.5	123,311.9	123,259.7
Lowest Flow (cubic meters / hour)	2.7	2.7	2.7	2.7	0.0	0.0	0.0	0.0
Highest Flow Date	03/03/09	03/03/09	01/01/09	01/01/09	03/03/09	03/03/09	03/03/09	03/03/09
Lowest Flow Date	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09	01/01/09
Median Flow (cubic meters / hour)	3.1	3.1	3.1	3.1	0.0	0.0	0.0	0.0
Number of flow events ABOVE median flow	9.0	9.0	4.0	4.0	13.0	13.0	12.0	12.0
Average length of flow events with flow ABOVE median (hours)	485.6	485.6	1,299.7	1,299.3	204.6	205.6	213.6	213.6
High Flow: Number of flow events ABOVE 1 standard deviation	8.0	8.0	1.0	1.0	6.0	6.0	12.0	12.0
Average length of flow events ABOVE 1 standard deviation (hours)	554.7	554.7	2.0	2.0	271.8	273.7	213.6	213.6
Number of flow events BELOW median flow	8.0	8.0	3.0	3.0	0.0	0.0	0.0	0.0
Average length of events BELOW median (hours)	546.0	546.0	1,456.0	1,456.0	0.0	0.0	0.0	0.0

i-Tree Hydro: Determining Cost Savings Avoided Runoff

Avoided Stormwater Runoff from 2005 to 2012

Canopy Percentage = 14.49

Year	Rainfall (mm)	Total Runoff (m^3)	Avoided Runoff (m^3)
2005	481	9,575,003	52,987
2006	419	5,230,958	43,859
2007	251	3,953,566	30,668
2008	332	6,872,335	38,141
2009	394	7,557,633	43,516
2010	529	10,748,824	111,172
2011	396	7,060,042	84,091
2012	482	10,035,877	57,530
Average	410	7,629,280	57,745

Canopy Percentage =	14.49
Canopy Acres =	1394.38
Storm Water Cost =	0.008
Total Reduction	57,745
Total Gallons	15,254,700
Gallons per Acre	10,940
Stormwater Contribution	$122,038

Avoided Pollutant Runoff (in pounds) from Tree Canopy

Year	Mean Concentration	Total Suspended Solids	Biochemical Oxygen Demand	Chemical Oxyg[illegible] Demand					
2005	Median	6,365	1,343	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Mean	9,156	1,647	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2006	Median	5,269	1,112	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Mean	7,579	1,363	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2007	Median	3,683	777	3,020	18	7	99	22	7,627
	Mean	5,298	953	3,568	21	9	117	61	10,027
2008	Median	4,580	967	3,757	22	9	124	61	9,519
	Mean	6,589	1,185	4,438	26	11	145	76	12,471
2009	Median	5,227	1,103	4,287	25	10	141	69	10,861
	Mean	7,518	1,352	5,063	30	12	166	86	14,229
2010	Median	13,355	2,818	10,954	63	25	360	177	27,753
	Mean	19,212	3,455	12,939	77	32	424	221	36,359
2011	Median	10,102	2,132	8,286	48	19	272	134	20,993
	Mean	14,532	2,614	9,787	58	24	321	167	27,503
2012	Median	6,911	1,458	5,668	33	13	186	92	14,361
	Mean	9,940	1,788	6,695	40	16	219	114	18,813
Average	**Median**	**6,936**	**1,464**	**5,689**	**33**	**13**	**187**	**89**	**14,411**
	Mean	**9,978**	**1,795**	**6,720**	**40**	**16**	**220**	**115**	**18,884**

Other Use Cases

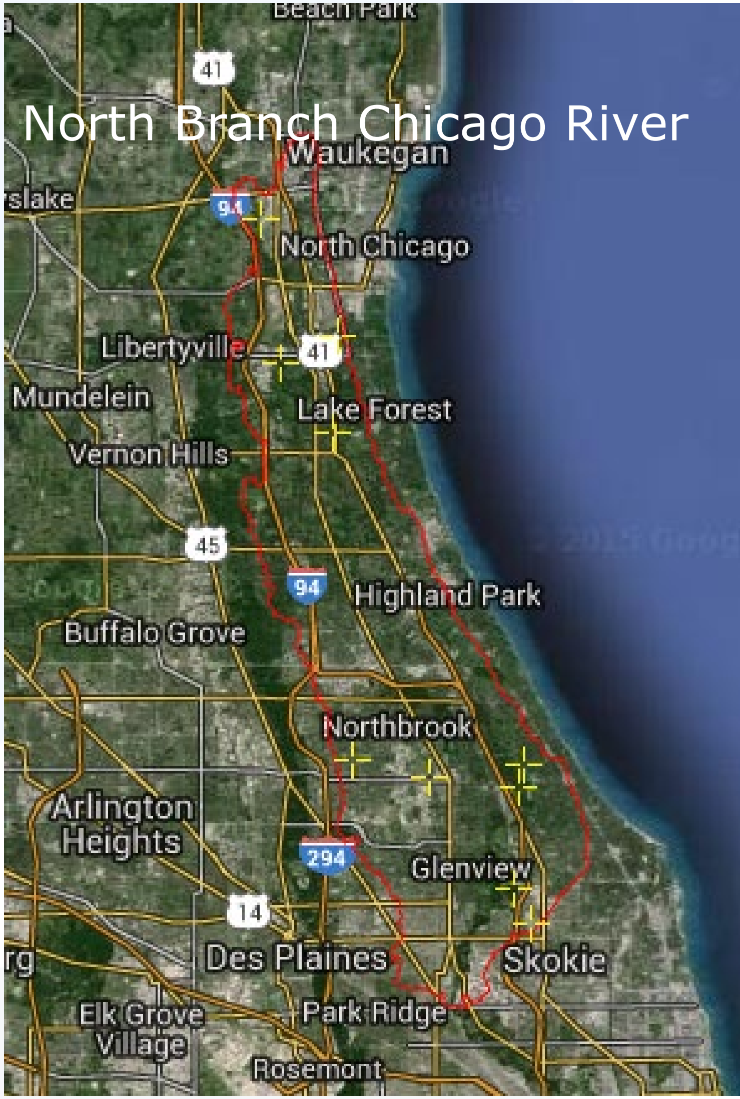
i-Tree Hydro Watershed Parameters

Pre-loaded inputs

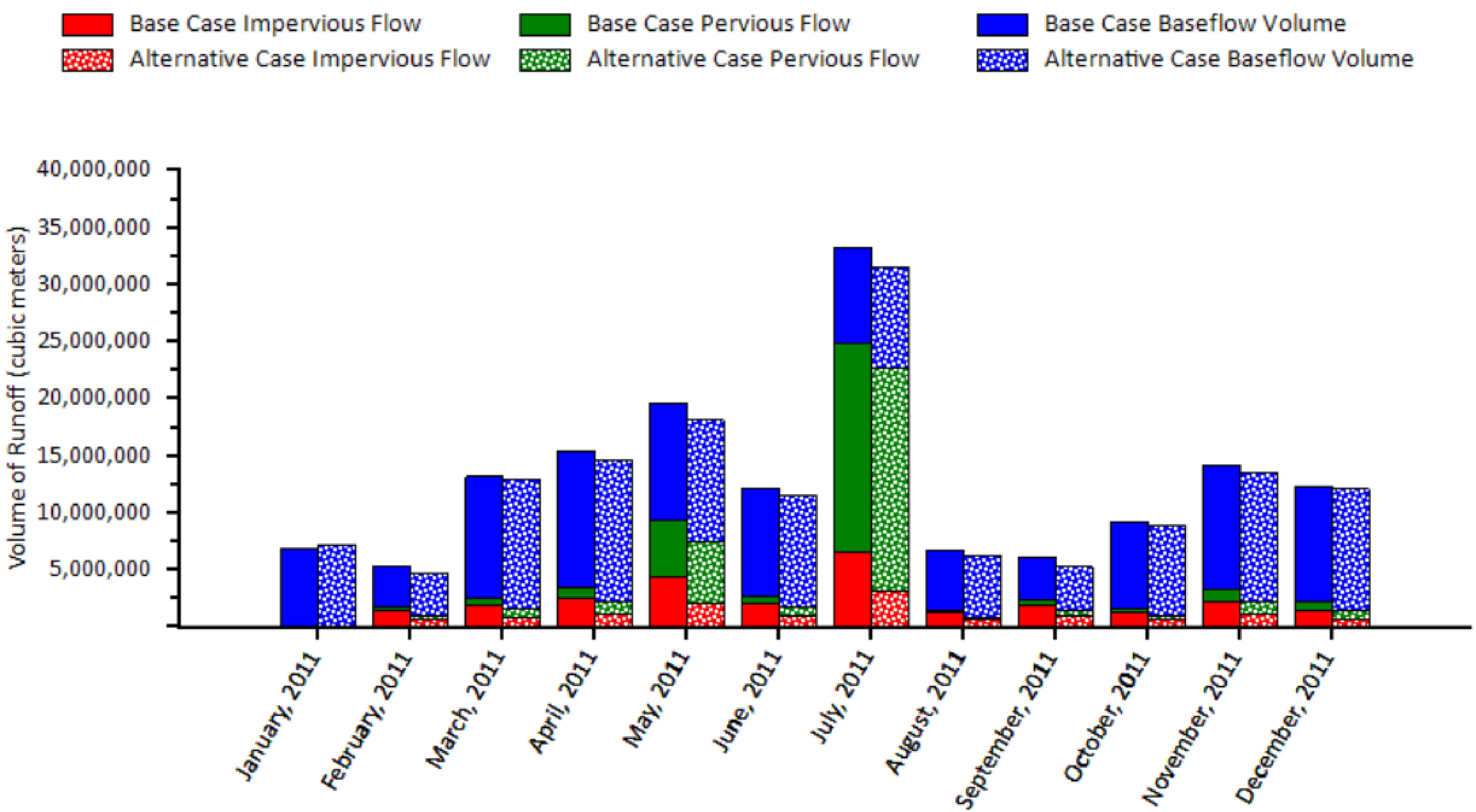
- Watershed area: 254.8 km^2
- USGS stream gauge data/Calibration Data
- Weather station: CHICAGO/O'HARE

User supplied inputs

- Time period of interest (2005-2012)
- Relative cover
  Tree, pervious, impervious, shrub, herbaceous, water, soil
- Directly connected impervious area
- Leaf area index
- DEM
- Alternative scenario

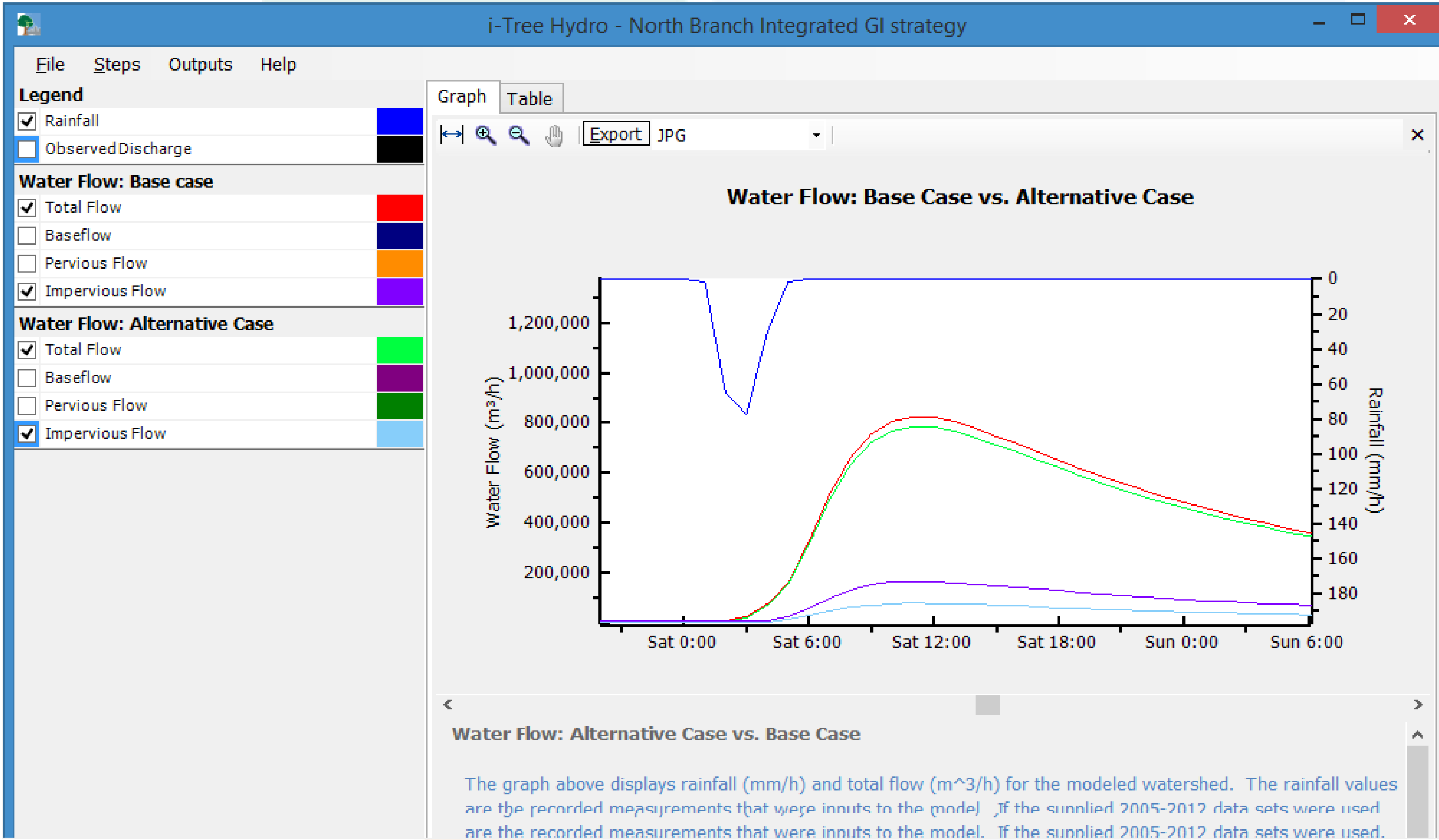


Watershed example output: Base vs Alternative, monthly timestep



i-Tree is a Cooperative Initiative among these

Watershed example output:
Base vs Alternative, hourly timestep



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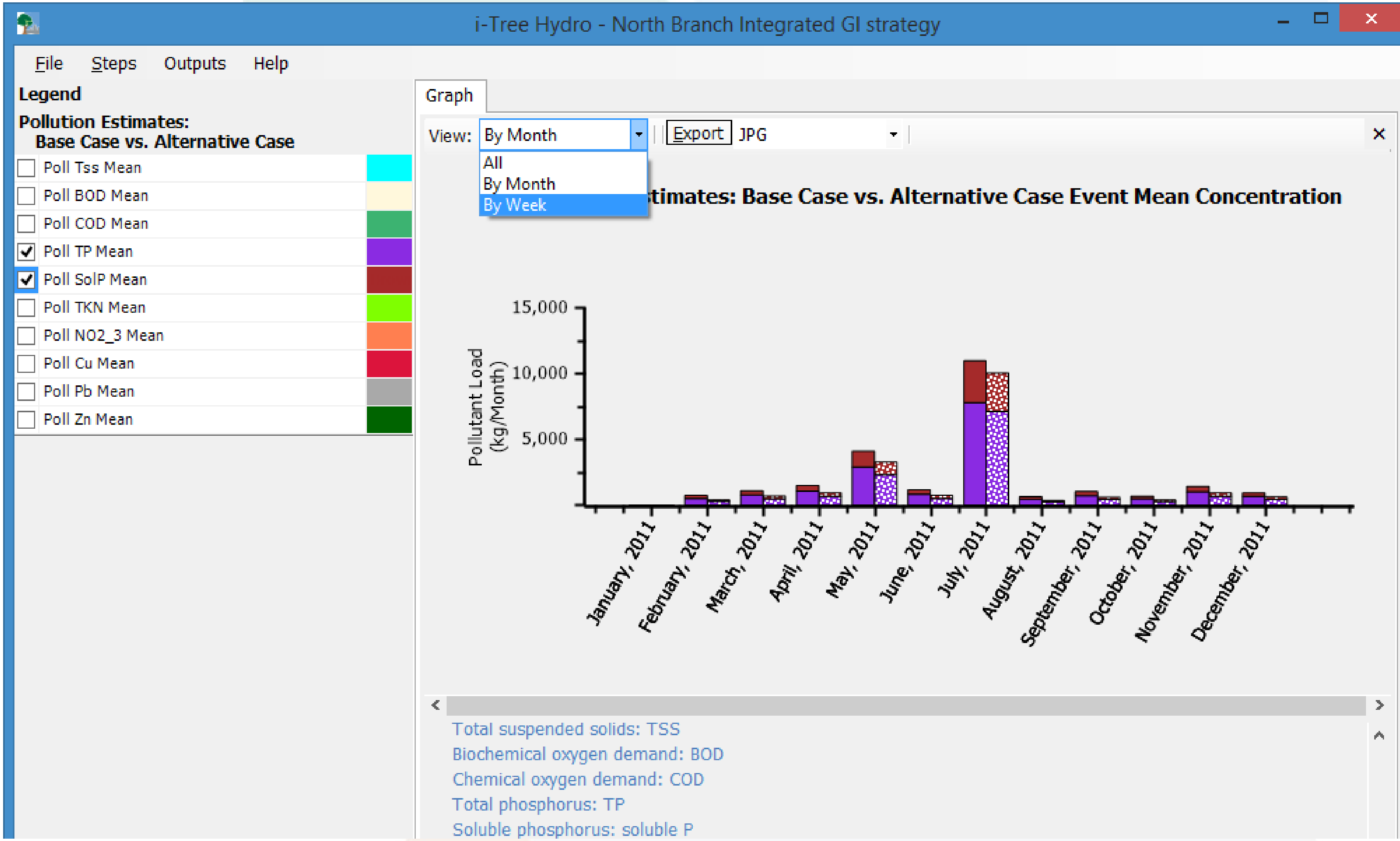
Watershed example output:
Pollutant Estimate Base vs Alternative



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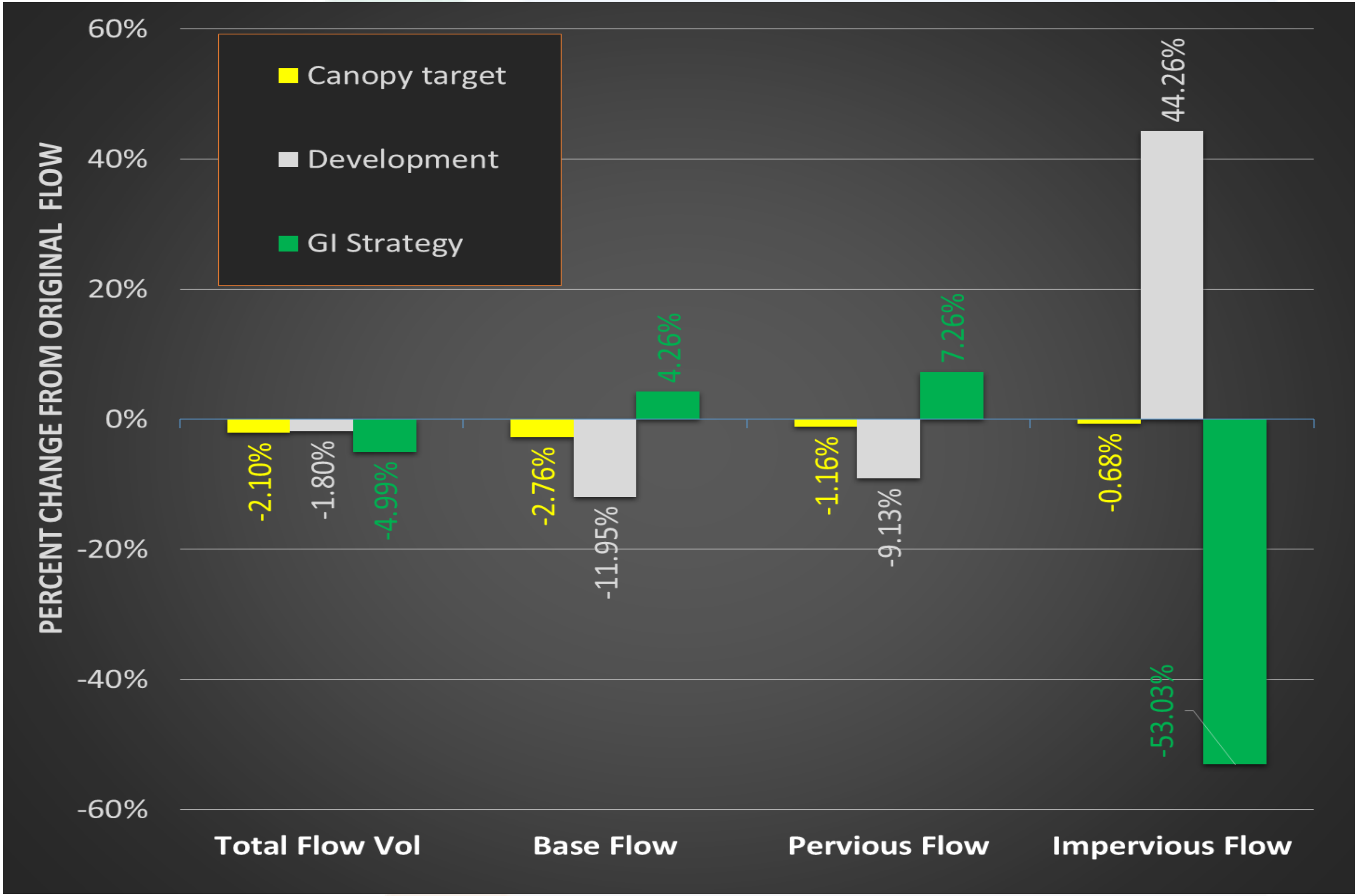
Watershed Project: Geographical & land cover inputs

	Base Case	Tree Canopy – focus on tree canopy increase	Development – increase in gray and decrease in green	Integrated GI – increase tree and other GI strategies
TOTAL AREA (km²)	258	258	258	258
Land Cover Area (%)				
Tree Canopy (TC)	36.0	45.0	32	41
Pervious under TC	91.7	88.9	90	90
Impervious under TC	8.3	11.1	10	10
Shrub Canopy	15.5	12.0	14.5	14.5
Herbaceous	15.5	12.0	12.5	14.5
Water	2.0	2.0	2.0	2.0
Bare Soil	.3	.3	.3	1.3
Impervious	30.7	28.7	38.7	26.7
Directly Connected Impervious Area (%)	**29.2**	**29.2**	**34.2**	**15.0**

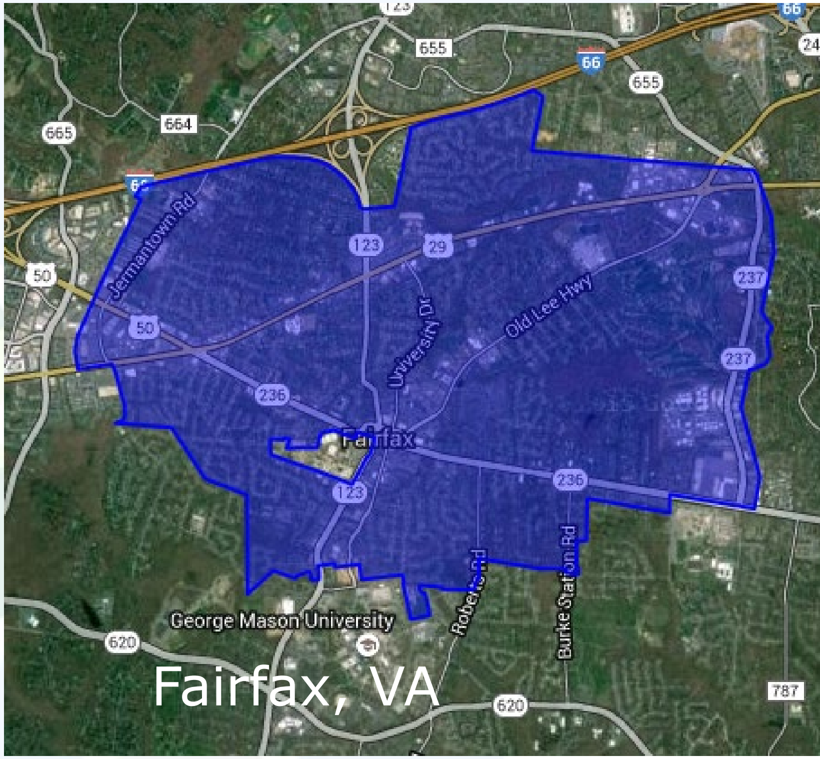
Multiple scenario comparisons



i-Tree Hydro: Municipality example

Pre-loaded inputs

- Watershed area: 16.3 km^2
- U~~SGS stream gauge data/Calibration Data~~
- Weather station: Davison AAF
- Topographic Index

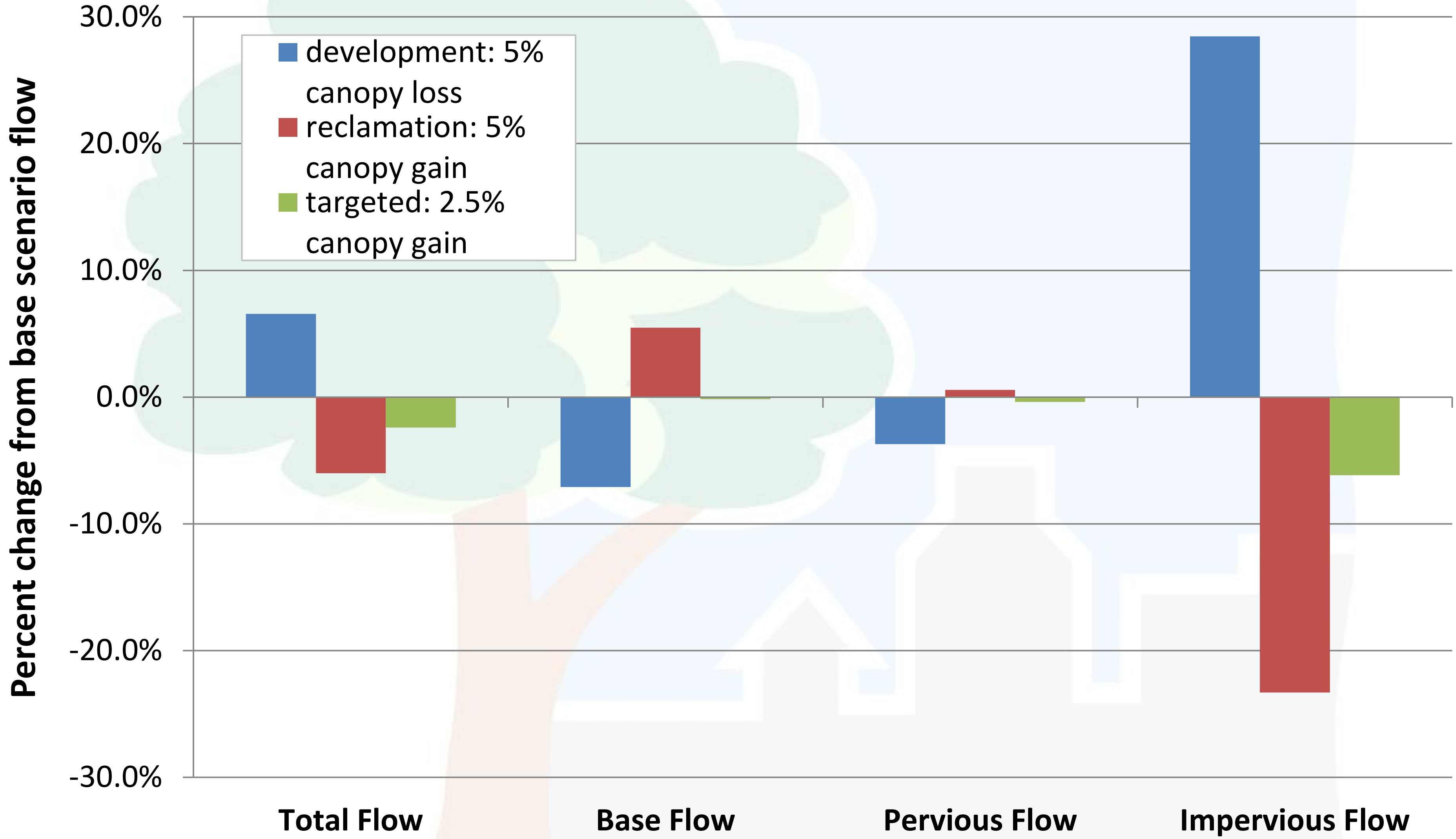


User supplied inputs

- Time period of interest (2005-2012)
- Relative cover
  Tree, pervious, impervious, shrub, herbaceous, water, soil
- Directly connected impervious area
- Leaf area index
- Alternative scenario

i-Tree is a Cooperative Initiative among these

Municipality example output: Planning scenarios



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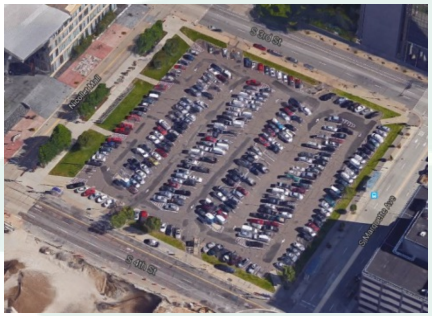
Future Modeling

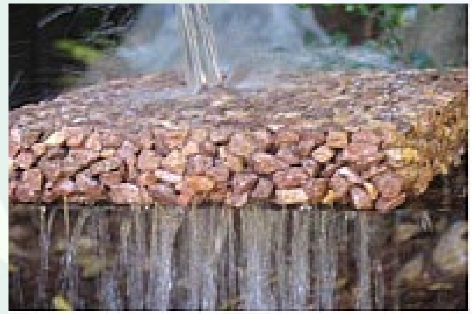
i-Tree Hydro project scale example: Green infrastructure (GI) cases

BASE CASE



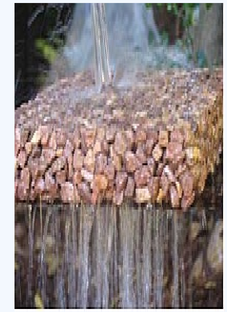
Parking Lot:
1 Square Block
Minneapolis, MN

GI 1



Parking Lot: with Permeable Pavement

GI 2



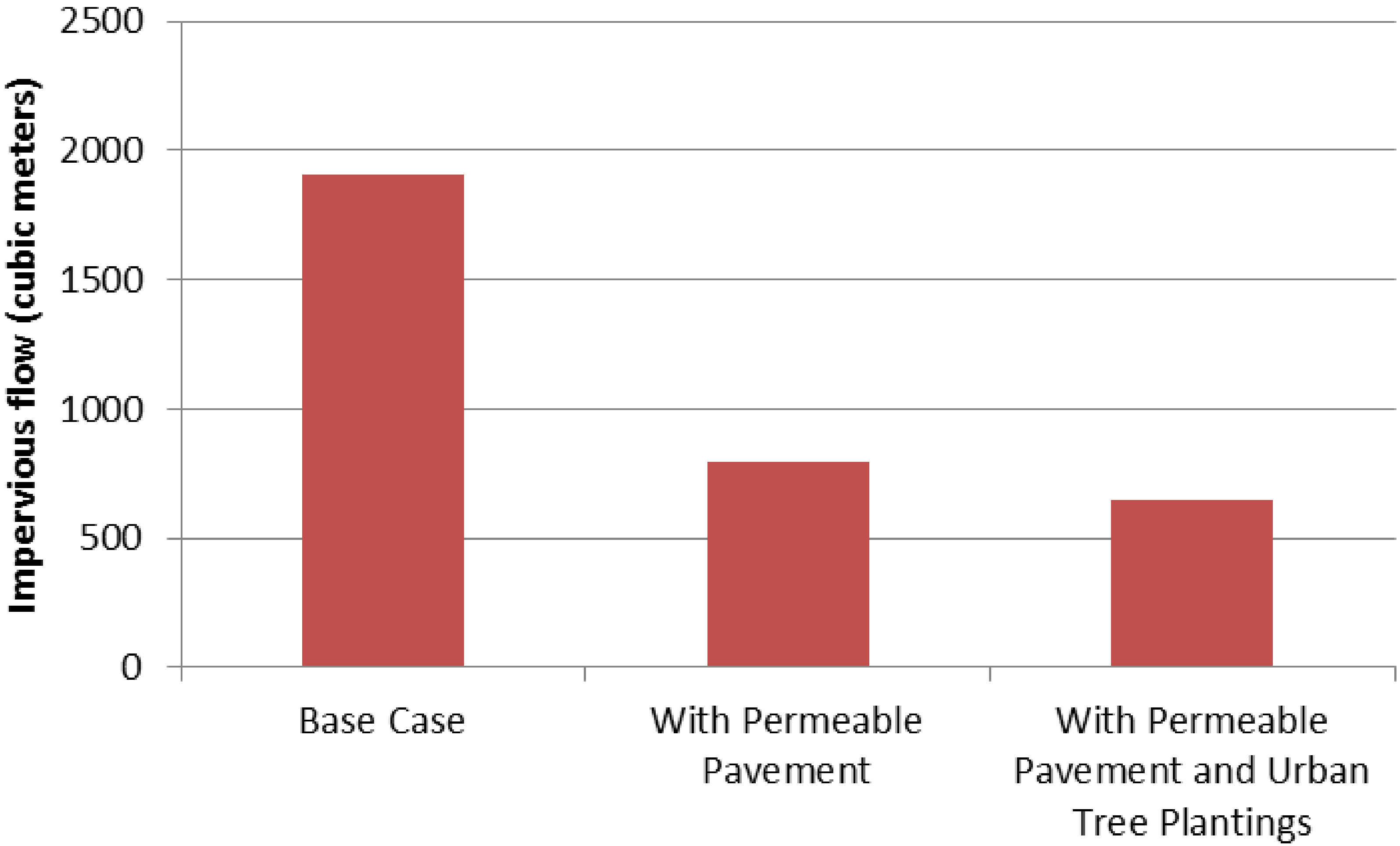
Parking Lot: with Permeable Pavement + Urban Tree Plantings

GI Project: Geographical & land cover inputs

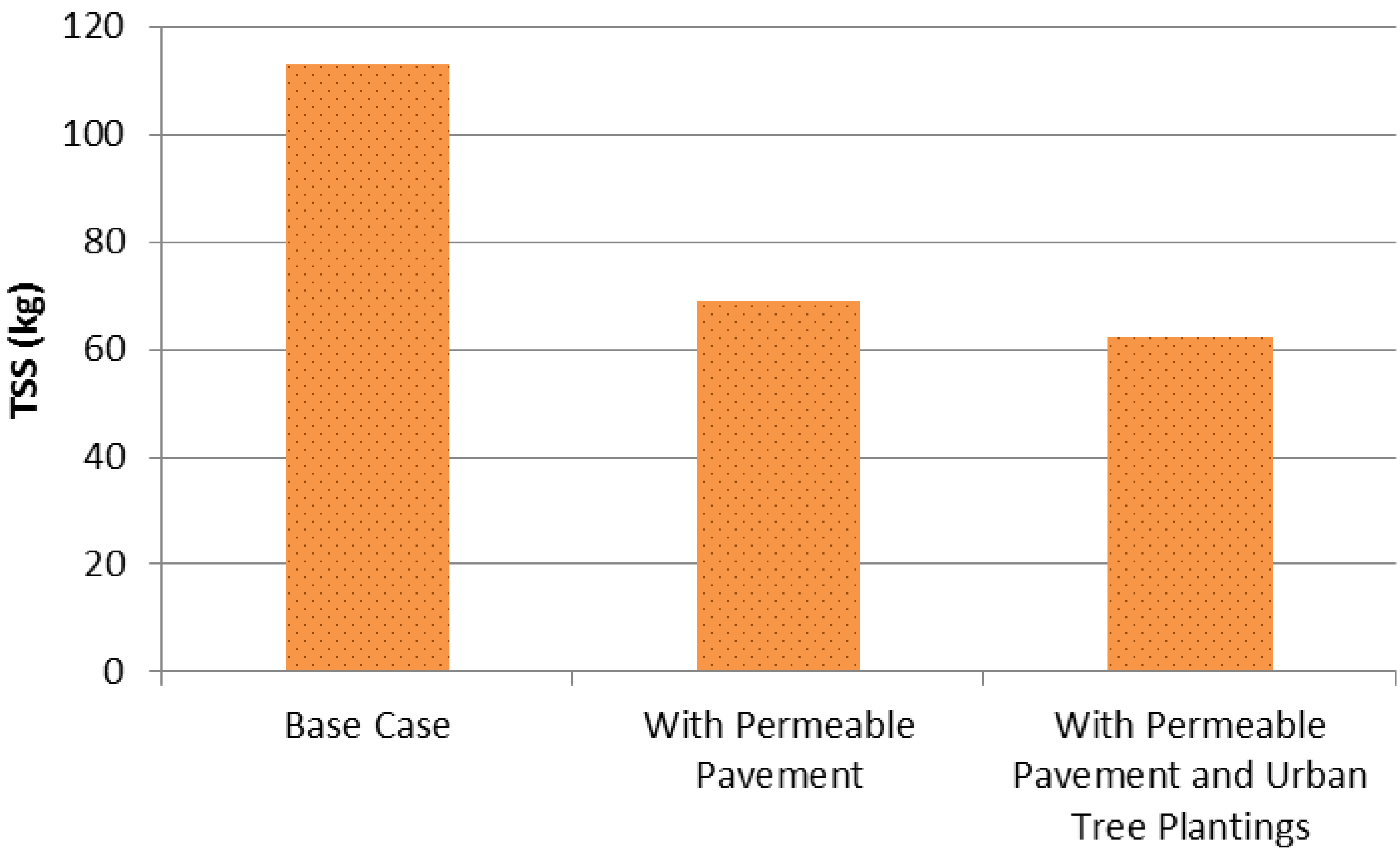
- **Geographic Location:**
  - Parking Lot, 1 Square Block - Minneapolis, MN
- **Weather Data:**
  - CRYSTAL 726575-94960
- **Time Period:**
  - 01/01/2012 – 9/30/2012

	Base Case	GI 1 – Permeable Pavement	GI 2 – Permeable Pavement and Urban Tree Plantings
TOTAL AREA (m^2)	12,488	12,488	12,488
Land Cover Area (%)			
Tree Canopy (TC)	2.3	2.3	5.1
Pervious under TC	82.3	82.3	78.8
Impervious under TC	17.7	17.7	21.2
Shrub Canopy	0	0	1.1
Herbaceous	10.9	10.9	8.3
Water	0	0	0
Bare Soil	0	38.3	38.1
Impervious	86.7	48.5	47.5
Directly Connected Impervious Area (%)	**31.4**	**23.4**	**19.3**

GI Project Output: Impervious flow by case



GI Project Output:
Total suspended solids by case



Contact Information and Links

- How to obtain i-Tree Hydro
  - https://www.itreetools.org/hydro/
- Technical Support
  - https://www.itreetools.org/support/index.php
  - (877) 574-8733
- Assessment and Analysis
  - William.Ayersman@davey.com
  - 330-673-5685 x8048

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