Reducing Erosion in Yellow Creek with Storm Water Management and Stream Restoration

Bob Hawley, Ph.D., P.E. & David Koontz, P.E., S.I.

March 11, 2020

Outline

Reducing Erosion Yellow Creek

- **Background**
  - Surface Water Management District Establishment
- **Problem**
  - Stream Assessments & Watershed Inventory
- **Process**
  - Stormwater Management & Stream Erosion
- **Solutions**
  - Mitigation Strategies & High Priority Concepts
- **Questions**

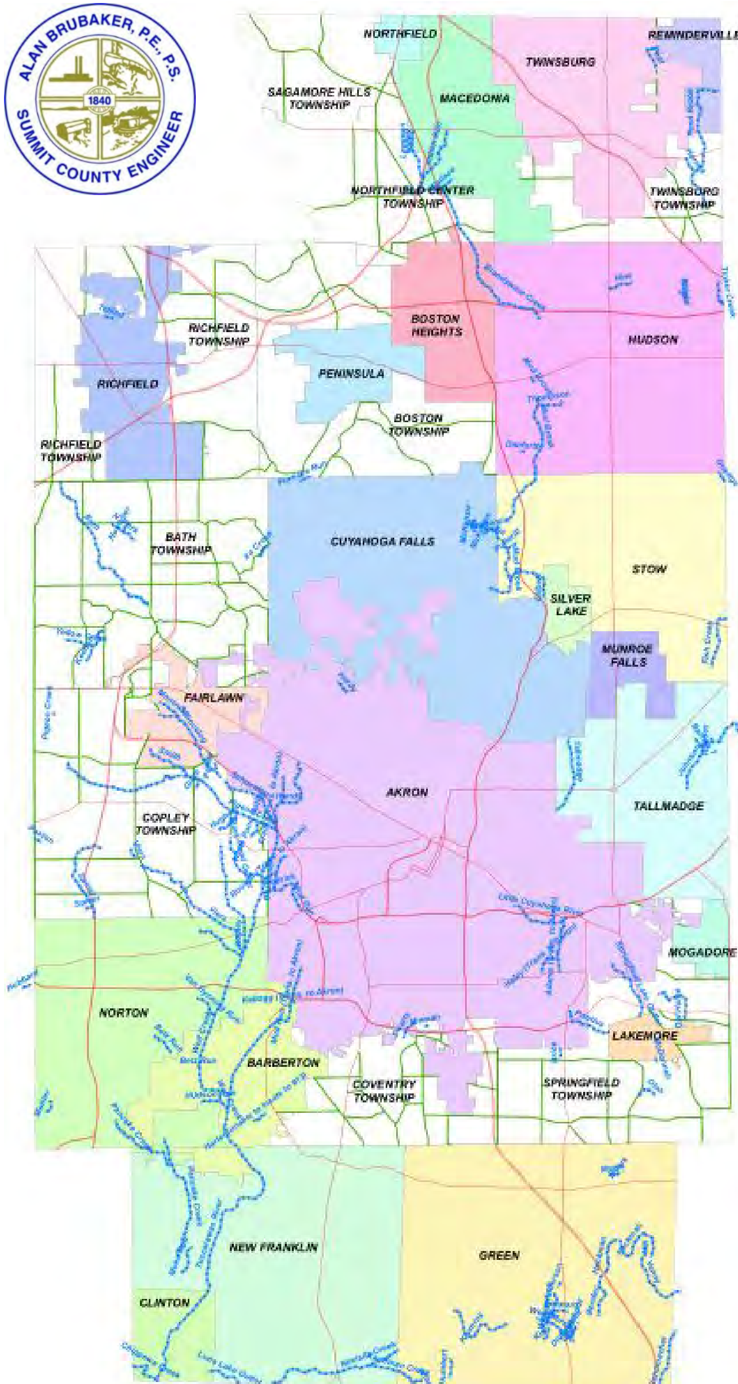
Surface Water Management District

Summit County Engineer Alan Brubaker, P.E., P.S.

SWMD Coordinator David Koontz, P.E., S.I.

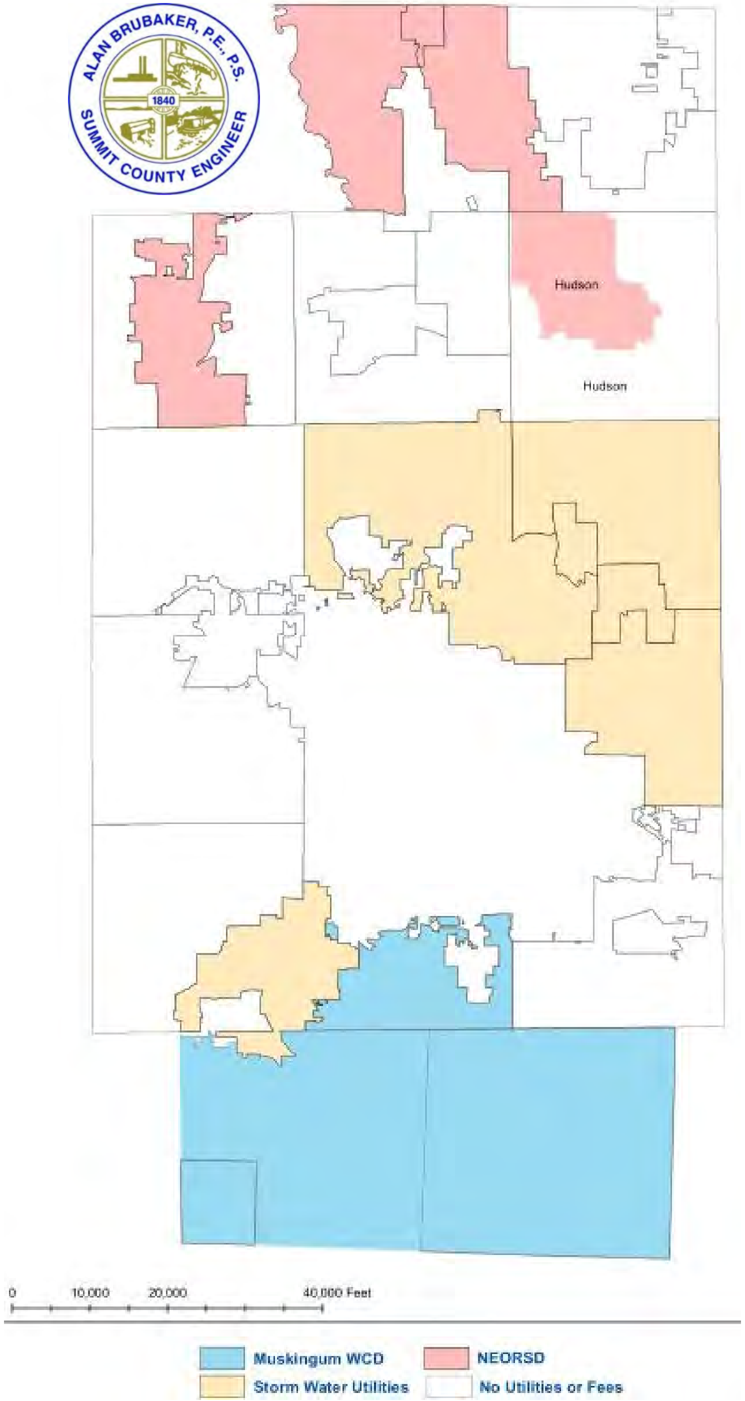

Toledo
Cleveland
Lake Erie Watershed
SUMMIT
Akron
COUNTY
Columbus
Dayton
Ohio River Watershed
Cincinnati

ALAN BRUBAKER, P.E., P.S.
SUMMIT COUNTY ENGINEER
1840



Summit County

- 542,000 people
- 31 communities
  - 13 cities
  - 9 villages
  - 9 townships

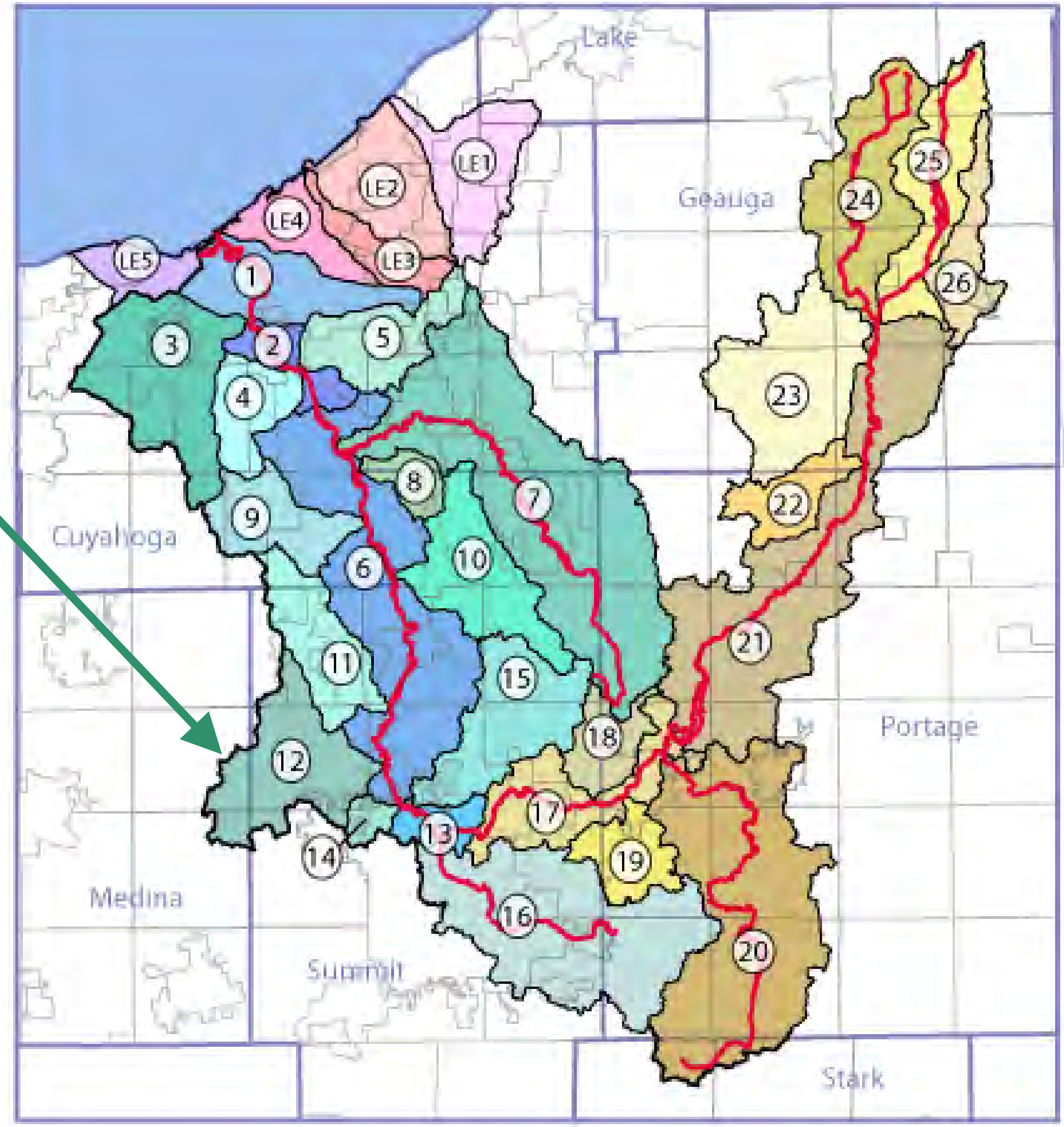


Stormwater Utility Billing Is Uncommon in Summit County

- 5 communities in the **Northeast Ohio Regional Sewer District** SW program
- 6 cities with **local stormwater utility** billing
- 2 full cities, 1 village, and parts of 3 more cities and 1 township are within the **Muskingum Watershed Conservancy District**

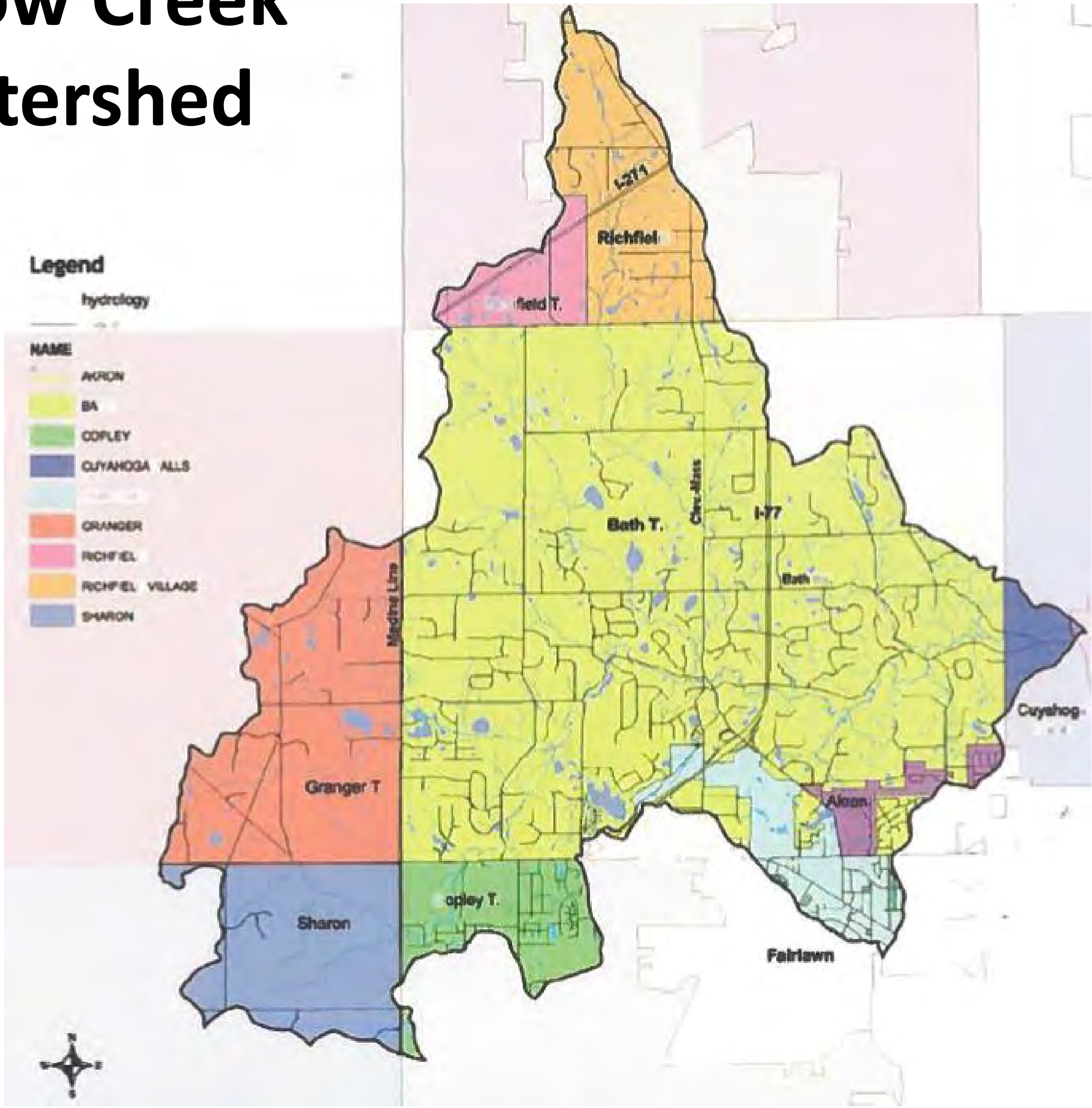
Yellow Creek watershed

1 of 26 watersheds that drain to the Cuyahoga River



Yellow Creek Watershed

- Most of Bath Township
- Parts of 6 other Summit Co. communities
- Parts of 2 townships in Medina Co.

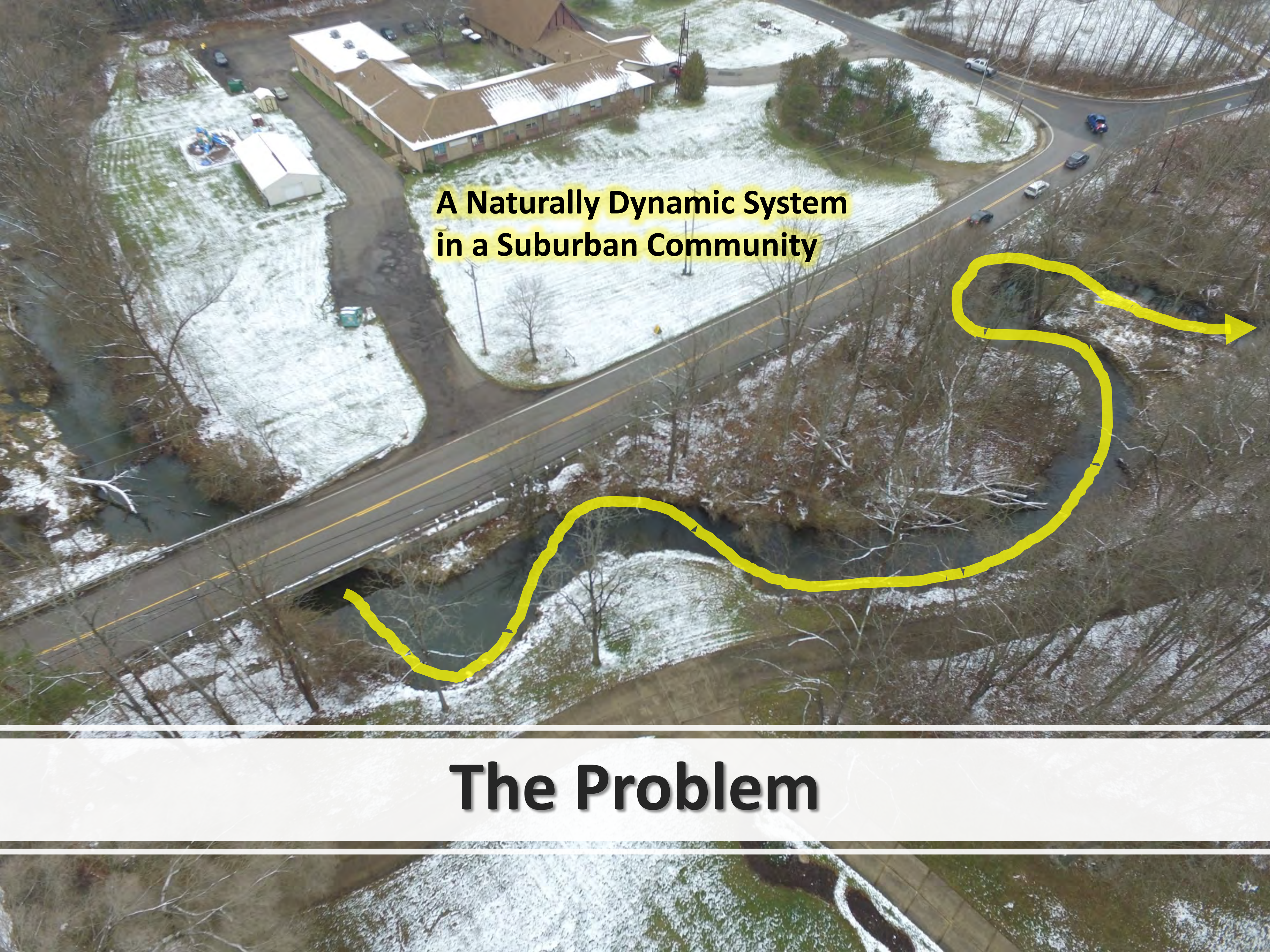


Stormwater

- We spent nine years devising various solutions to stormwater issues in Summit County, in addition to efforts for decades by prior County Engineers
- With no current SW revenue stream, we were left to use **the ditch petition process,** where citizens or the township petition the county to do a surface water project and pay assessments, as the only way to address most stormwater problems
- Two citizens' petitions brought forward in 2016 elicited so many objections at their public hearings that Summit County Council declined to proceed

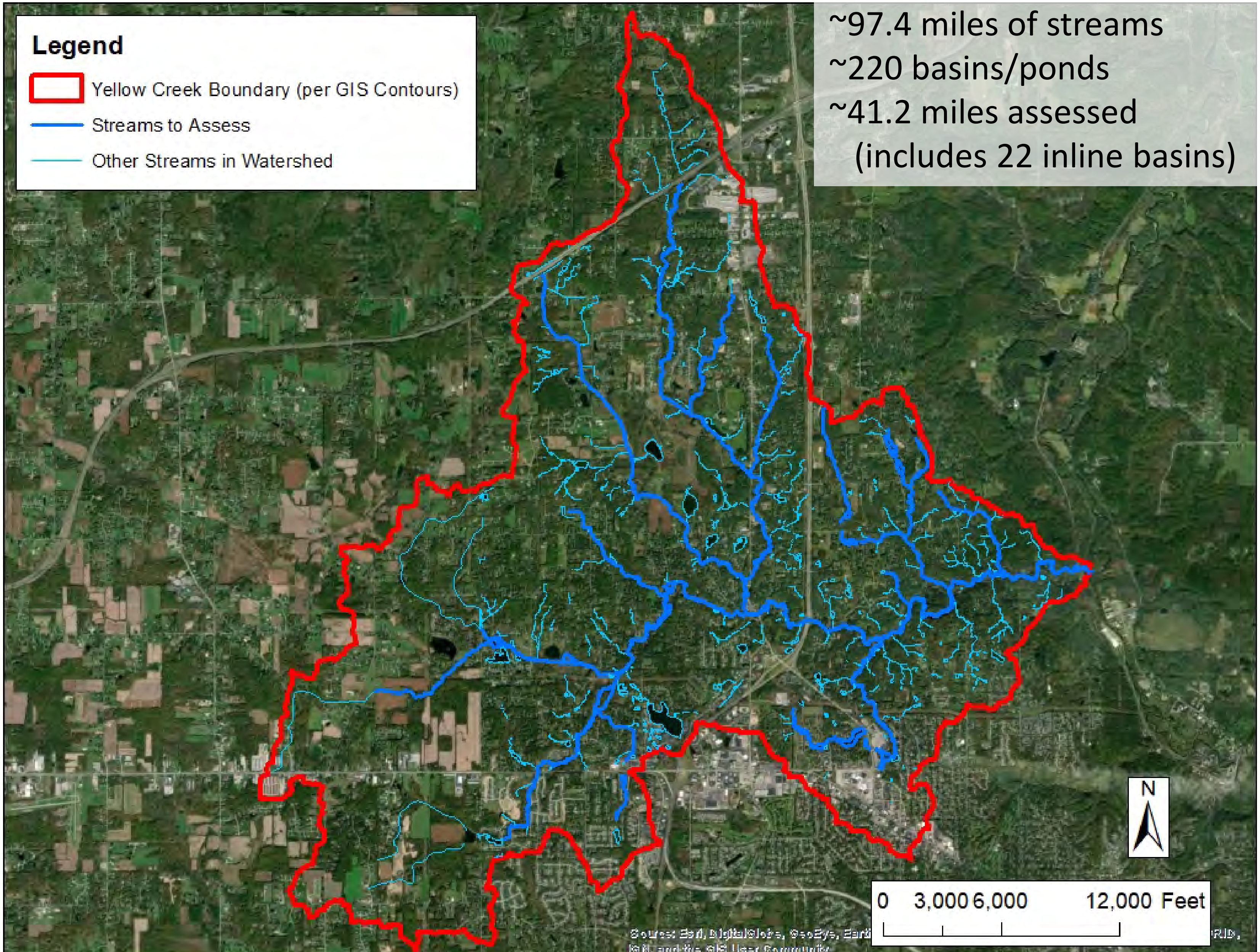
Surface Water Management District

- SCE now manages the **Surface Water Management District** as a utility & charges a small monthly fee in conjunction with the ditch petition process
- Participation is opt-in, or **entirely voluntary** and is open to all Summit County townships, cities, and villages
- Residential Rate (1, 2, and 3 family residences) is **$4/month, billed annually**, as initiated in June 2018
- Commercial, industrial & institutional properties rate is $4/mo **per ERU or 3,000 SF** of impervious area


A Naturally Dynamic System
in a Suburban Community
The Problem

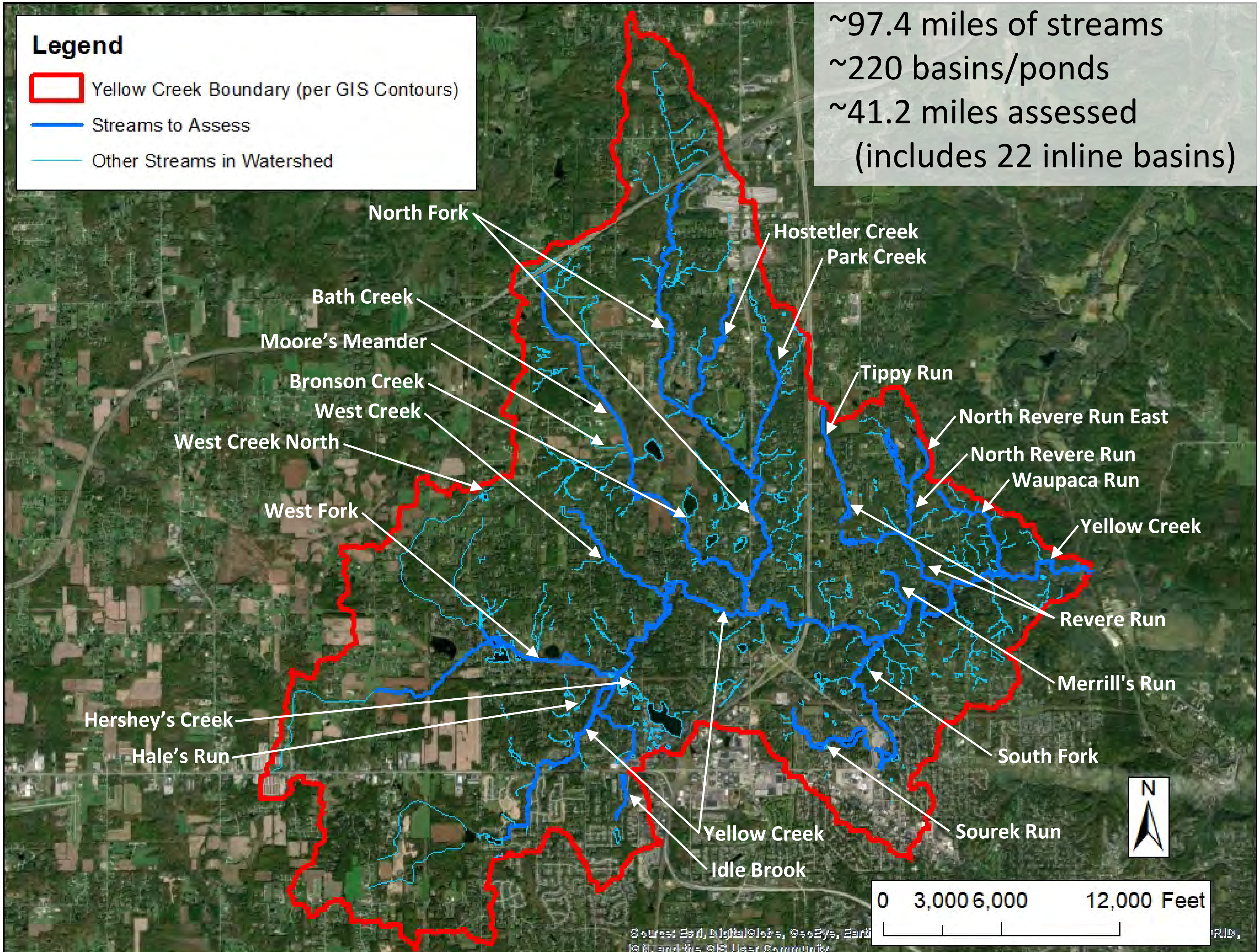
Stream Assessments & Watershed Inventory

Streams



Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
~97.4 miles of streams
~220 basins/ponds
~41.2 miles assessed
(includes 22 inline basins)
N
0 3,000 6,000 12,000 Feet

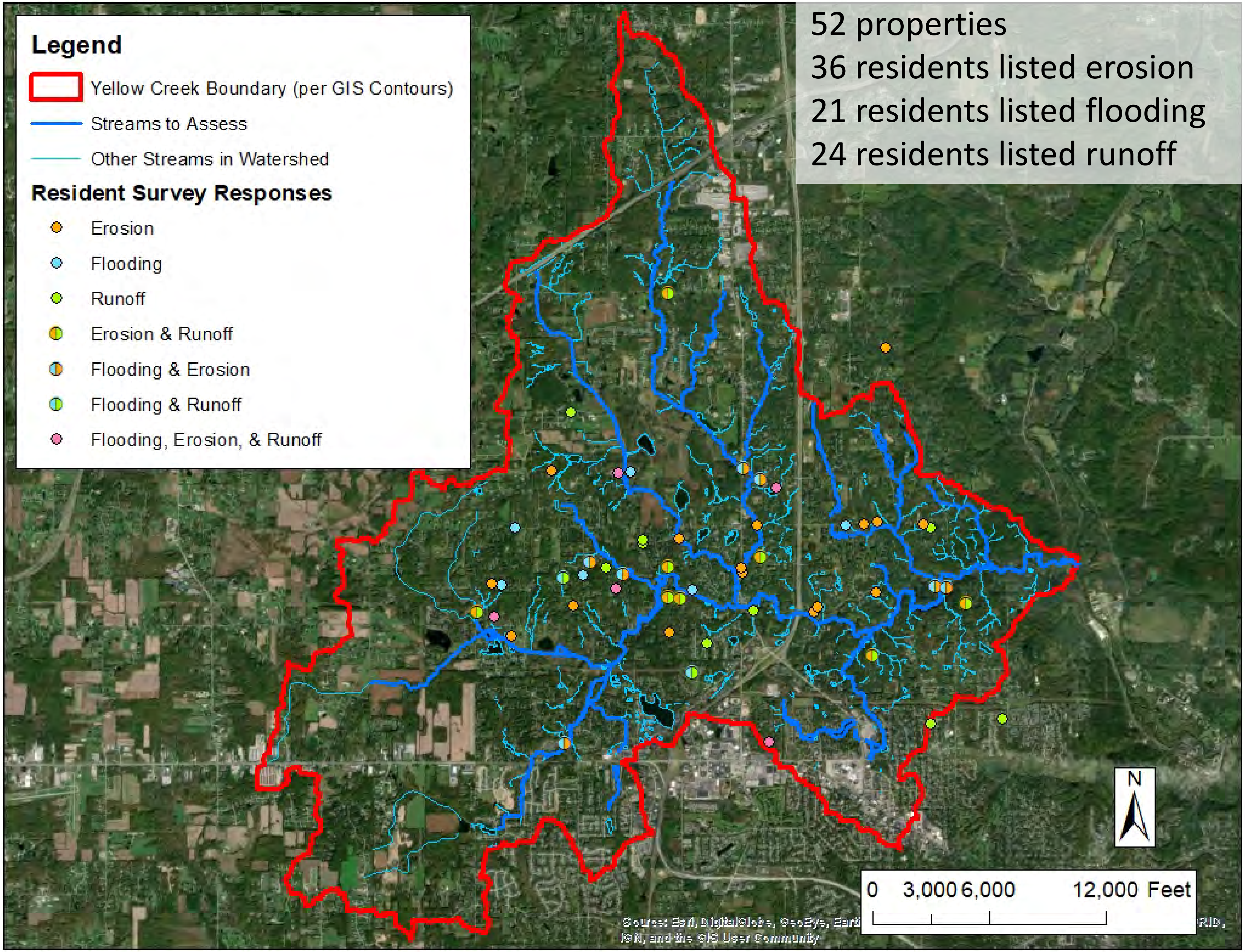
Streams



Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
~97.4 miles of streams
~220 basins/ponds
~41.2 miles assessed
(includes 22 inline basins)
North Fork
Hostetler Creek
Park Creek
Bath Creek
Moore's Meander
Bronson Creek
West Creek
West Creek North
Tippy Run
North Revere Run East
North Revere Run
Waupaca Run
Yellow Creek
West Fork
Revere Run
Merrill's Run
Hershey's Creek
Hale's Run
South Fork
Sourek Run
Yellow Creek
Idle Brook
N
0 3,000 6,000 12,000 Feet

Resident Survey Responses

52 properties
36 residents listed erosion
21 residents listed flooding
24 residents listed runoff



Resident Survey Responses

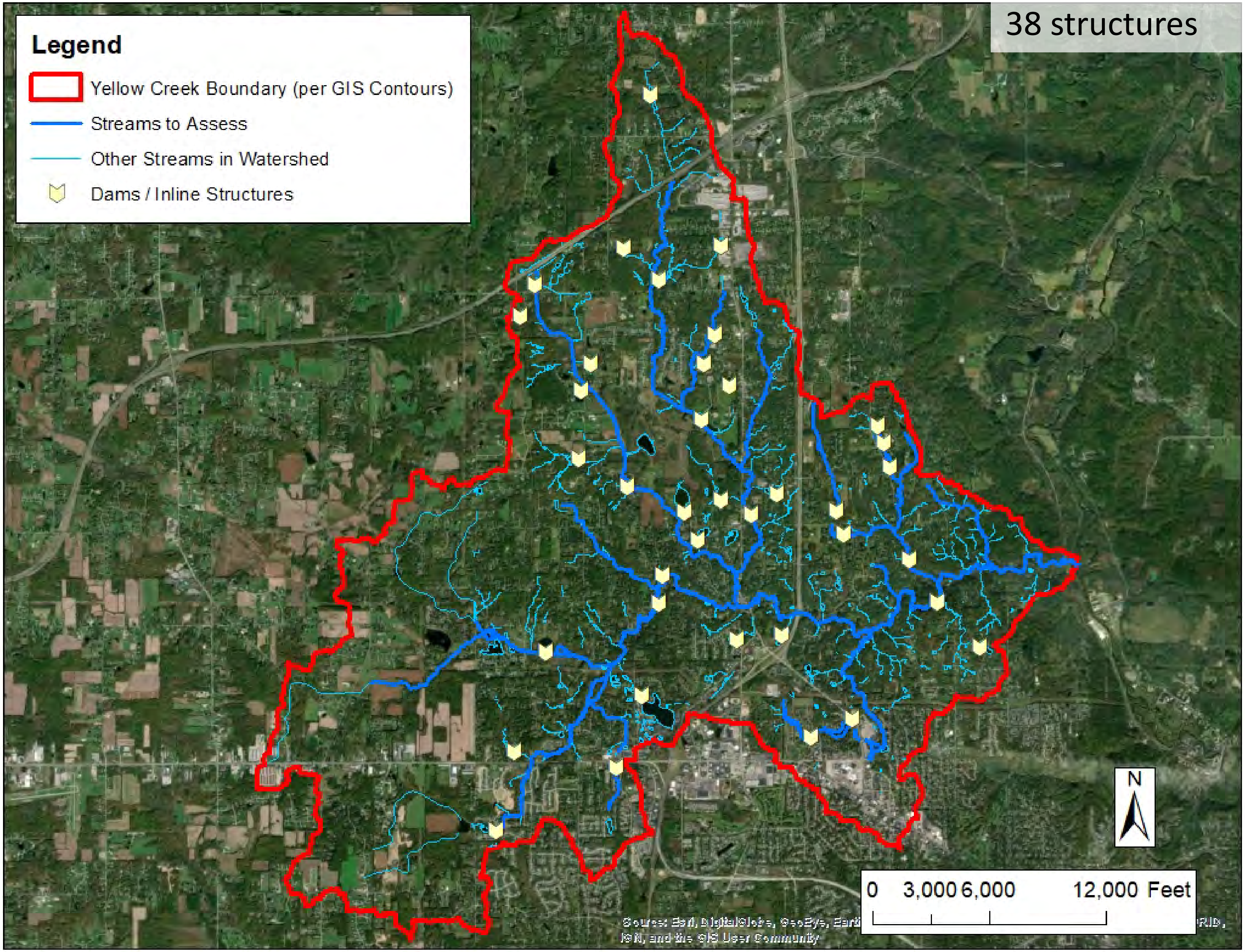

N. Cleveland-Massillon Road


W. Bath Road


W. Bath Road

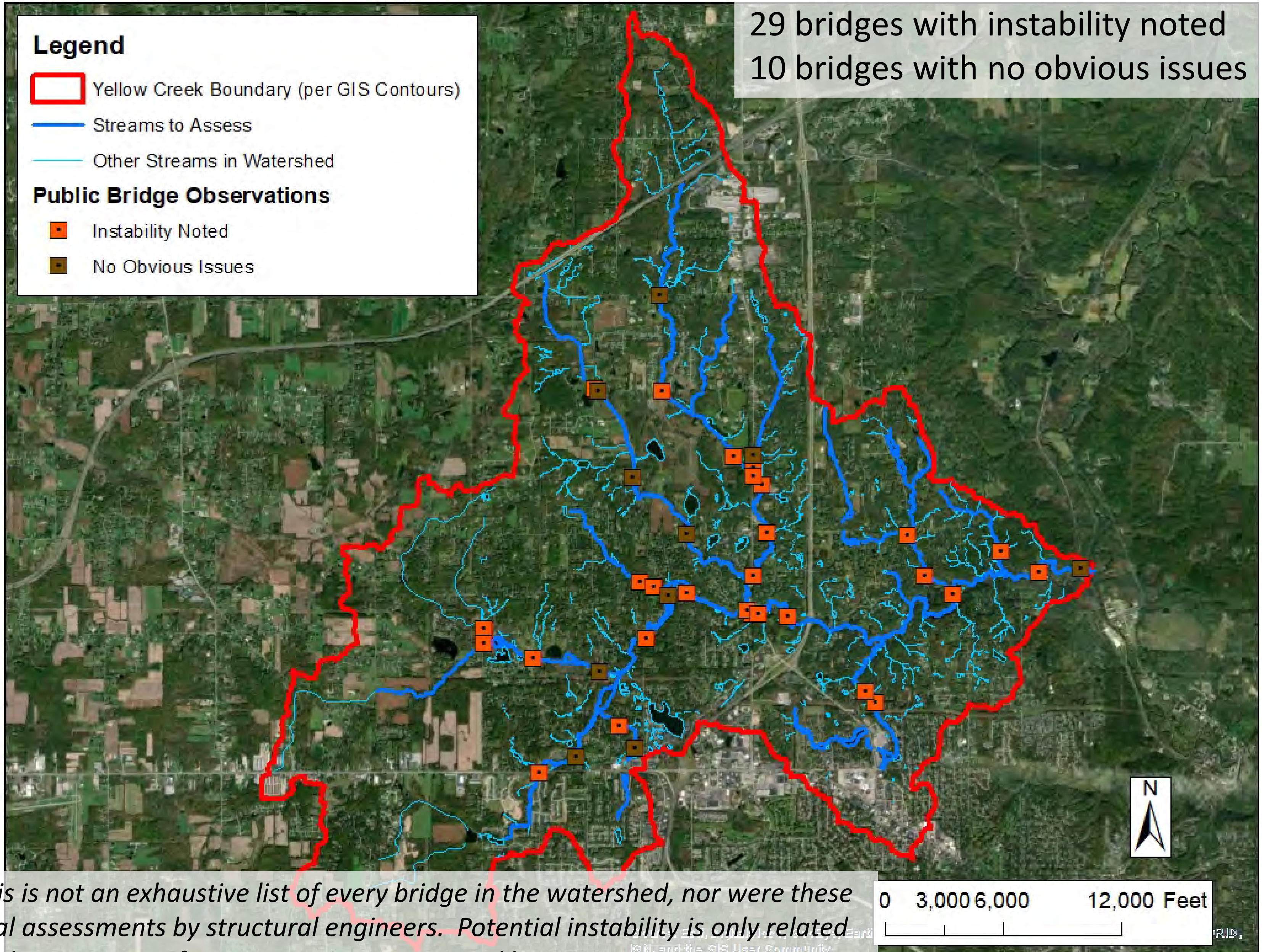

Harmony Road

Dams/Inline Structures



Dams/Inline Structures

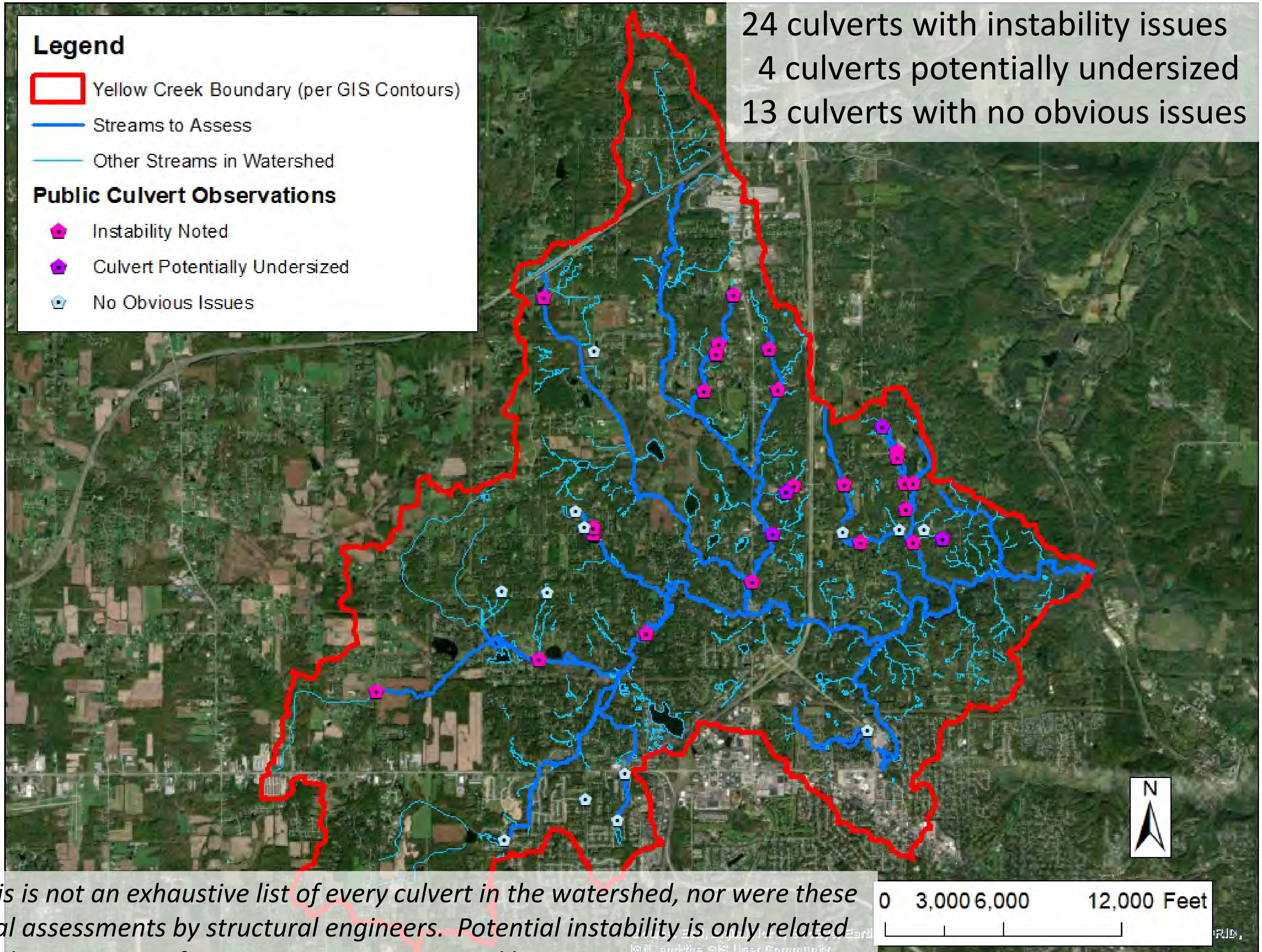
Public Bridge Observations



Note: this is not an exhaustive list of every bridge in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

Public Bridge Observations

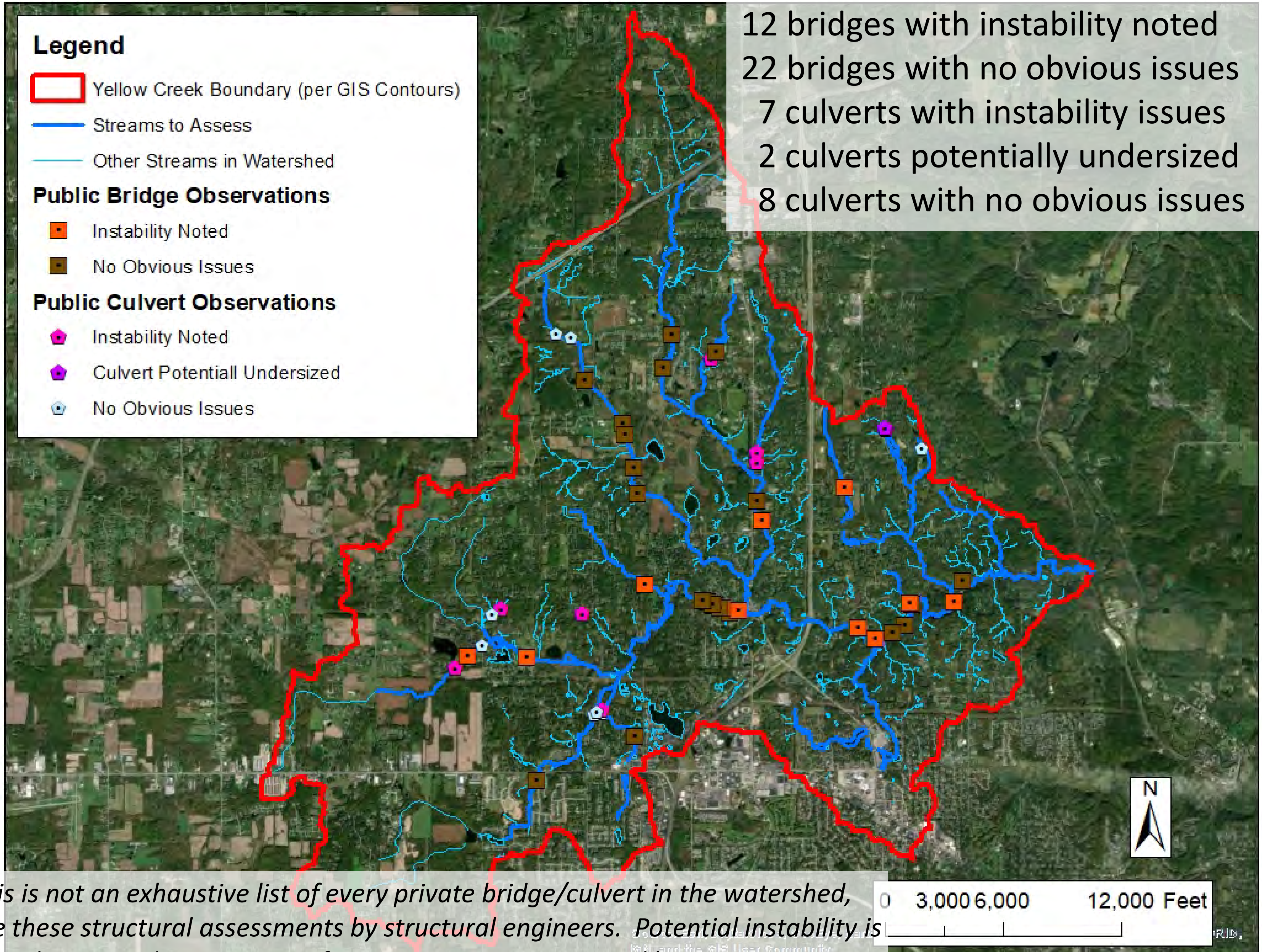
Public Culvert Observations



Note: this is not an exhaustive list of every culvert in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

Public Culvert Observations

Private Bridge and Culvert Observations

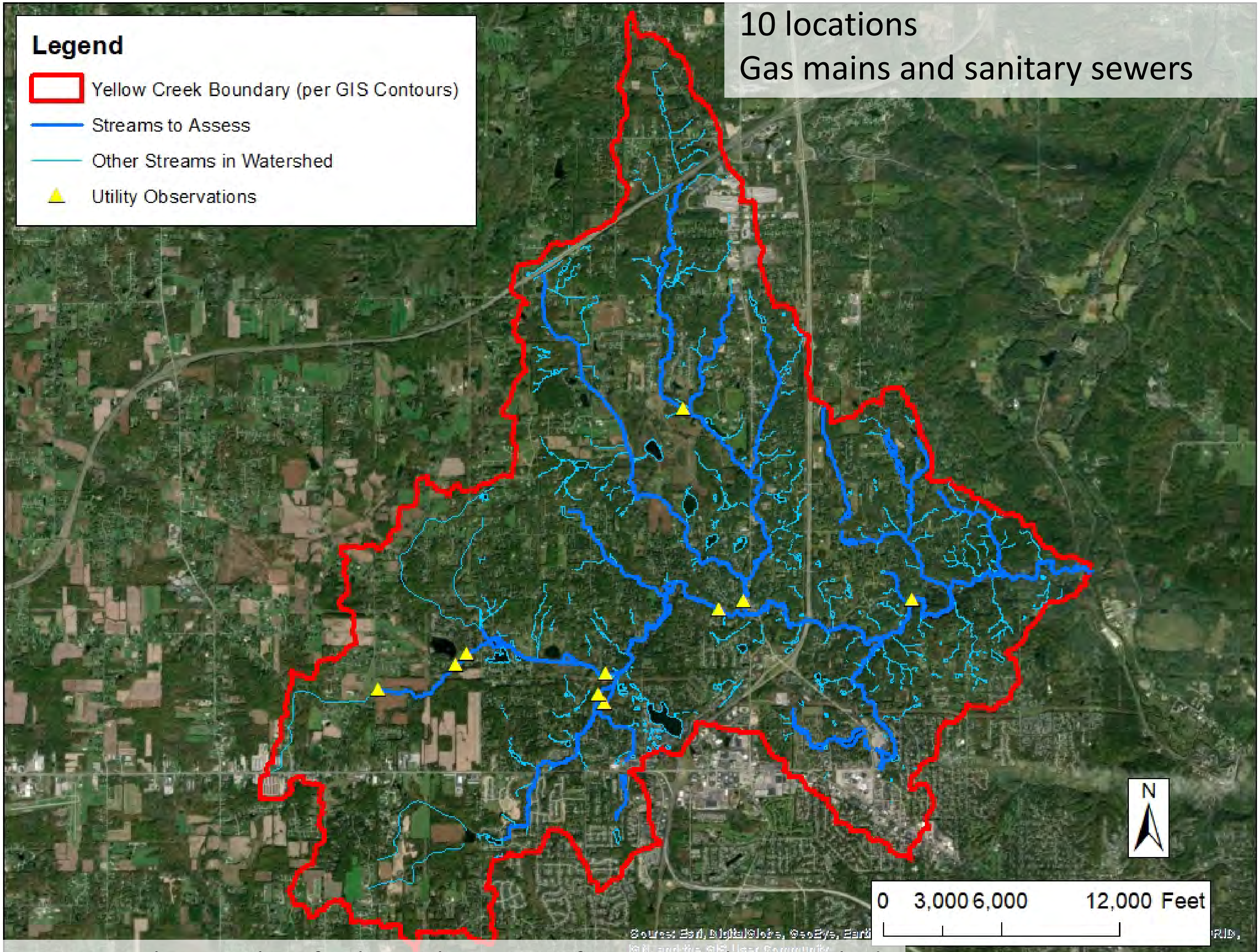


12 bridges with instability noted
22 bridges with no obvious issues
7 culverts with instability issues
2 culverts potentially undersized
8 culverts with no obvious issues

Note: this is not an exhaustive list of every private bridge/culvert in the watershed, nor were these structural assessments by structural engineers. Potential instability is only related to a rapid assessment of stream erosion as assessed by stream experts.

Private Bridge and Culvert Observations

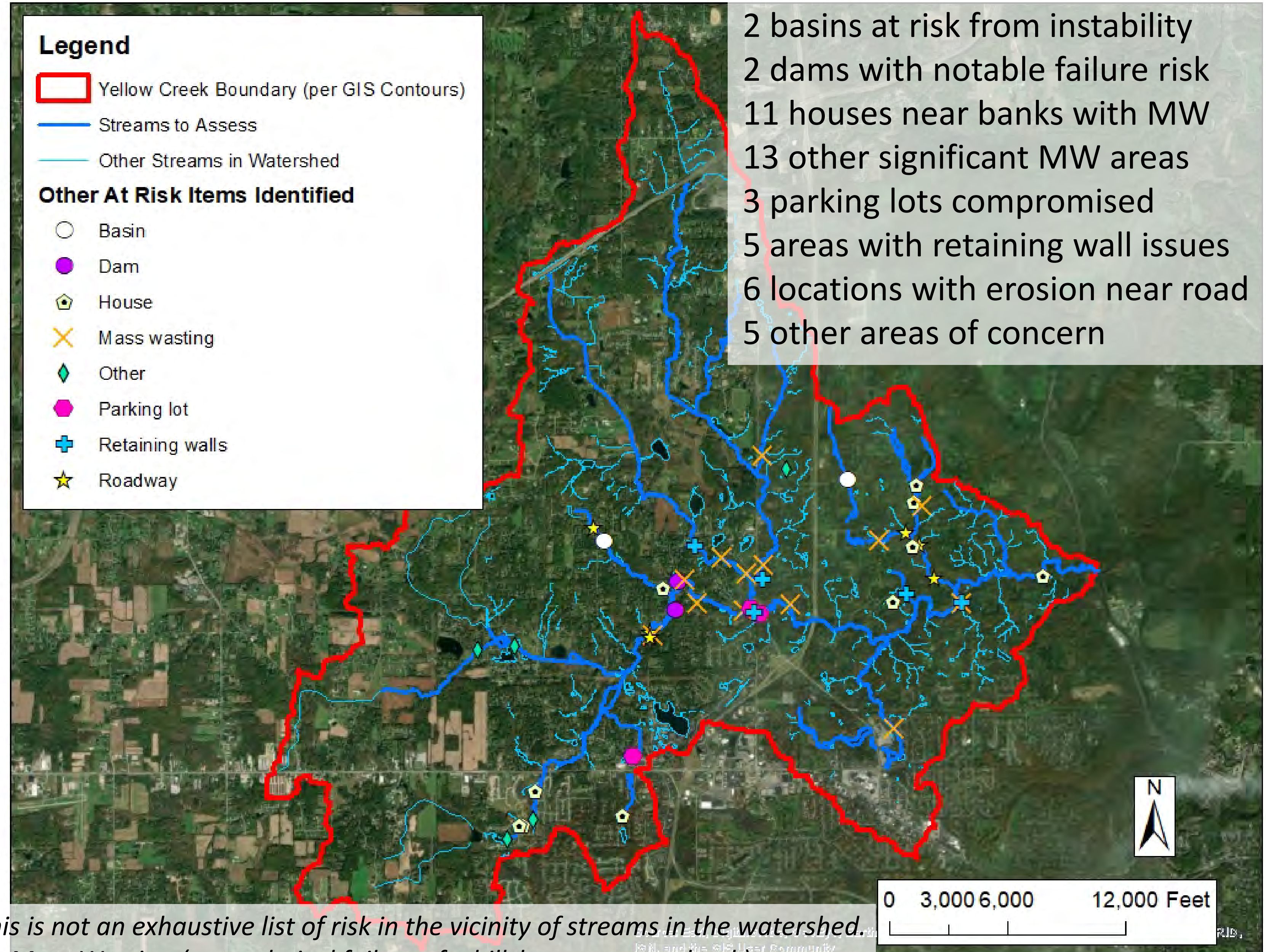
Utility Observations



Note: this is not an exhaustive list of utility in the vicinity of streams in the watershed.

Utility Observations

Additional Areas with Potential Risks



2 basins at risk from instability
2 dams with notable failure risk
11 houses near banks with MW
13 other significant MW areas
3 parking lots compromised
5 areas with retaining wall issues
6 locations with erosion near road
5 other areas of concern

Note: this is not an exhaustive list of risk in the vicinity of streams in the watershed.
"MW" = Mass Wasting (geotechnical failure of a hillslope or streambank)

Additional Areas with Potential Risks

Examples of Mass Wasting

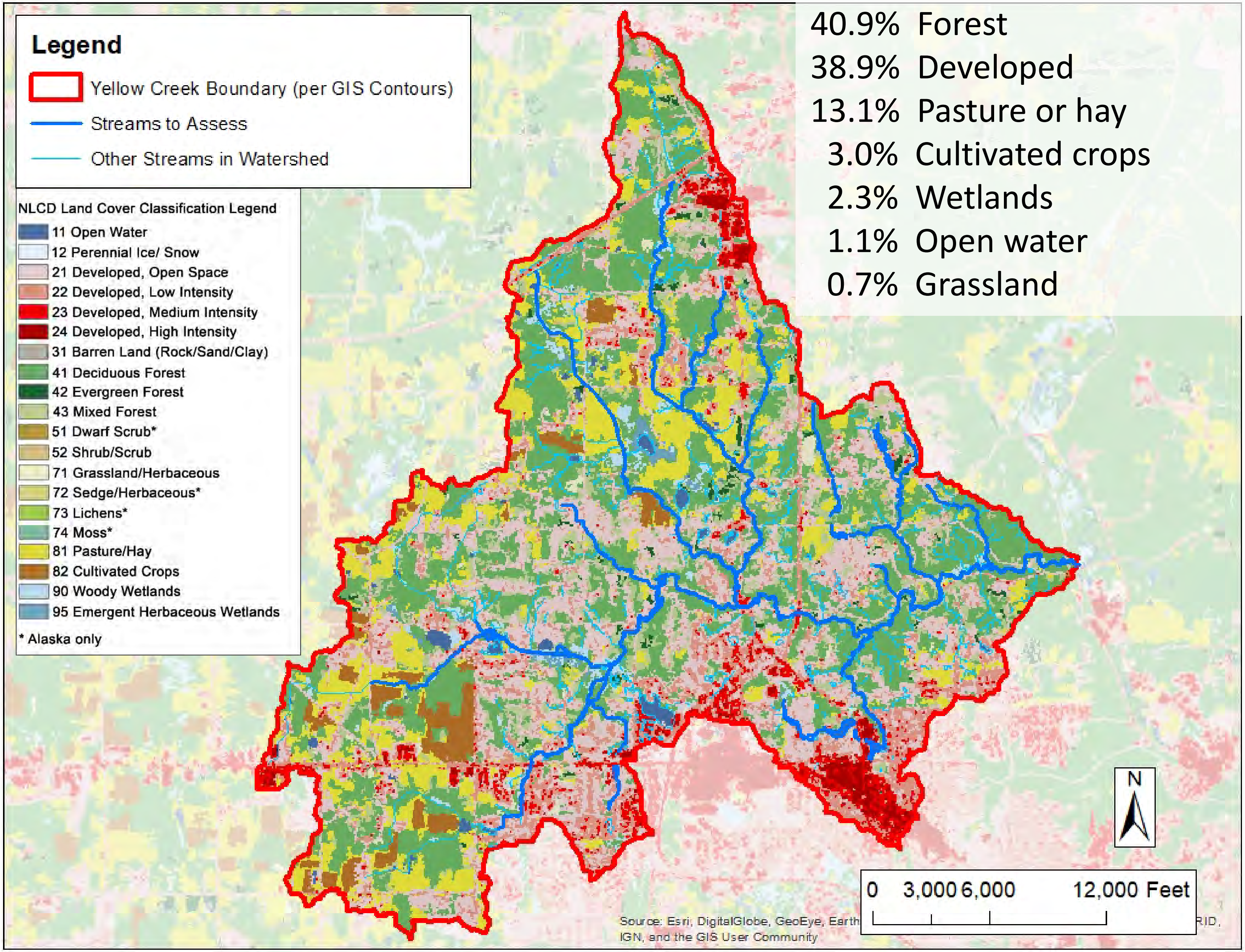
Watershed Inventory

LAND COVER & SOILS

TOPOGRAPHY

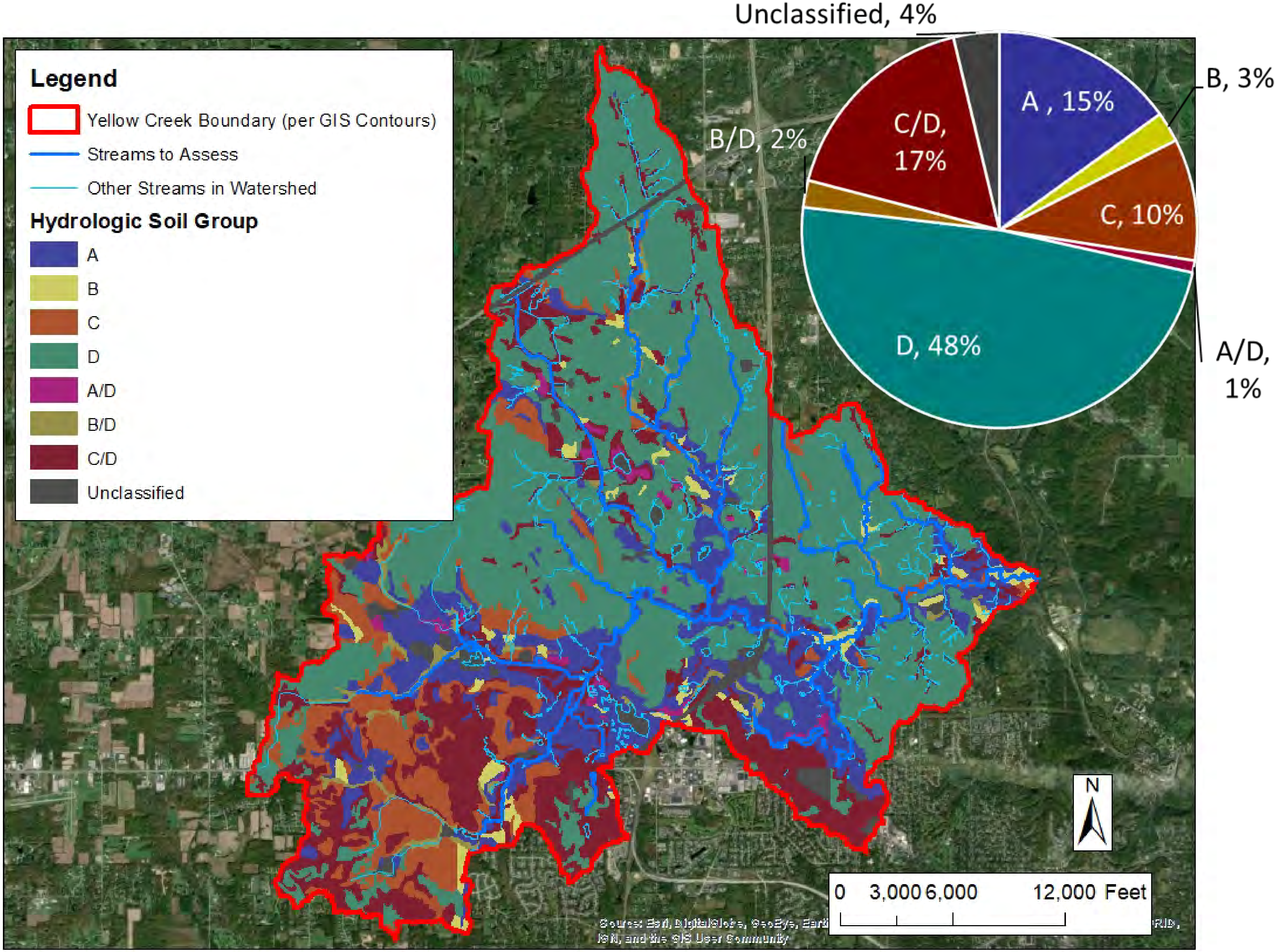
IMPERVIOUS SURFACES

Land Cover

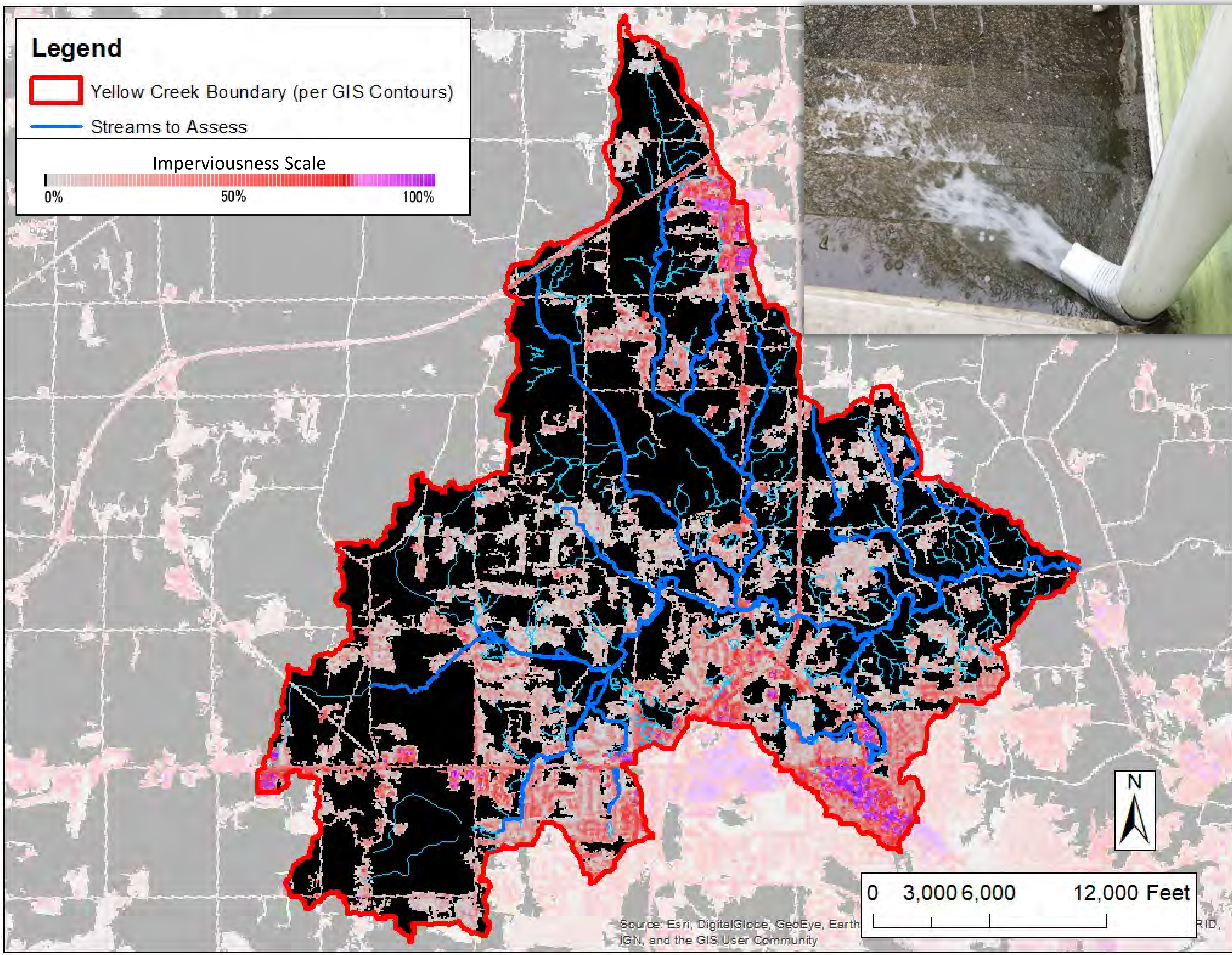


Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
51 Dwarf Scrub*
52 Shrub/Scrub
71 Grassland/Herbaceous
72 Sedge/Herbaceous*
73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only
40.9% Forest
38.9% Developed
13.1% Pasture or hay
3.0% Cultivated crops
2.3% Wetlands
1.1% Open water
0.7% Grassland
N
0 3,000 6,000 12,000 Feet
Source: Esri, DigitalGlobe, GeoEye, Earth
IGN, and the GIS User Community

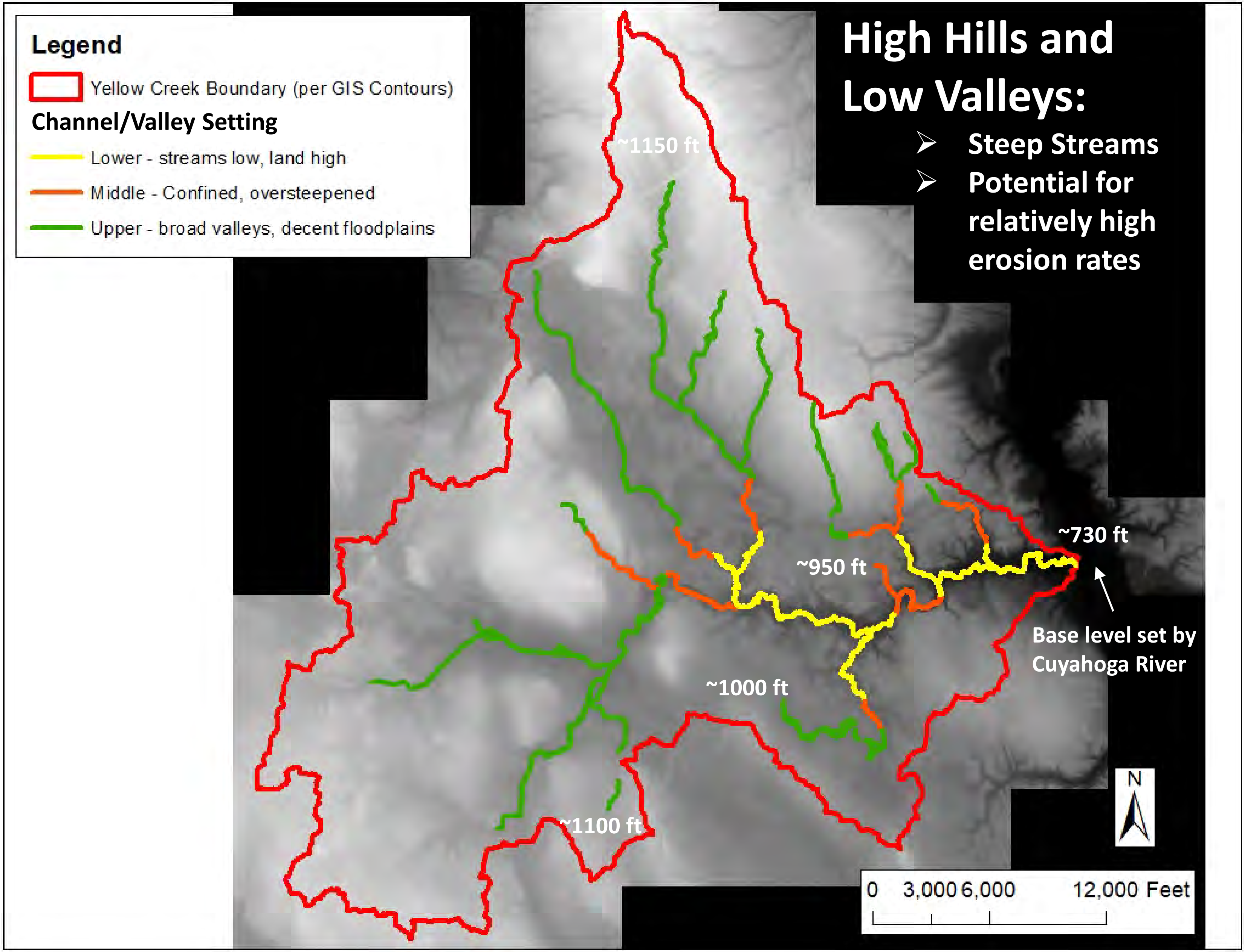
Soils


Unclassified, 4%
B, 3%
A , 15%
C/D, 17%
B/D, 2%
C, 10%
D, 48%
A/D, 1%
Legend
Yellow Creek Boundary (per GIS Contours)
Streams to Assess
Other Streams in Watershed
Hydrologic Soil Group
A
B
C
D
A/D
B/D
C/D
Unclassified
N
0 3,000 6,000 12,000 Feet

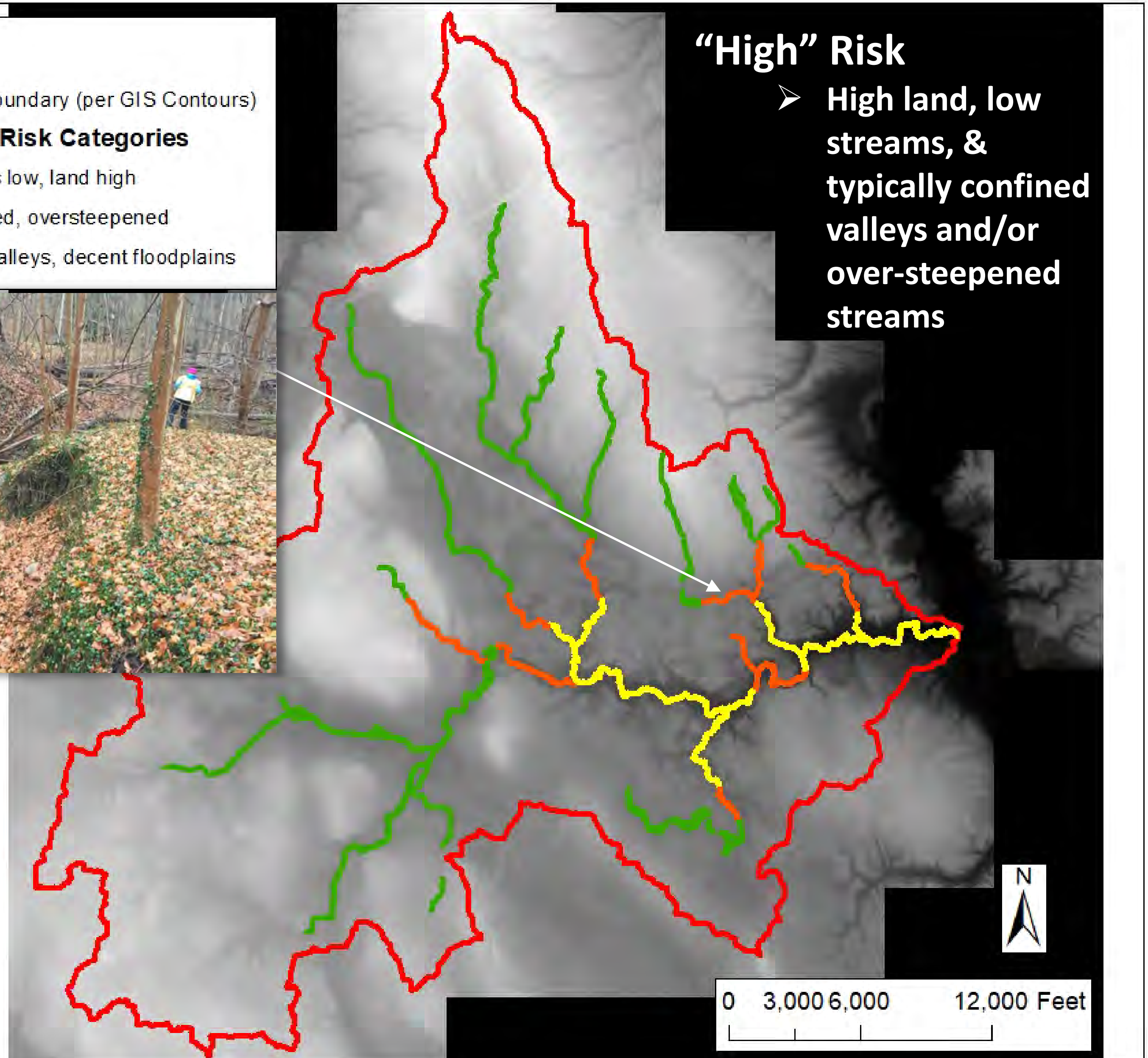
Impervious Cover



Topographic Setting



Valley Setting → Relative Risk Categories

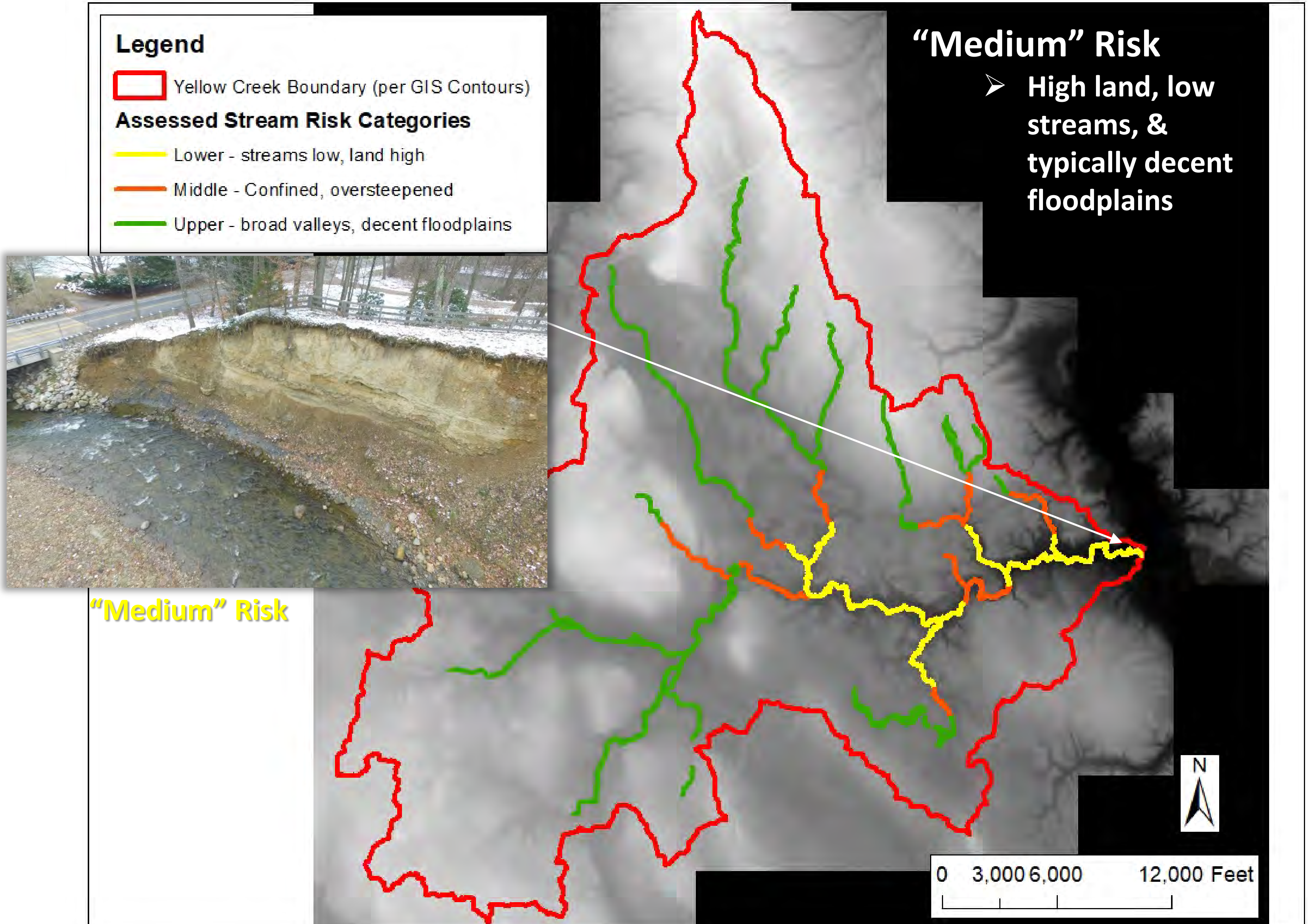


"High" Risk

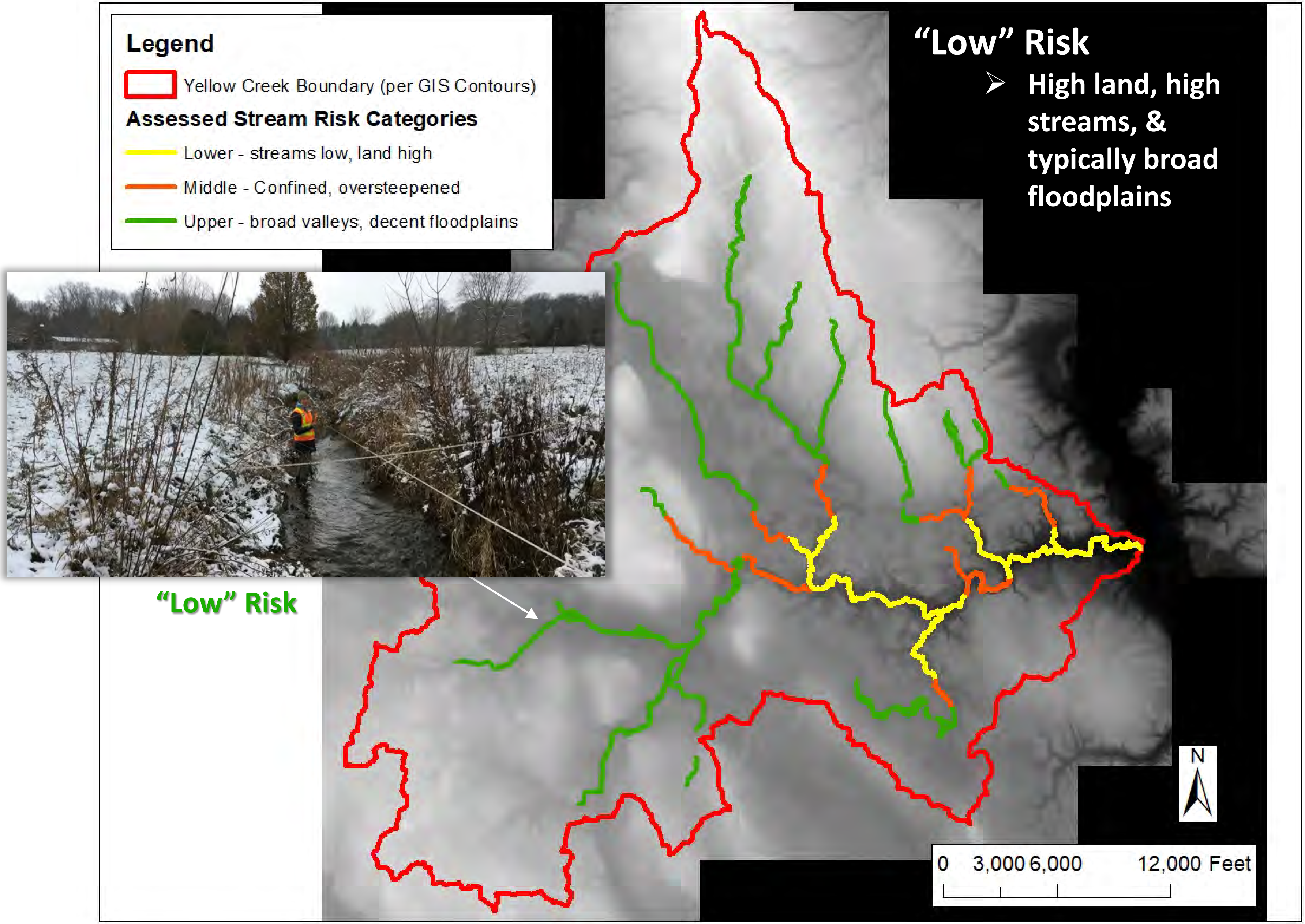
"High" Risk

- High land, low streams, & typically confined valleys and/or over-steepened streams

Valley Setting → Relative Risk Categories



Valley Setting → Relative Risk Categories

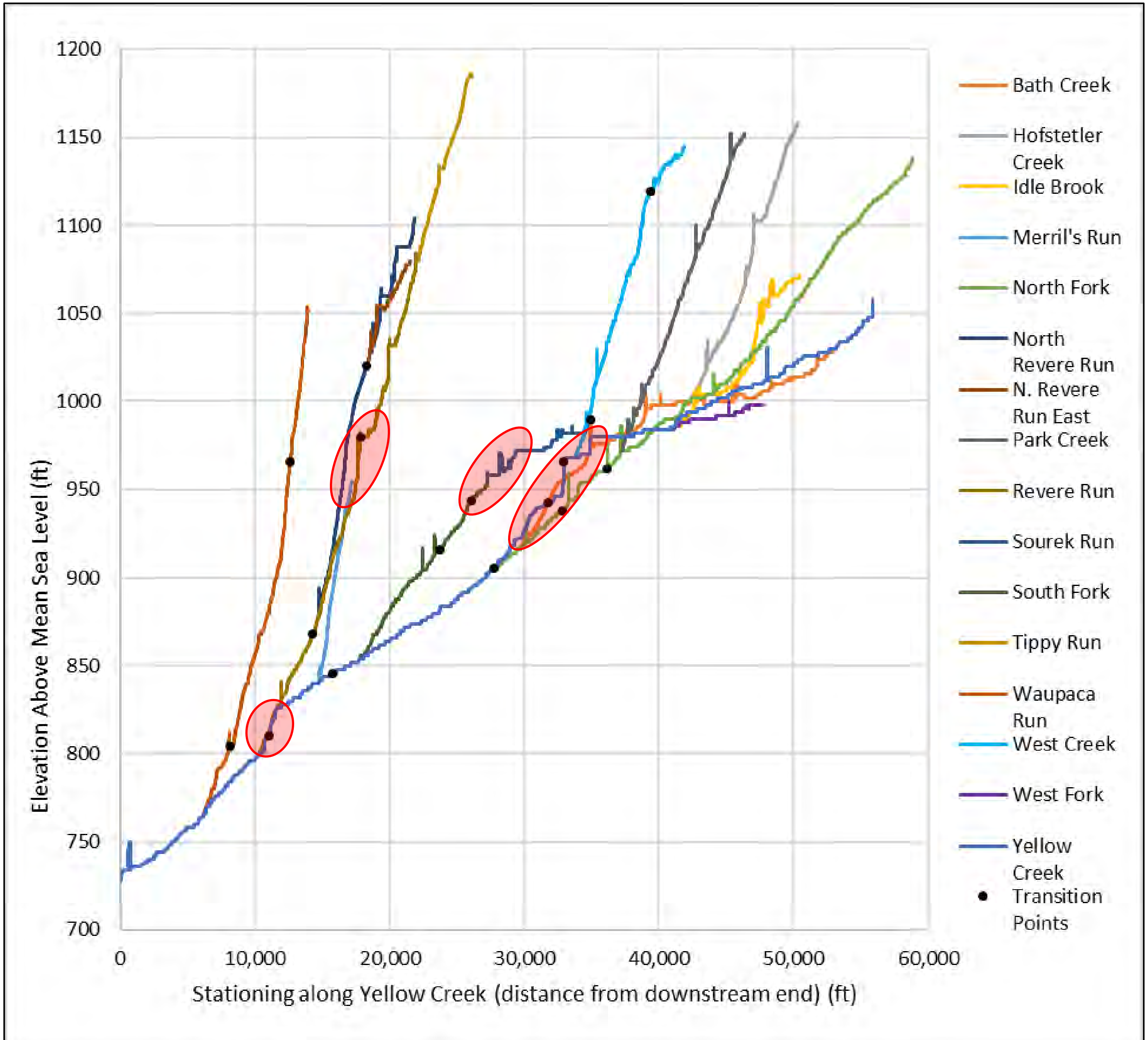


"Low" Risk

"Low" Risk
- High land, high streams, & typically broad floodplains

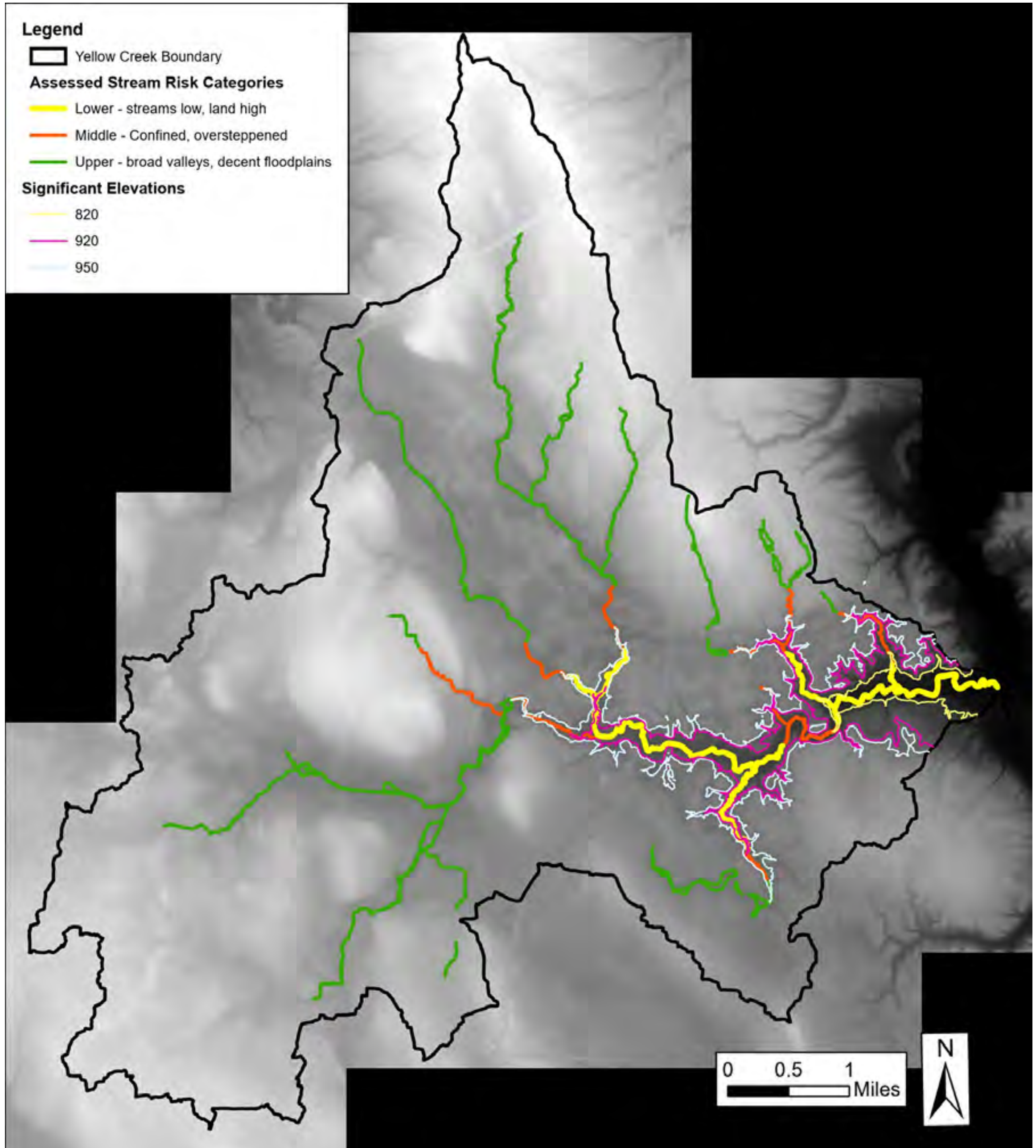

"Low" Risk Does NOT Equal No Risk

Over-steepened Reaches and Knickpoints




Bedrock Weathering at
“Knickpoint”

Knickpoints Correspond to Similar Elevations



Channel Evolution Stages

- Predictable trajectory of channel downcutting, widening, and enlargement in response to channelization and/or watershed urbanization

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
VOL. 36, NO. 1 AMERICAN WATER RESOURCES ASSOCIATION FEBRUARY 2000

CHANNEL INSTABILITY IN THE LOESS AREA OF THE MIDWESTERN UNITED STATES[1]

Andrew Simon and Massimo Rinaldi[2]

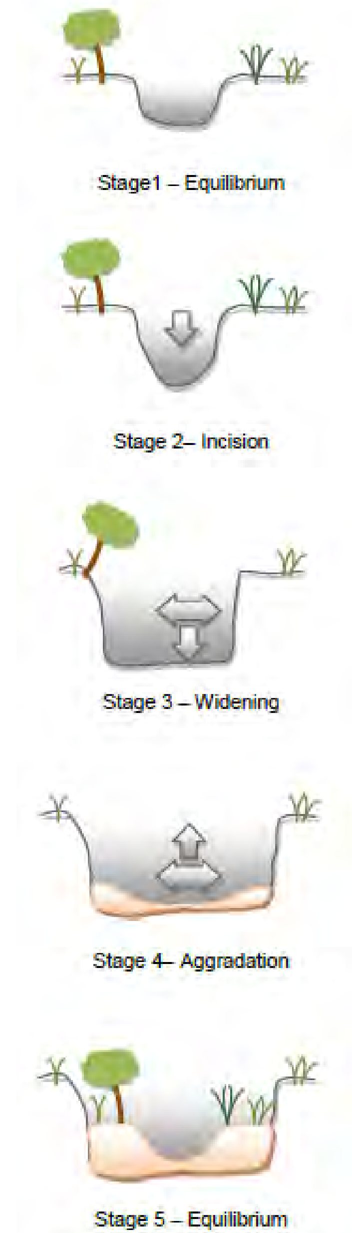
ABSTRACT: The loess area of the midwestern United States contains thousands of miles of unstable stream channels that are undergoing system-wide channel-adjustment processes as a result of (1) modifications to drainage basins dating back to the turn of the 20th century, including land clearing and poor soil-conservation practices, which caused the filling of stream channels, and consequently (2) direct, human modifications to stream channels such as dredging and straightening to improve drainage conditions and reduce the frequency of out-of-bank flows. Today, many of these channels are still highly unstable and threaten bridges, other structures, and land adjacent to the channels. The most severe, widespread instabilities are in western Iowa where a thick cap of loess and the lack of sand- and gravel-sized bed sediments in many channels hinders downstream aggradation, bed-level recovery and the consequent reduction of bank heights, and renewed bank stability. In contrast, streams draining west-central Illinois, east-central Iowa, and other areas, where the loess cap is relatively thin and there are ample supplies of sand- and gravel-sized material, are closer to recovery. Throughout the region, however, channel widening by mass-wasting processes is the dominant adjustment process.
(KEY TERMS: unstable channels; loess channels; degradation; bank instability; shear strength.)

INTRODUCTION

The dynamic nature of alluvial streams signifies the ability to adjust to changes imposed on the fluvial system, be they natural or a result of human activities. Channel adjustments migrate upstream and downstream in an attempt to offset the disturbance by altering aspects of their morphology, sediment load, and hydraulic characteristics. Under "natural" conditions, in geologically stable areas such as the midwestern United States, the processes of erosion and deposition might occur at such low rates and over such extended periods of time, that they can be virtually imperceptible. Human and natural factors or disturbances, however, combine to accelerate and exacerbate these processes, and as a result, rapid and observable morphologic changes occur as the channel attempts to offset the disturbance and return to an equilibrium condition. Adjustments to human disturbances can involve short time scales (days) and limited spatial extents (a stream reach), or longer periods of time (scores to hundreds of years) and entire fluvial systems, depending on the magnitude, extent, and type of disturbance (Williams and Wolman, 1984; Simon, 1994).

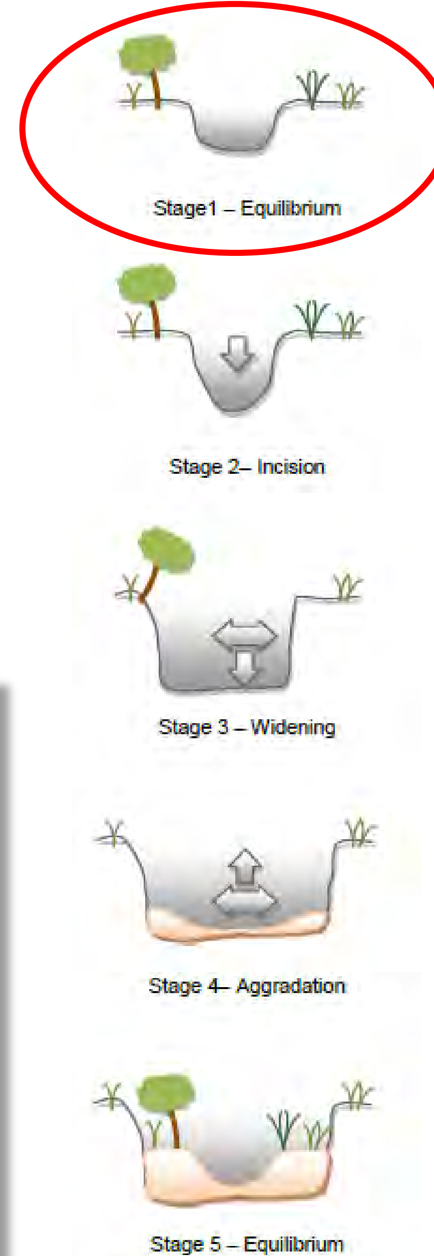
In the highly erodible loess area of the midwestern United States (Figure 1), human disturbances to flood plains and upland areas culminating near the turn of the 20th century resulted in channels being choked with sediment and debris. Beginning about 1910, channels were enlarged and straightened throughout the region to alleviate frequent and prolonged flooding of bottomlands (Speer *et al.,* 1965). Over the next 80 years, accelerated channel erosion and the formation of canyon-like stream channels have resulted in severe damage to highway structures, pipelines, fiber-optic lines, and land adjacent to the stream channels. Accelerated stream-channel degradation has resulted in an estimated $1.1 billion in damages to infrastructure and the loss of agricultural lands since the turn of the century in western Iowa (Baumel, 1994). A survey of 15 counties in northwestern Missouri identified 957 highway structures as damaged by channel degradation. Degradation and channel widening in the loess area led to the collapse of several bridges in West Tennessee (Robbins and Simon, 1983), southwest Mississippi (Wilson, 1979), Missouri (Emerson,

[1]Paper No. 99012 of the *Journal of the American Water Resources Association.* **Discussions are open until October 1, 2000.**
[2]Respectively, USDA-Agricultural Research Service, National Sedimentation Laboratory, 598 McElroy Drive, P.O. Box 1157, Oxford, Mississippi 38655; and Universita degli Studi di Firenze, Florence, Italy (E-Mail/Simon: simon@sedlab.olemiss.edu).



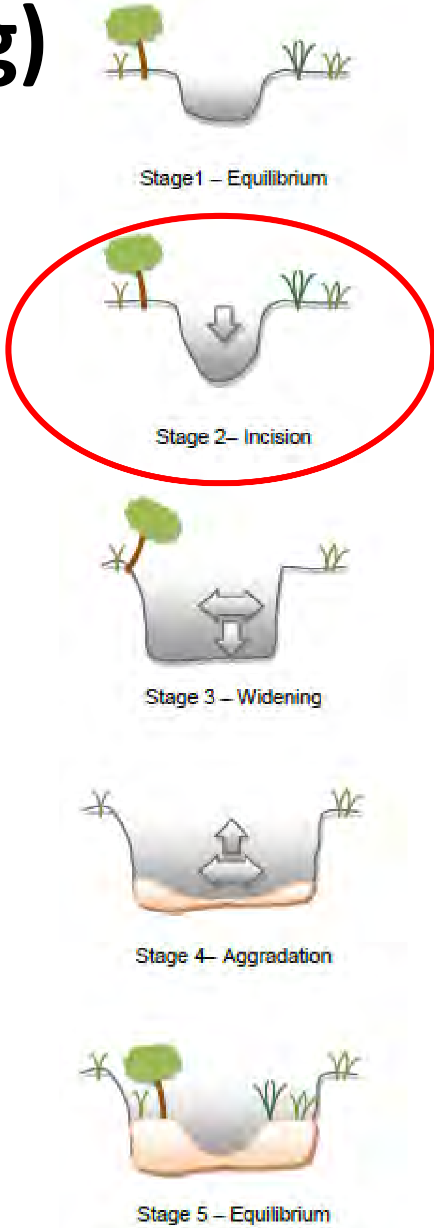
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 1 – Equilibrium



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 2 – Incision (Downcutting)



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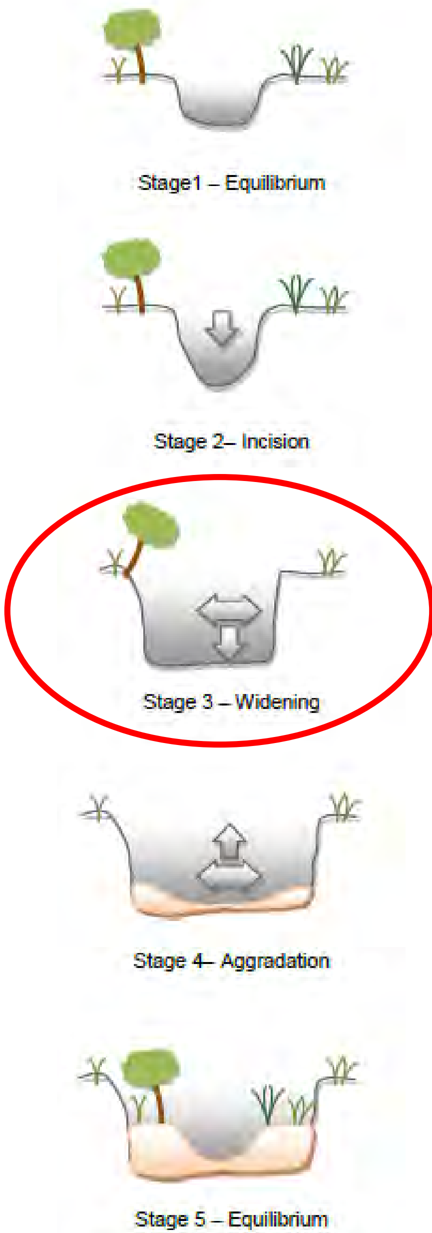
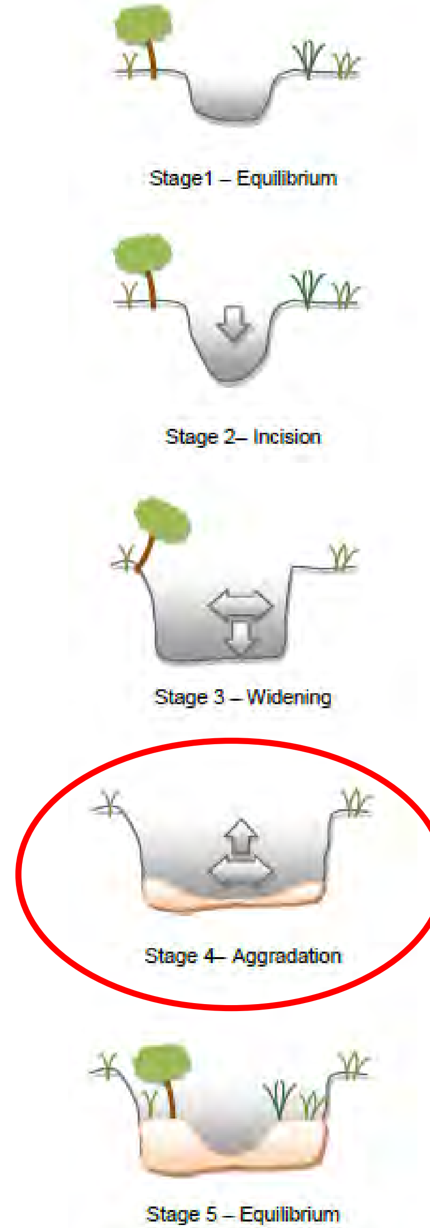
Stage 3 – Widening



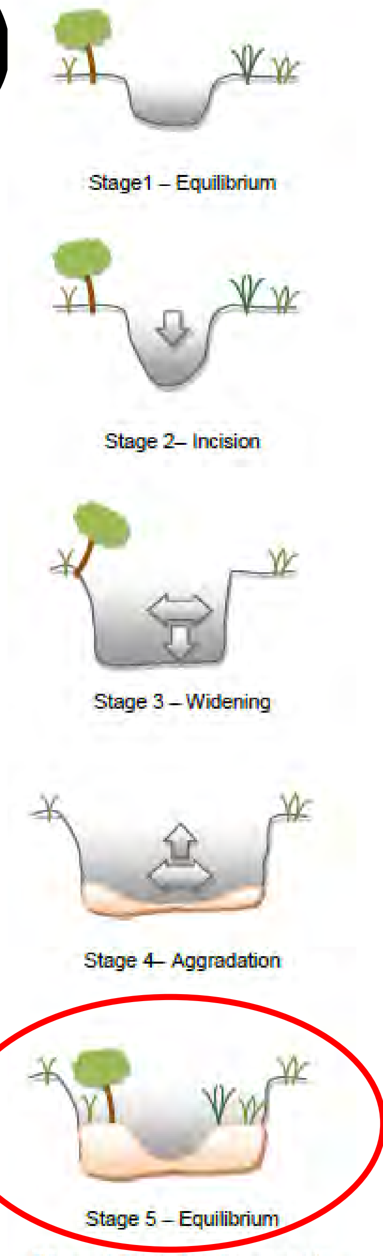
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

Stage 4 – Aggradation



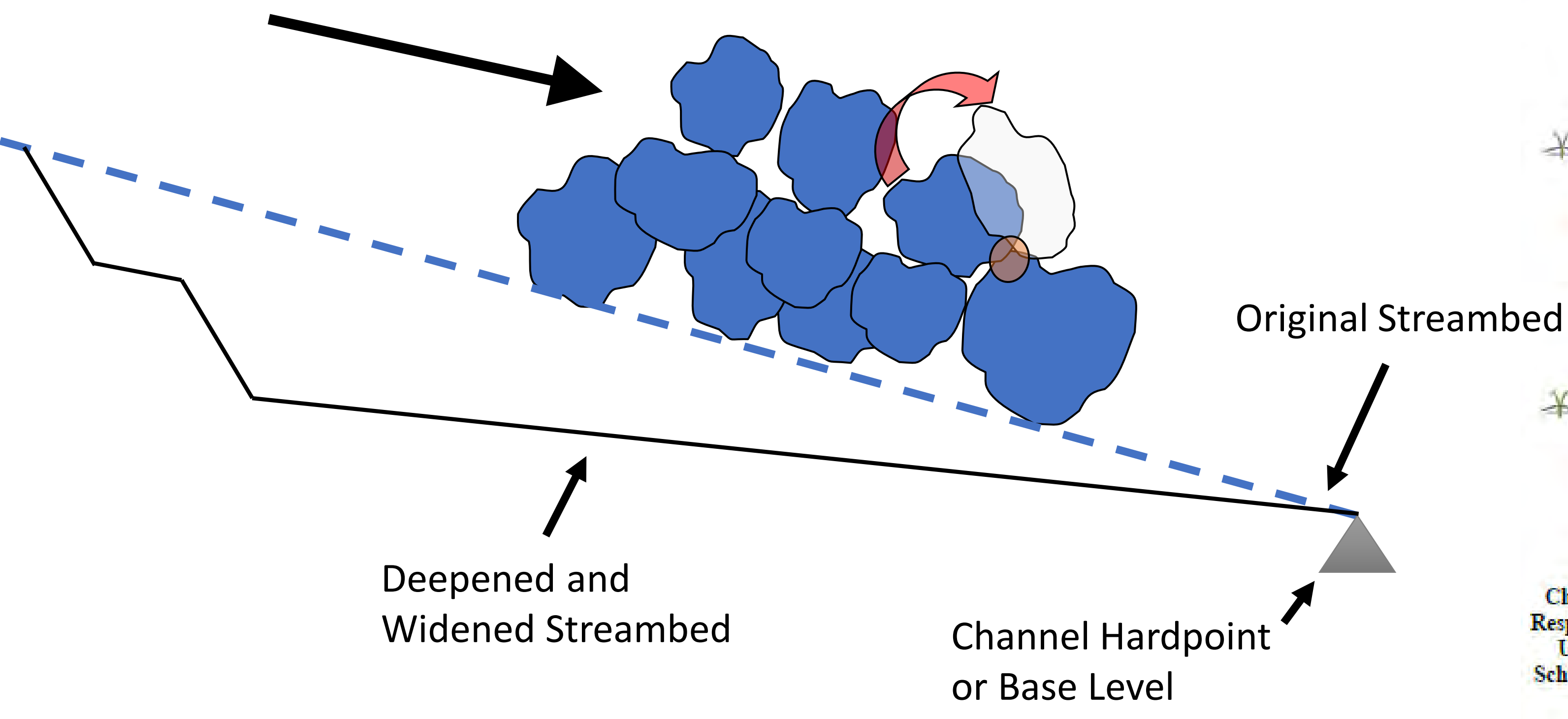
Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

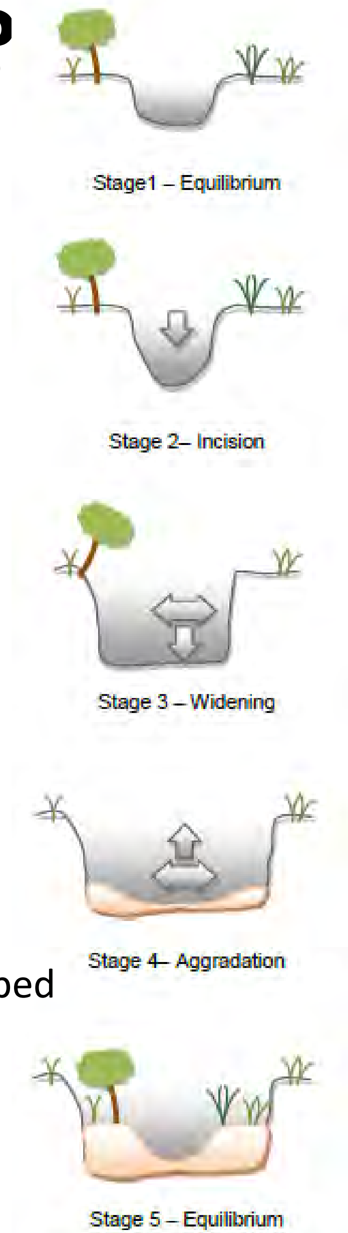
Stage 5 – Equilibrium (Recovered)



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

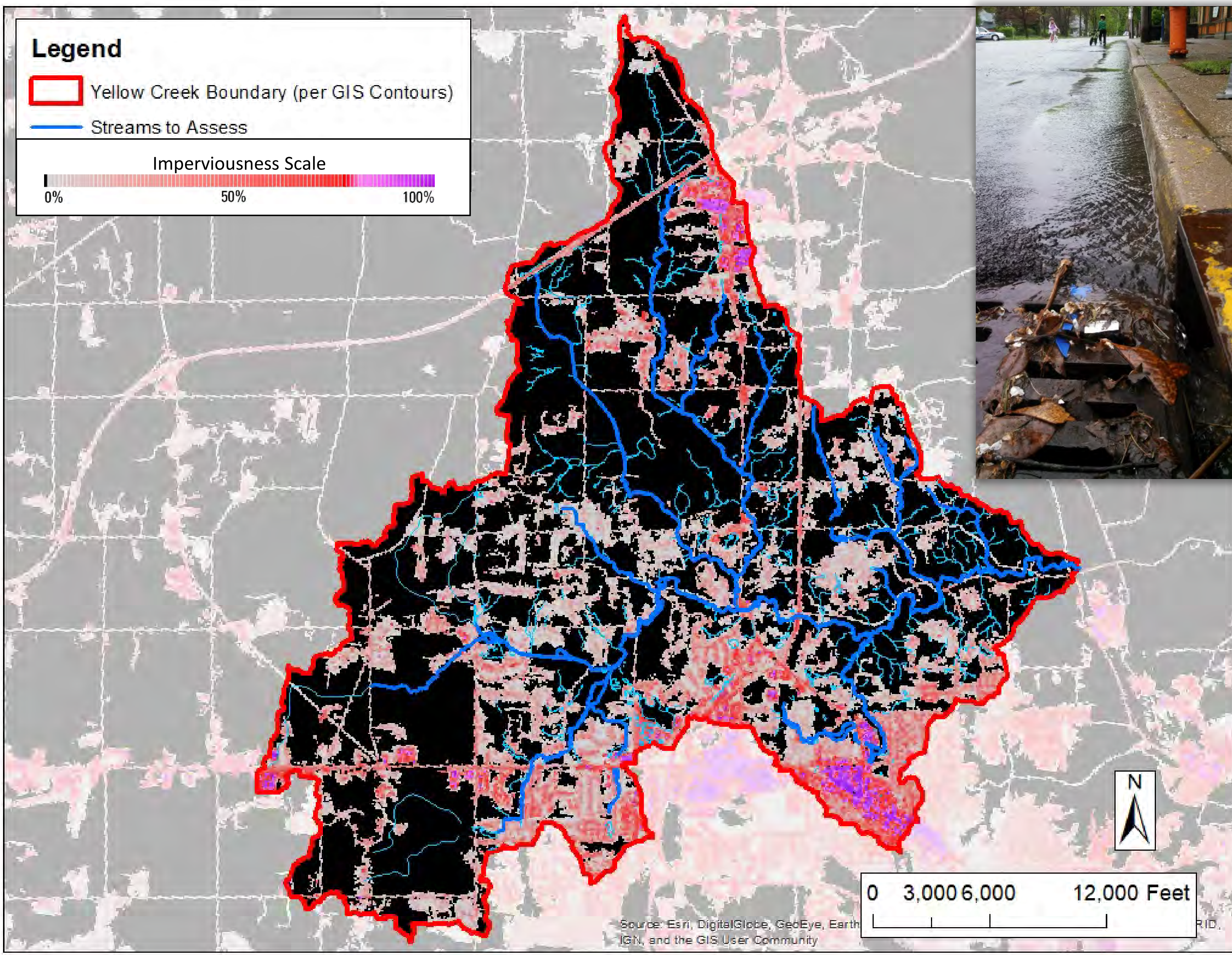
How Does A Stream Get Deeper?



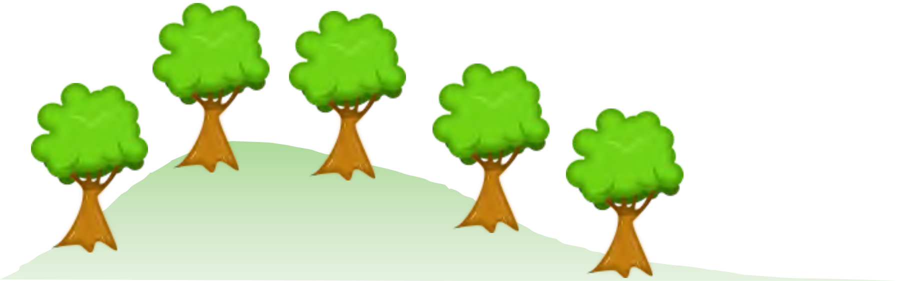


Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

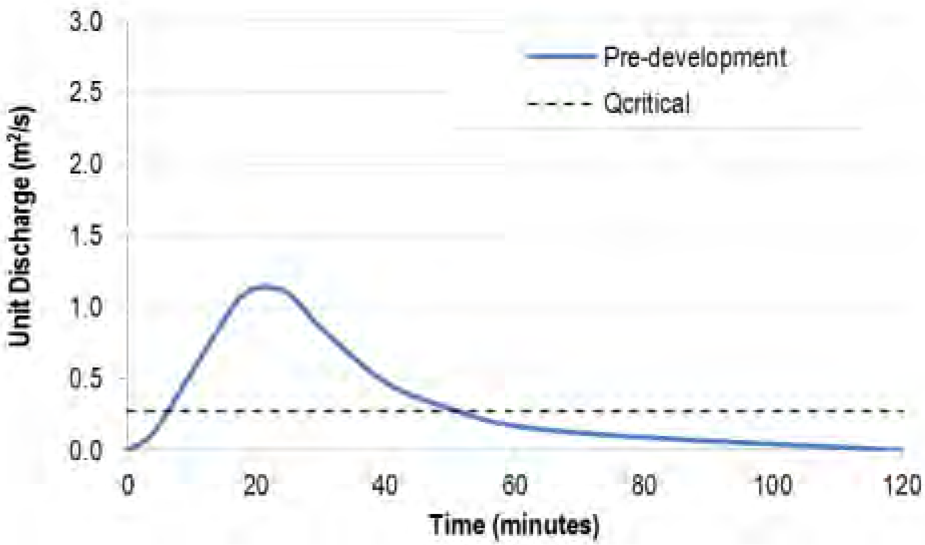
How Can Stormwater Runoff Contribute to Erosion?



History of Stormwater Management

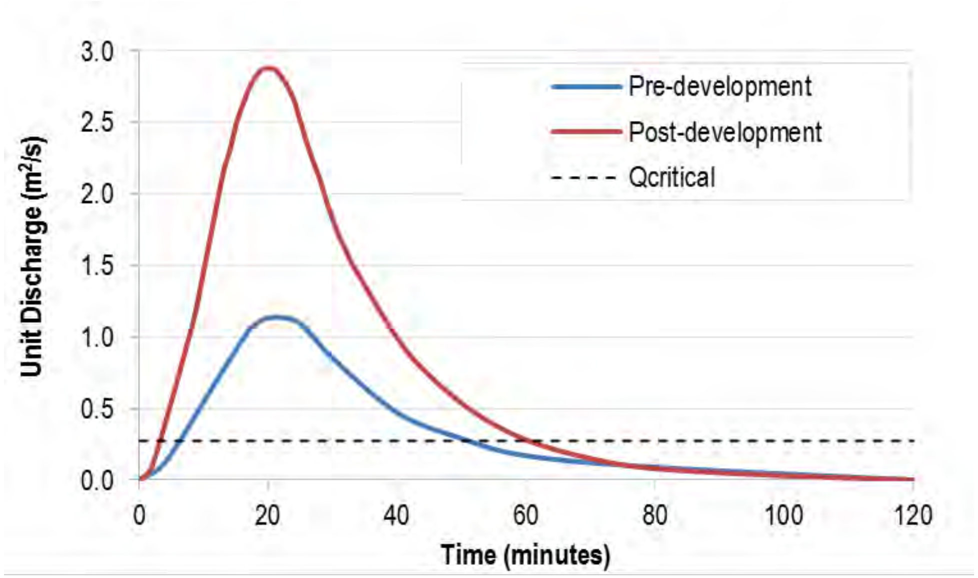


(sensu Roy et al., 2008)



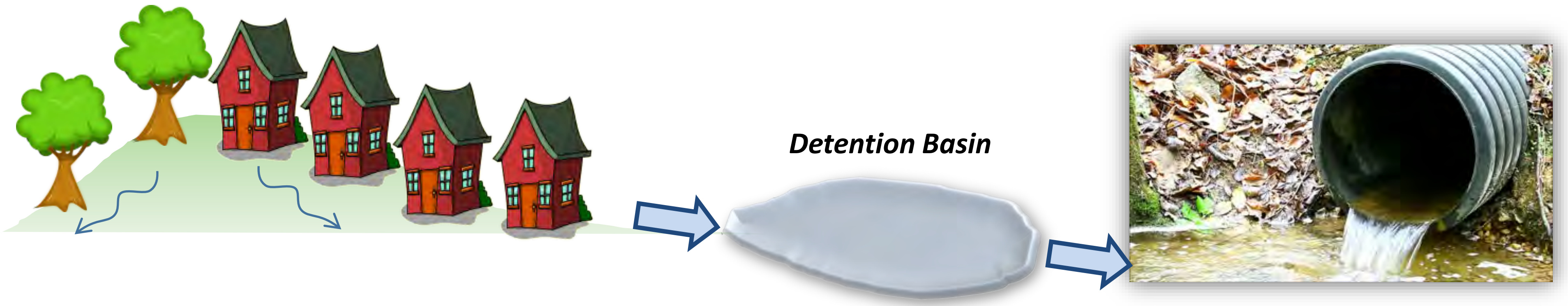
Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

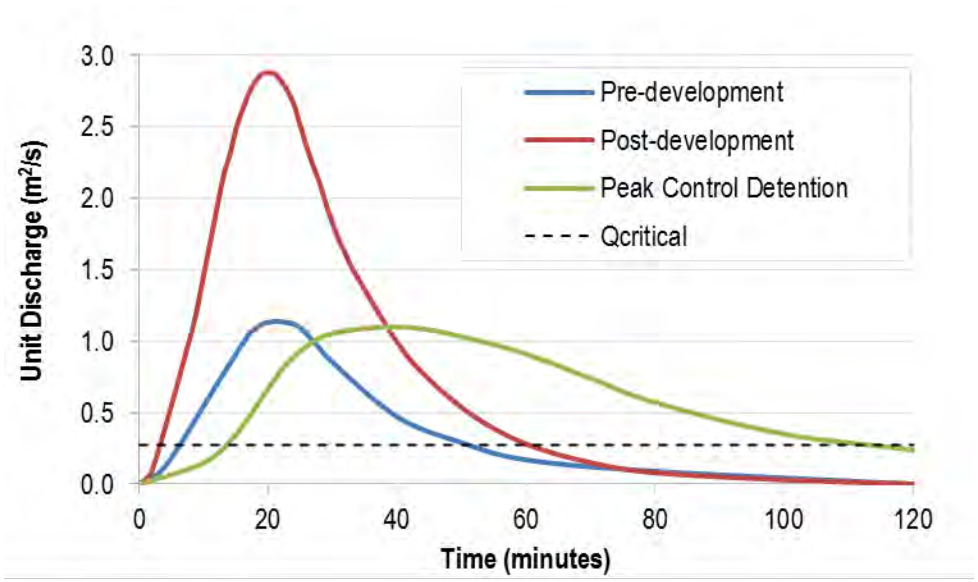
~Pre-1950



Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

~1980-2000





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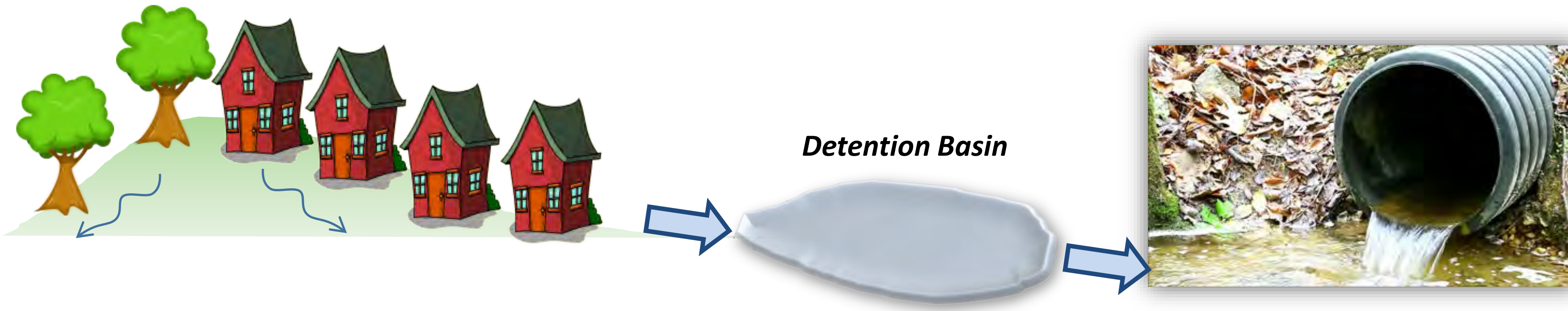
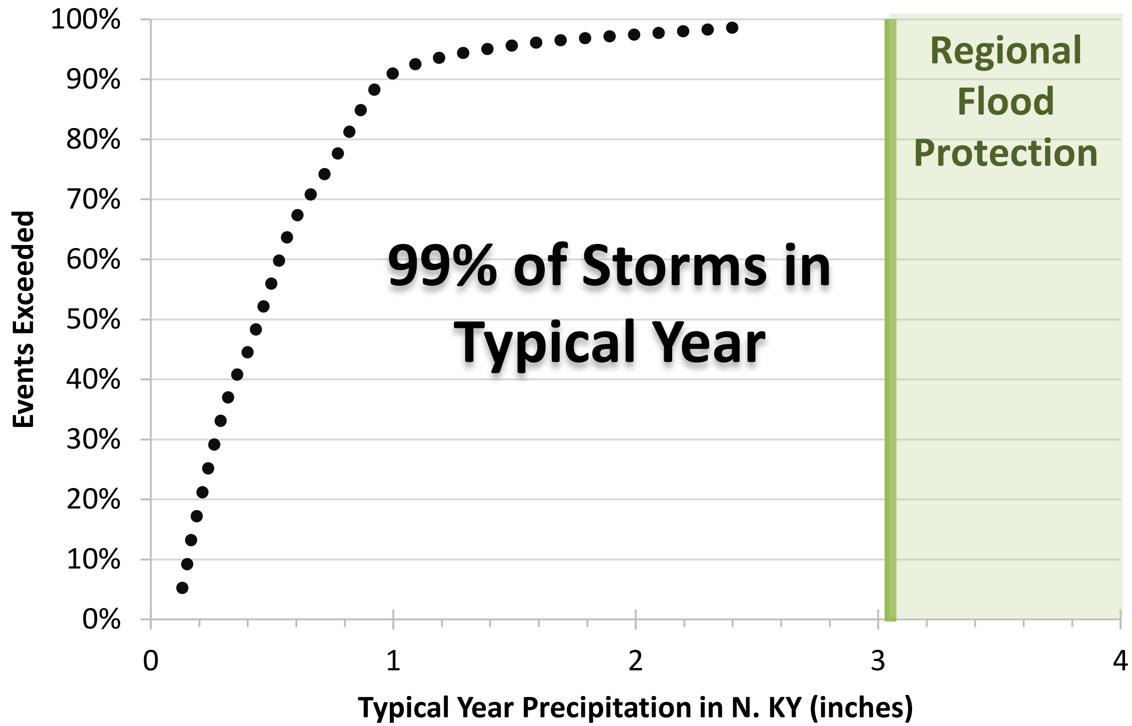
~1980-2000



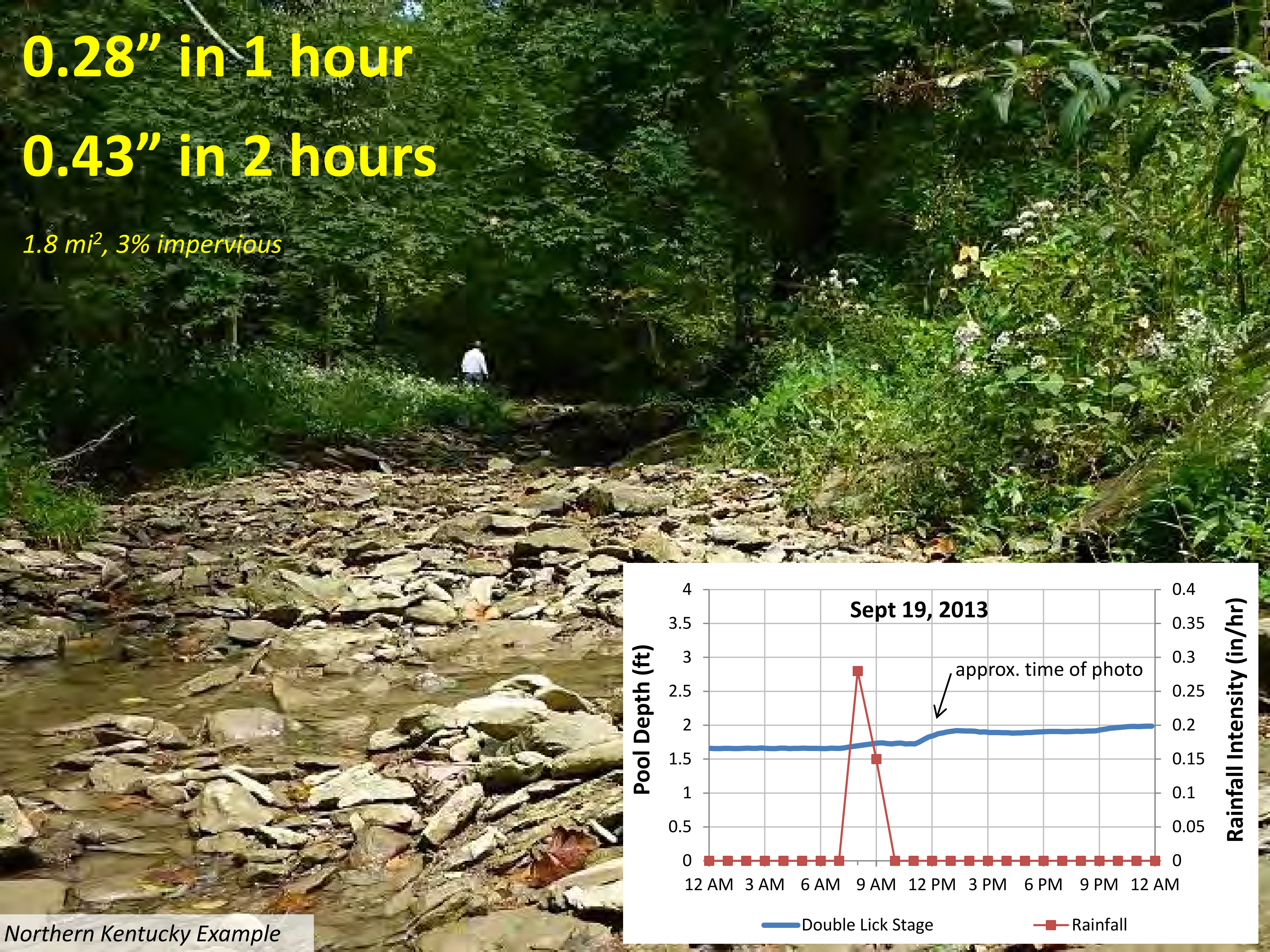


Adapted from Hawley (2012)

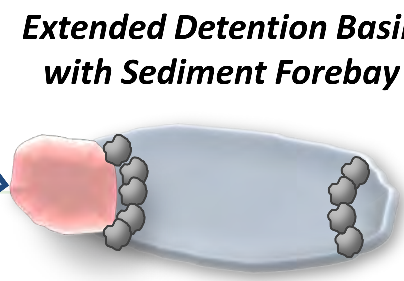
0.3” in 1 hour

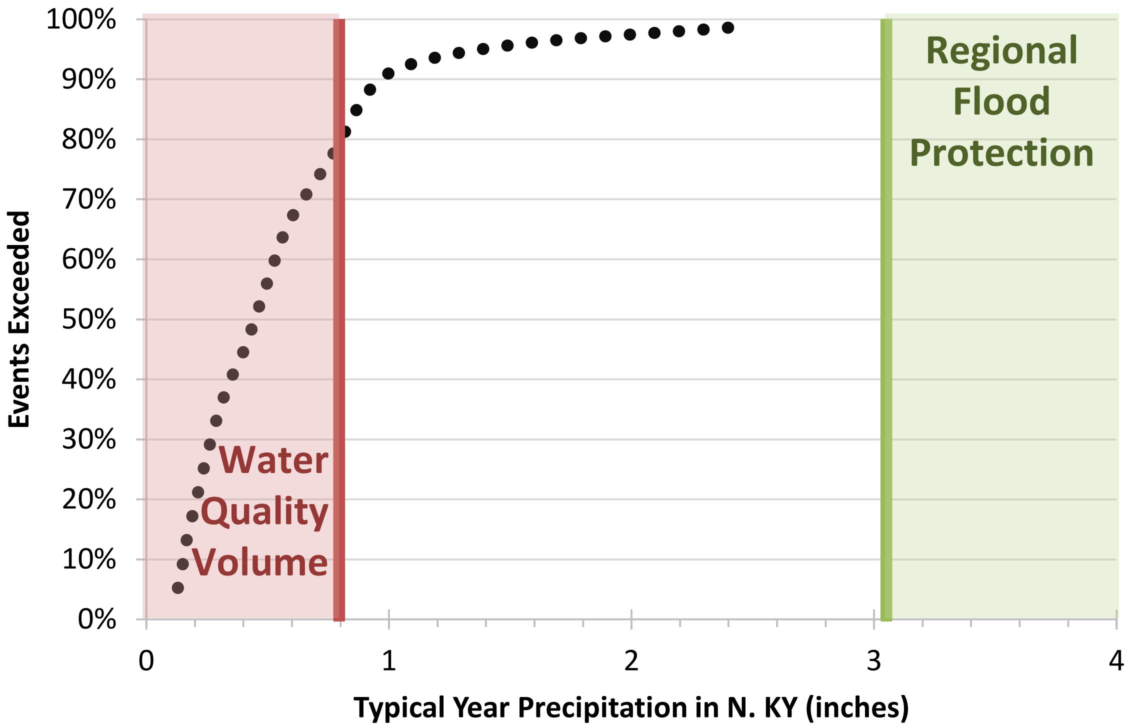
2.2 mi^2, 29% impervious

Northern Kentucky Example


0.28” in 1 hour
0.43” in 2 hours
1.8 mi², 3% impervious
Northern Kentucky Example
Sept 19, 2013
approx. time of photo
Pool Depth (ft)
Rainfall Intensity (in/hr)
4
3.5
3
2.5
2
1.5
1
0.5
0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
12 AM
3 AM
6 AM
9 AM
12 PM
3 PM
6 PM
9 PM
12 AM
Double Lick Stage
Rainfall

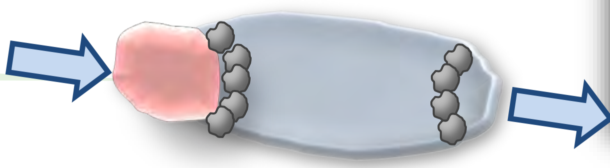
~2000-2015

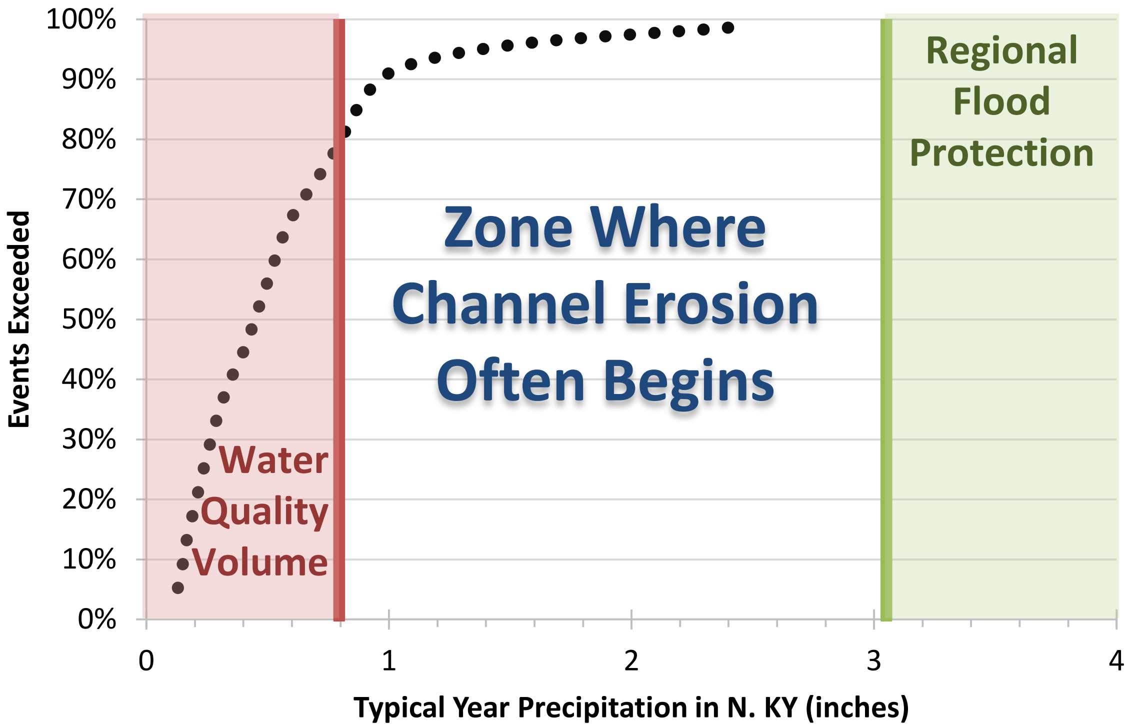




Adapted from Hawley (2012)

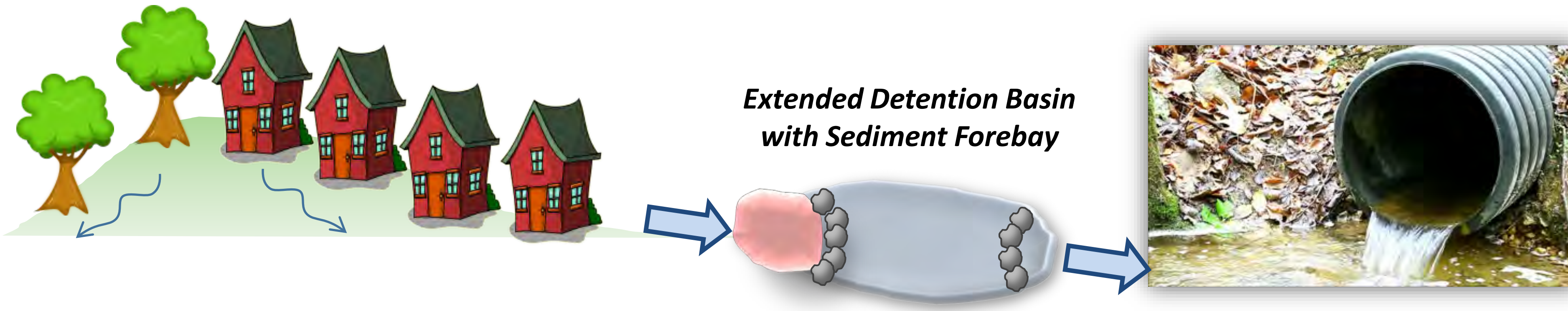
~2000-2015

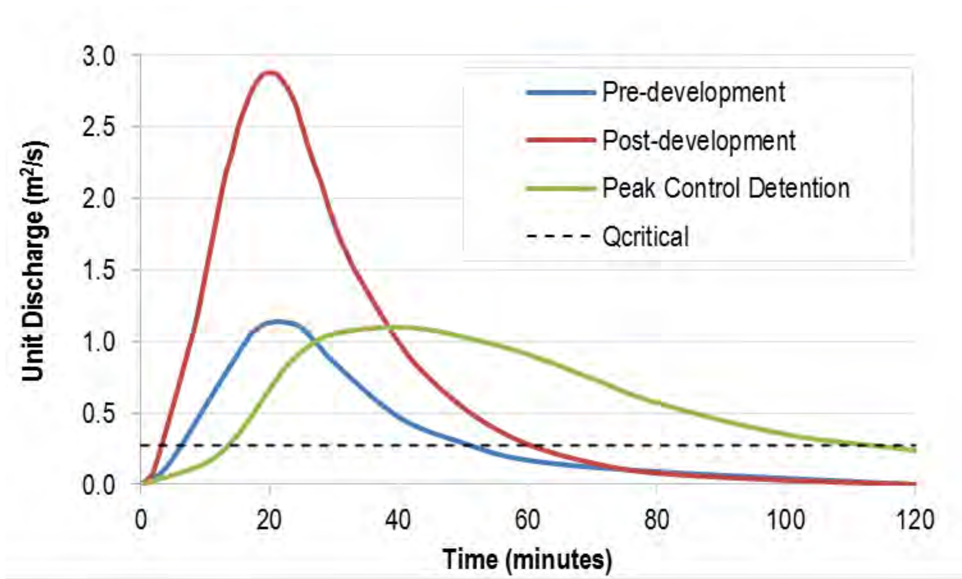




Adapted from Hawley (2012)

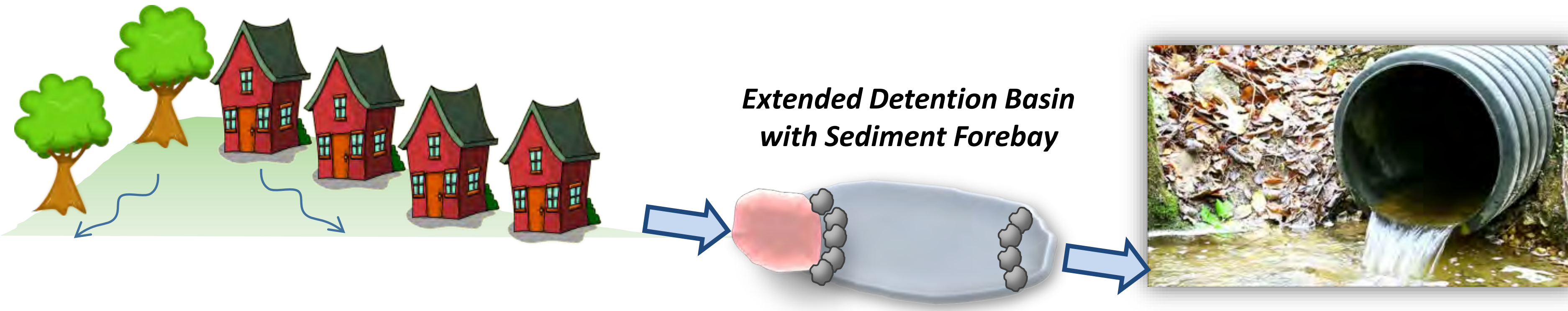
~2000-2015

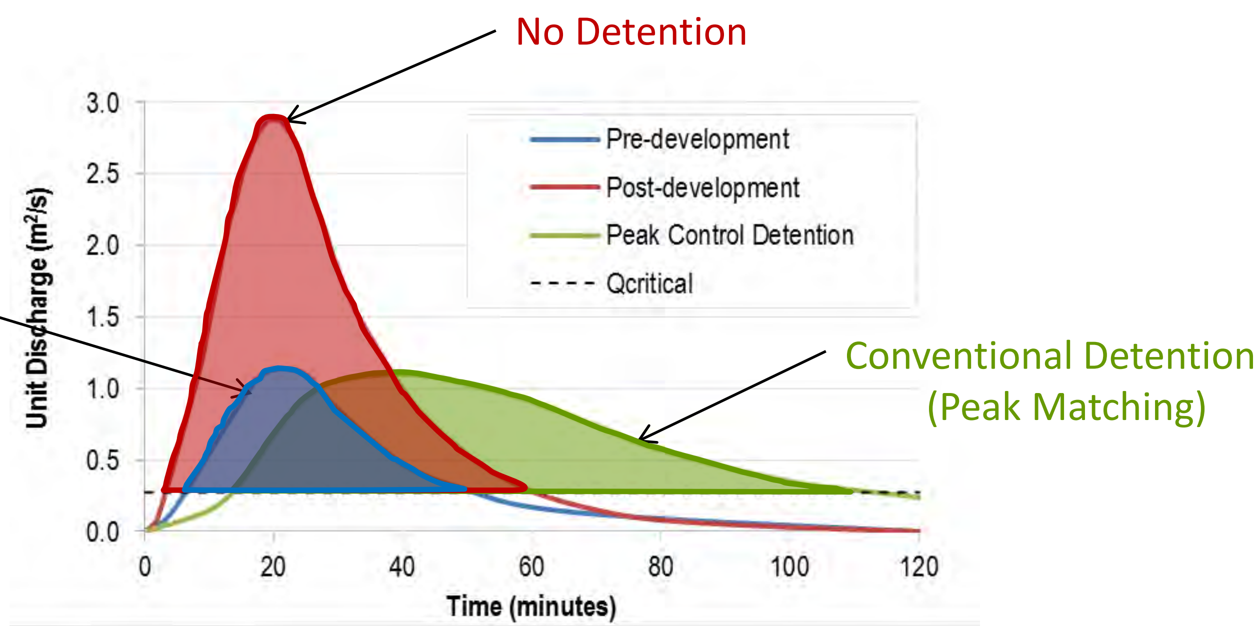




Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002),
Journal of Water Resources Planning and Management

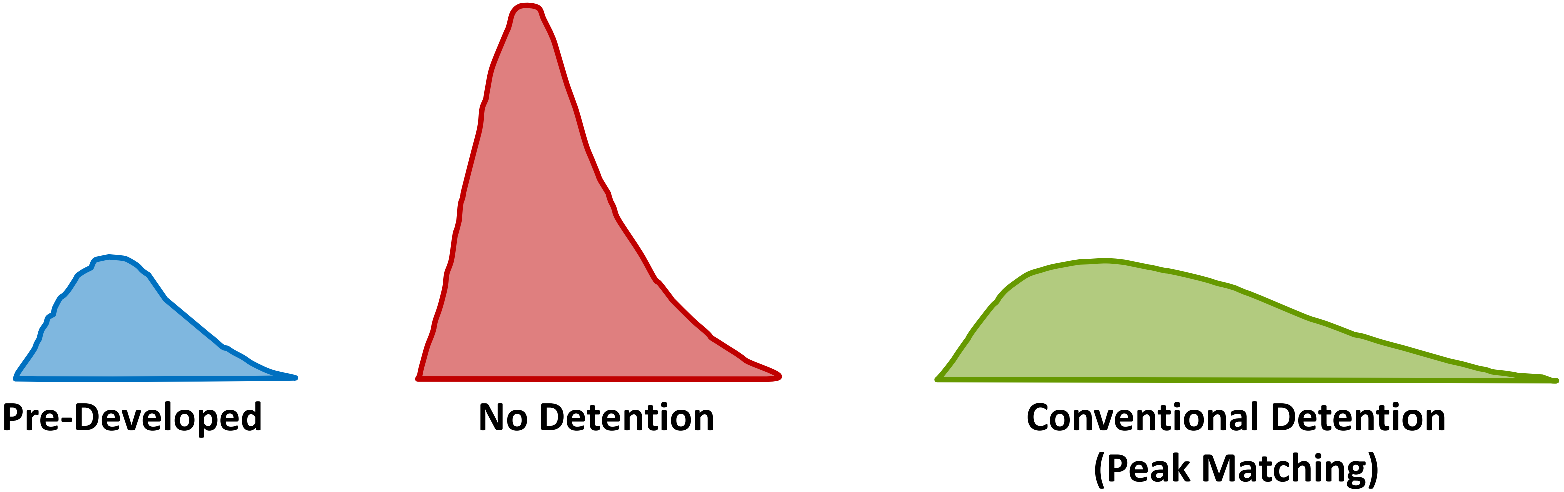
~2000-2015





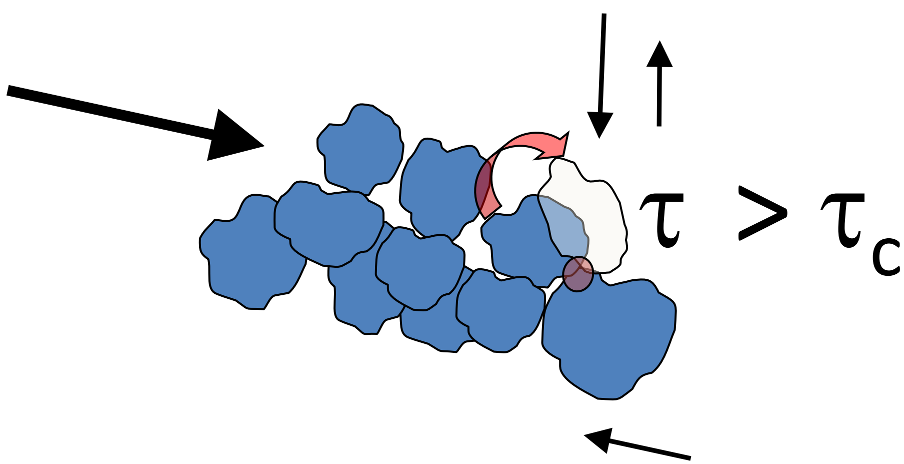
Analysis of the 2-yr, 2-hr storm from Fort Collins, CO by Bledsoe (2002), Journal of Water Resources Planning and Management

Conventional Detention = ***More Erosion*** than Pre-Developed Conditions



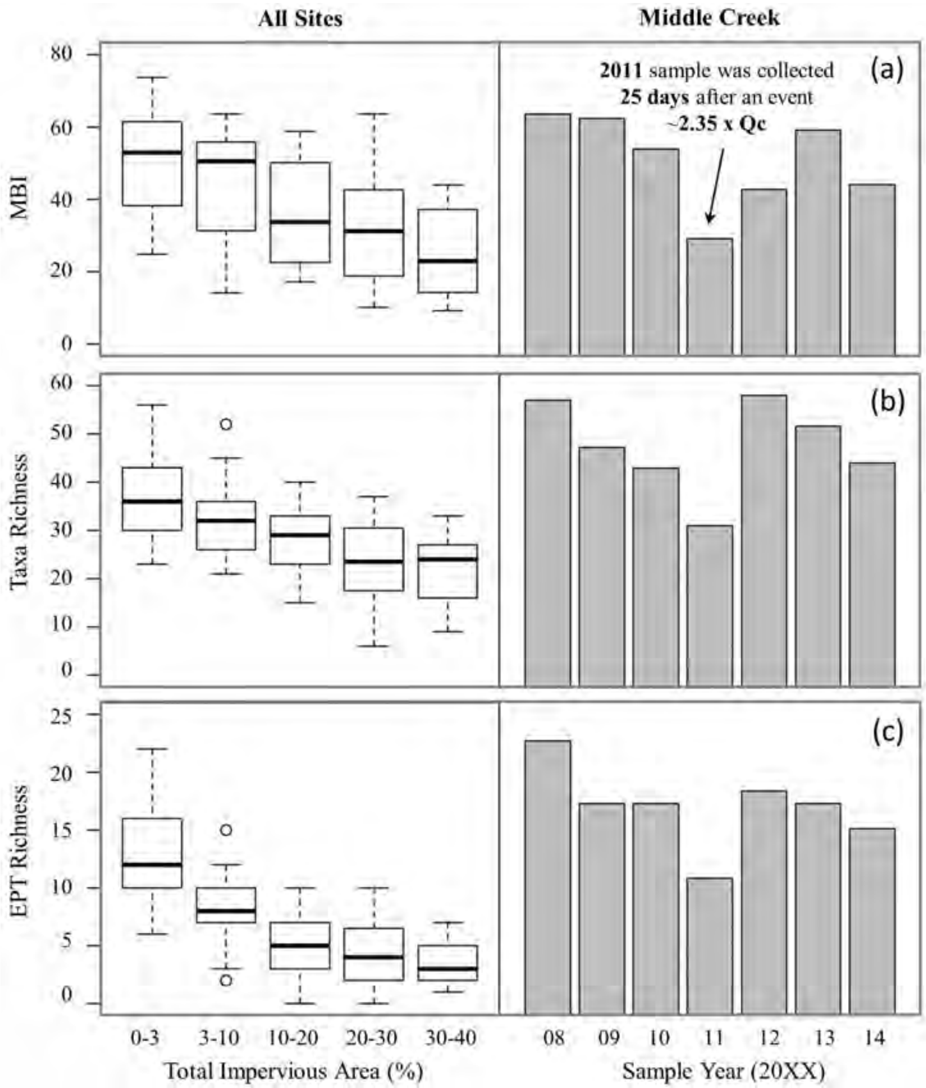
Introduction of $Q_{critical}$

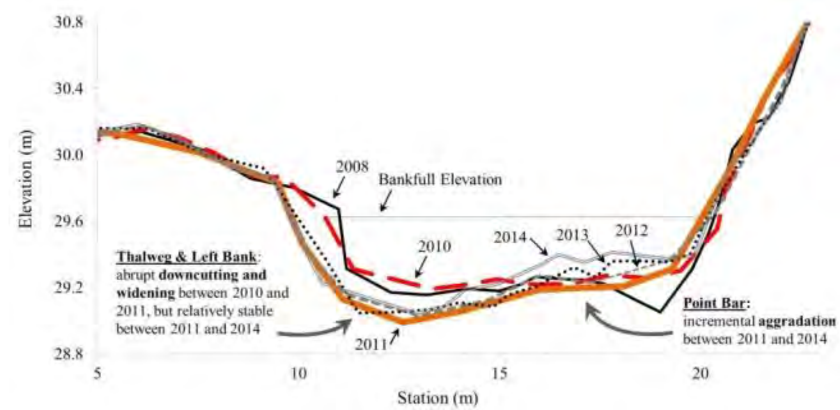
The Critical Flow for Stream Bed Erosion



Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

The Importance of $Q_{critical}$ Is even Evident at Reference Sites

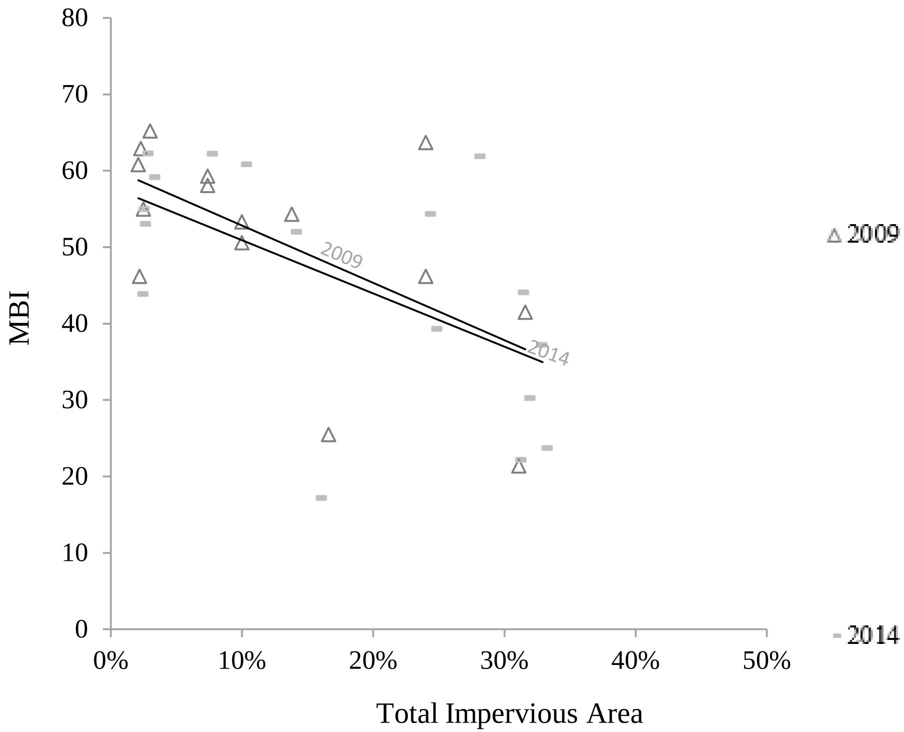




Adapted from Hawley et al. (2016, Freshwater Science)

Biological Impacts of $Q_{critical}$ Are Evident across the Full Gradient of Urbanization

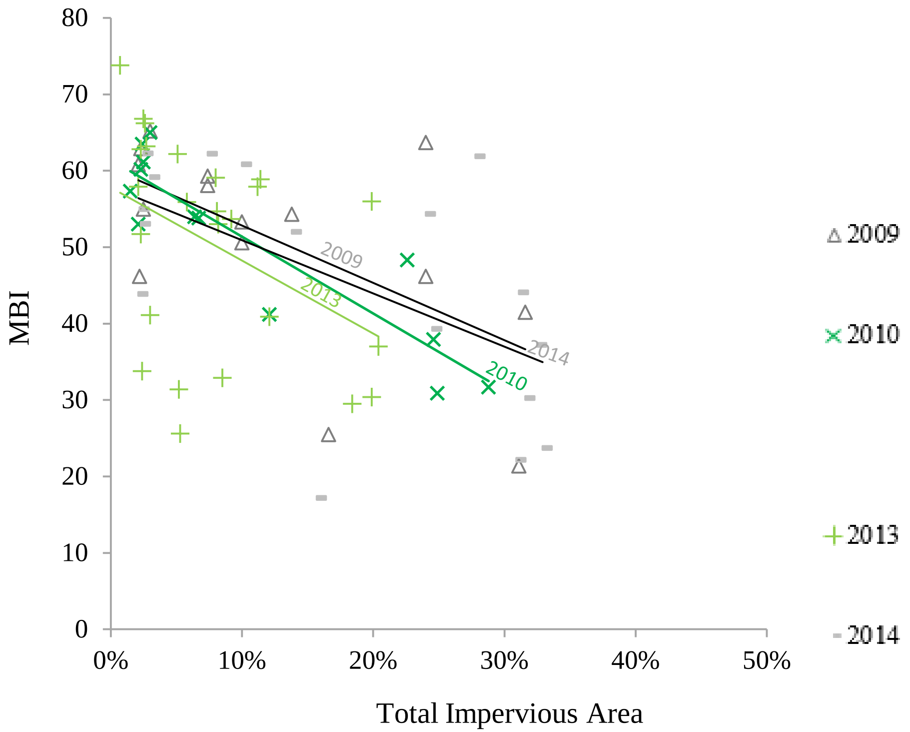
- **Lowest Disturbance (2009/2014)**
  - **Ref. sites** Good to Excellent
  - **20-30% TIA** Fair to <u>Excellent</u>



215-315 days since a $Q_{critical}$ event at MDC 5.5 (reference site) in 2009/2014
Adapted from Hawley et al. (2016, Freshwater Science)

Biological Impacts of $Q_{critical}$ Are Evident across the Full Gradient of Urbanization

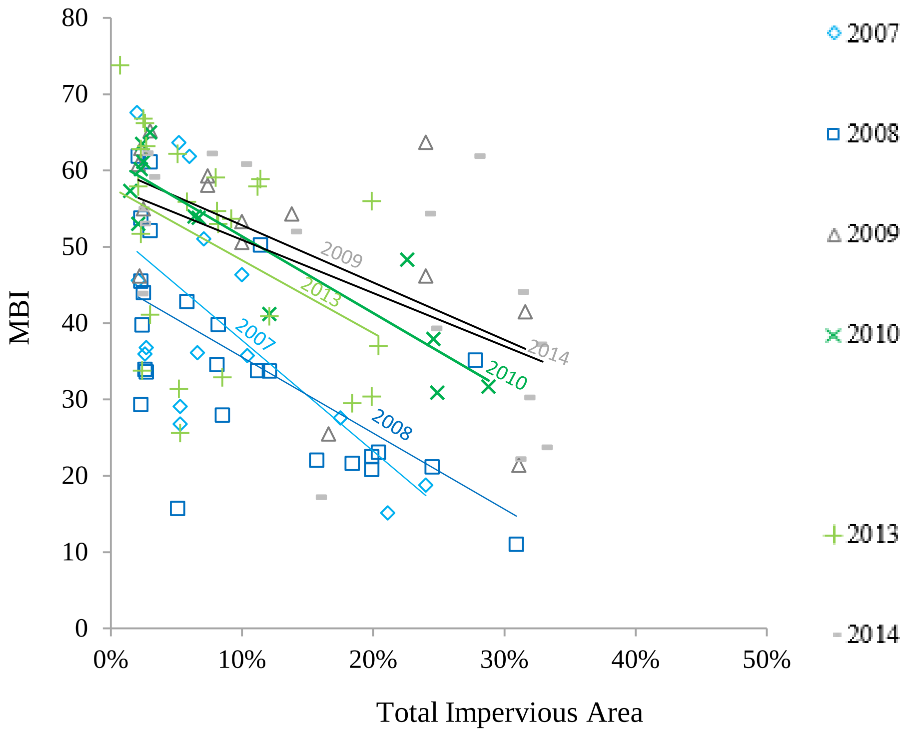
- **Lowest Disturbance (2009/2014)**
  - **Ref. sites** — **Good to Excellent**
  - **20-30% TIA** — **Fair to Excellent**
- **Low Disturbance (2010/2013)**
  - **Ref. sites** — **Good to Excellent**
  - **20-30% TIA** — **Poor to Good**



241-299 days since a $Q_{critical}$ event at MDC 5.5 (reference site) in 2010/2013
Adapted from Hawley et al. (2016, Freshwater Science)

Biological Impacts of $Q_{critical}$ Are Evident across the Full Gradient of Urbanization

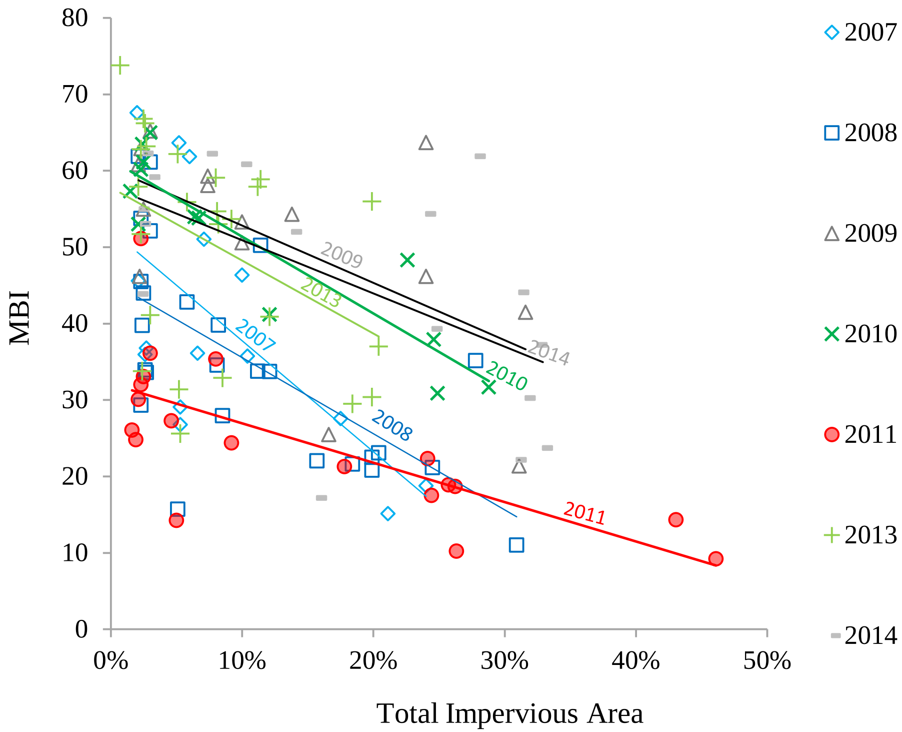
- **Lowest Disturbance (2009/2014)**
  - Ref. sites — Good to Excellent
  - 20-30% TIA — Fair to Excellent
- **Low Disturbance (2010/2013)**
  - Ref. sites — Good to Excellent
  - 20-30% TIA — Poor to Good
- **Intermediate Disturbance (2007/2008)**
  - Ref. sites — Poor to Excellent
  - 20-30% TIA — Very Poor to Poor



206 days since a $Q_{critical}$ event at MDC 5.5 (reference site) in 2008
<60 days prior to the 2008 sample, an event almost exceeded $Q_{critical}$ at MDC5.5
Adapted from Hawley et al. (2016, Freshwater Science)

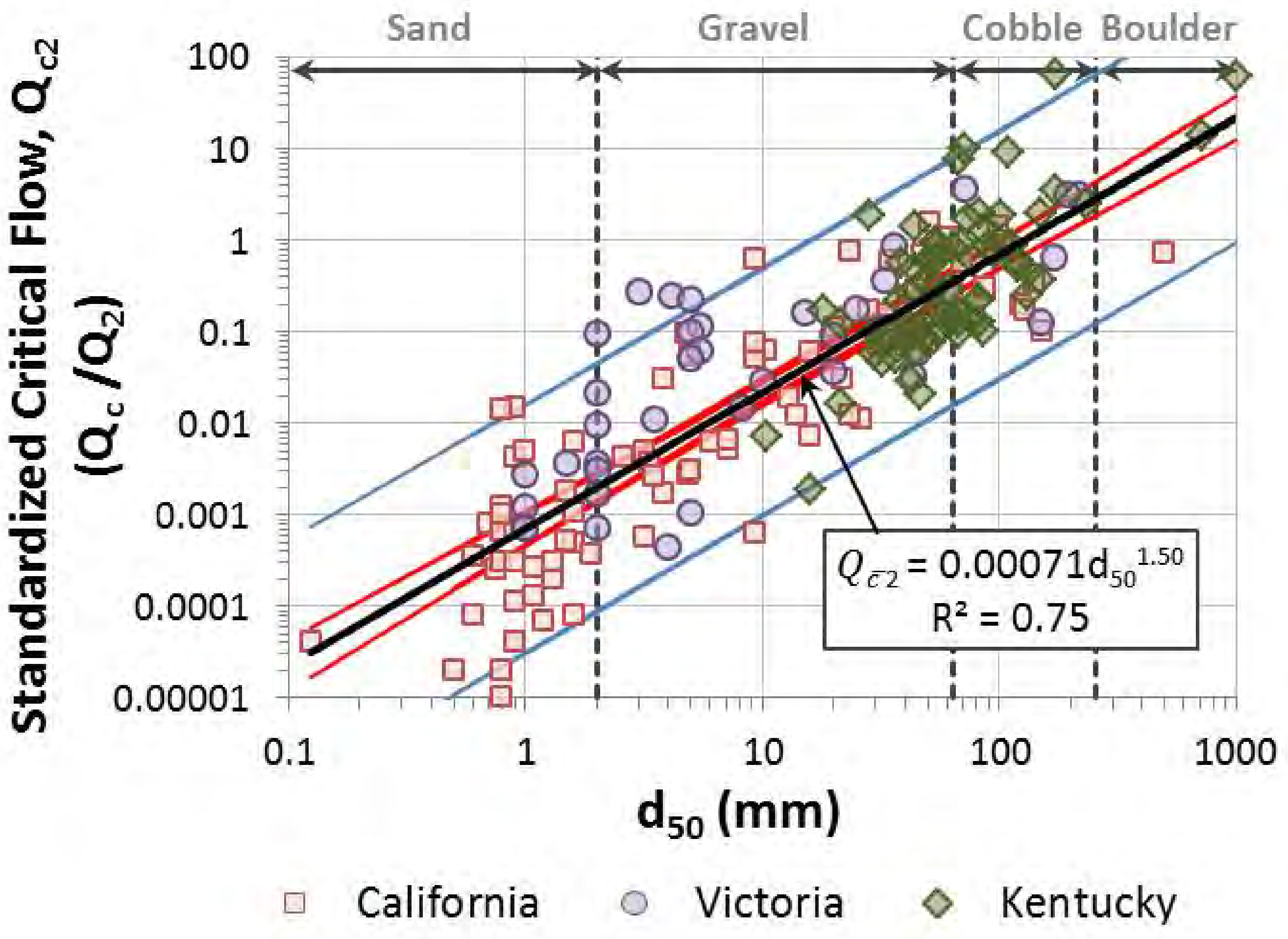
Biological Impacts of $Q_{critical}$ Are Evident across the Full Gradient of Urbanization

- Lowest Disturbance (2009/2014)
  - Ref. sites — Good to Excellent
  - 20-30% TIA — Fair to Excellent
- Low Disturbance (2010/2013)
  - Ref. sites — Good to Excellent
  - 20-30% TIA — Poor to Good
- Intermediate Disturbance (2007/2008)
  - Ref. sites — Poor to Excellent
  - 20-30% TIA — Very Poor to Poor
- High Disturbance (2011)
  - Ref. sites — Poor to Good
  - 20-30% TIA — Very Poor to Poor



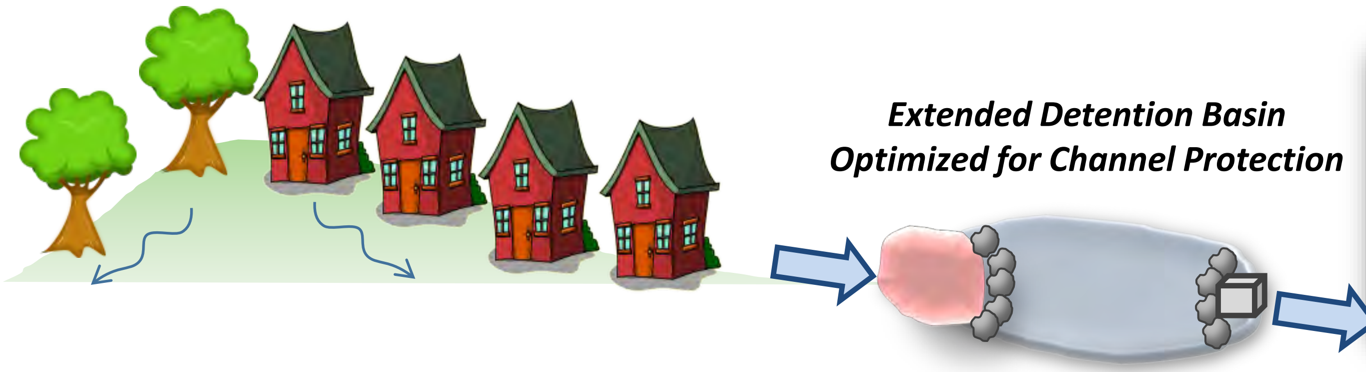
25 days since a $Q_{critical}$ event at MDC 5.5 (reference site) in 2011
Adapted from Hawley et al. (2016, Freshwater Science)

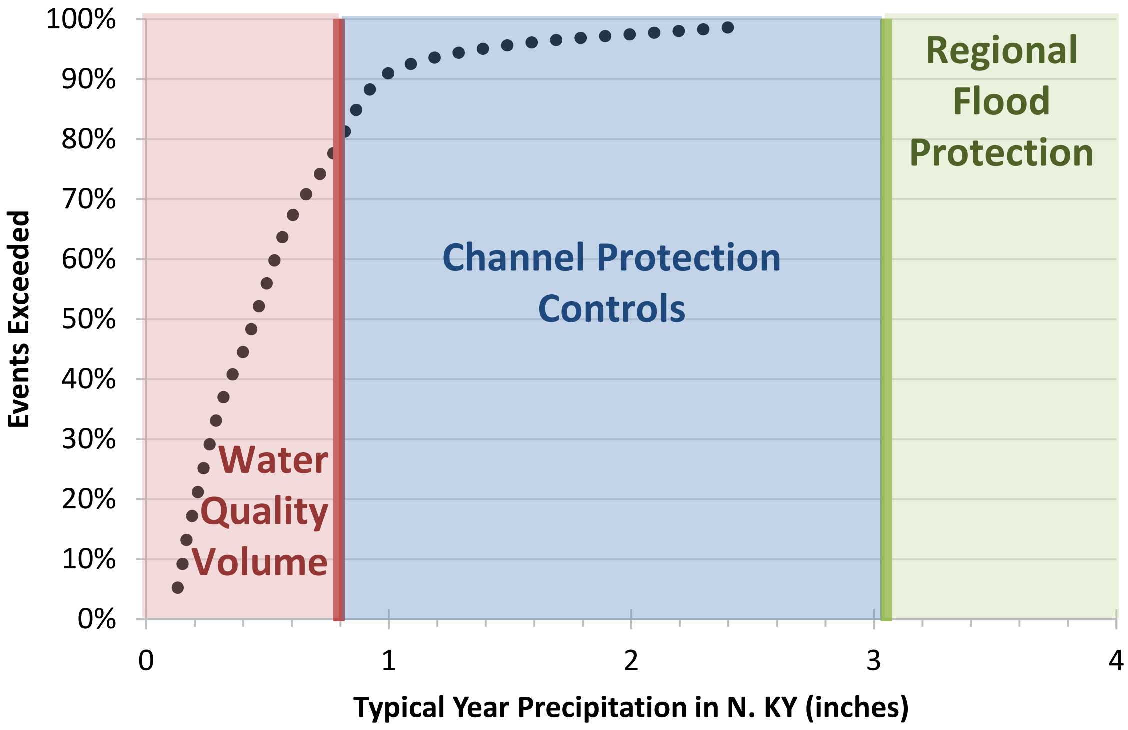
$Q_{critical}$ Needs to Be Calibrated to Stream/Region



Adapted from Hawley and Vietz (2016, Freshwater Science)

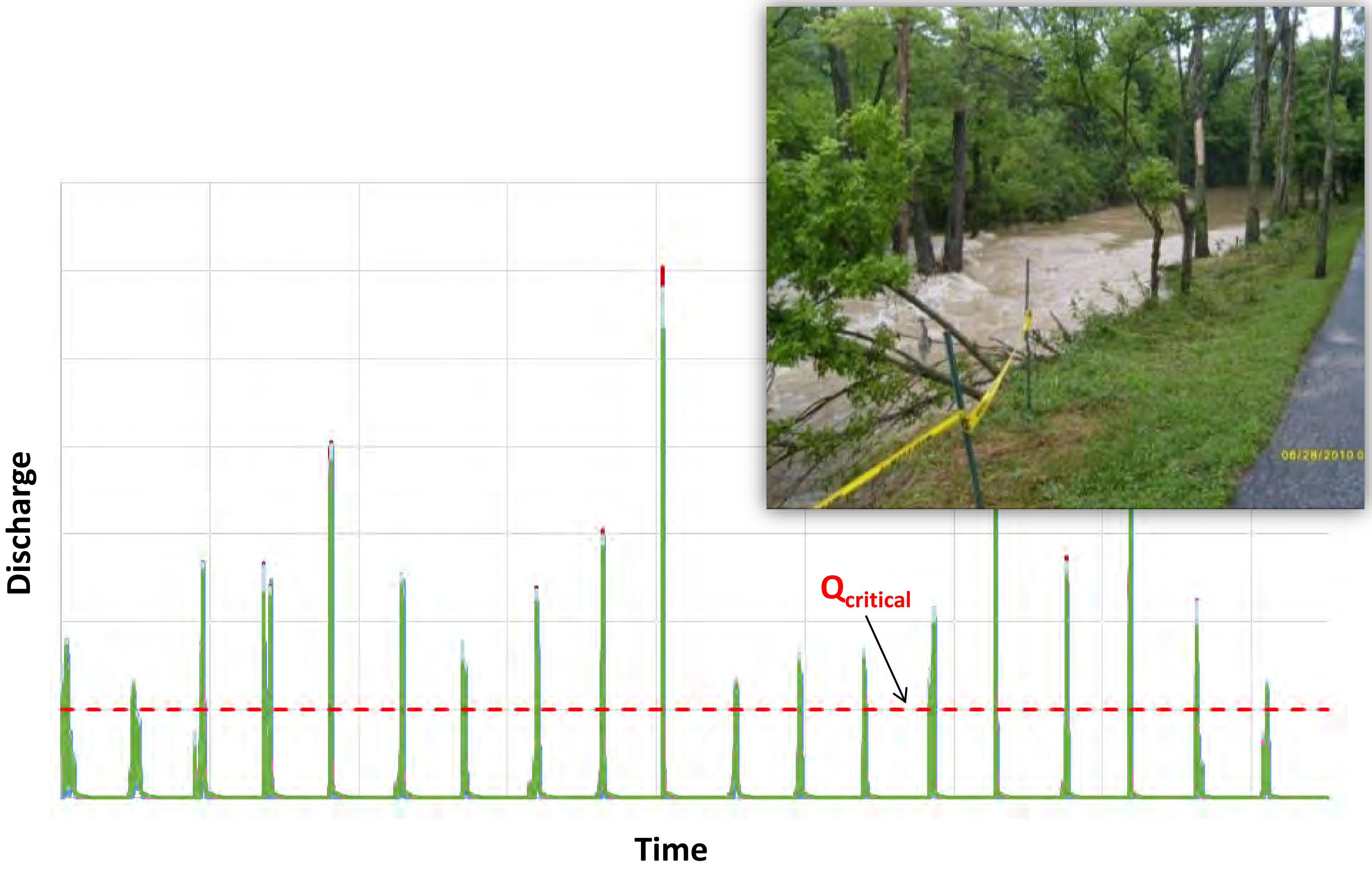
Future of Stormwater Management



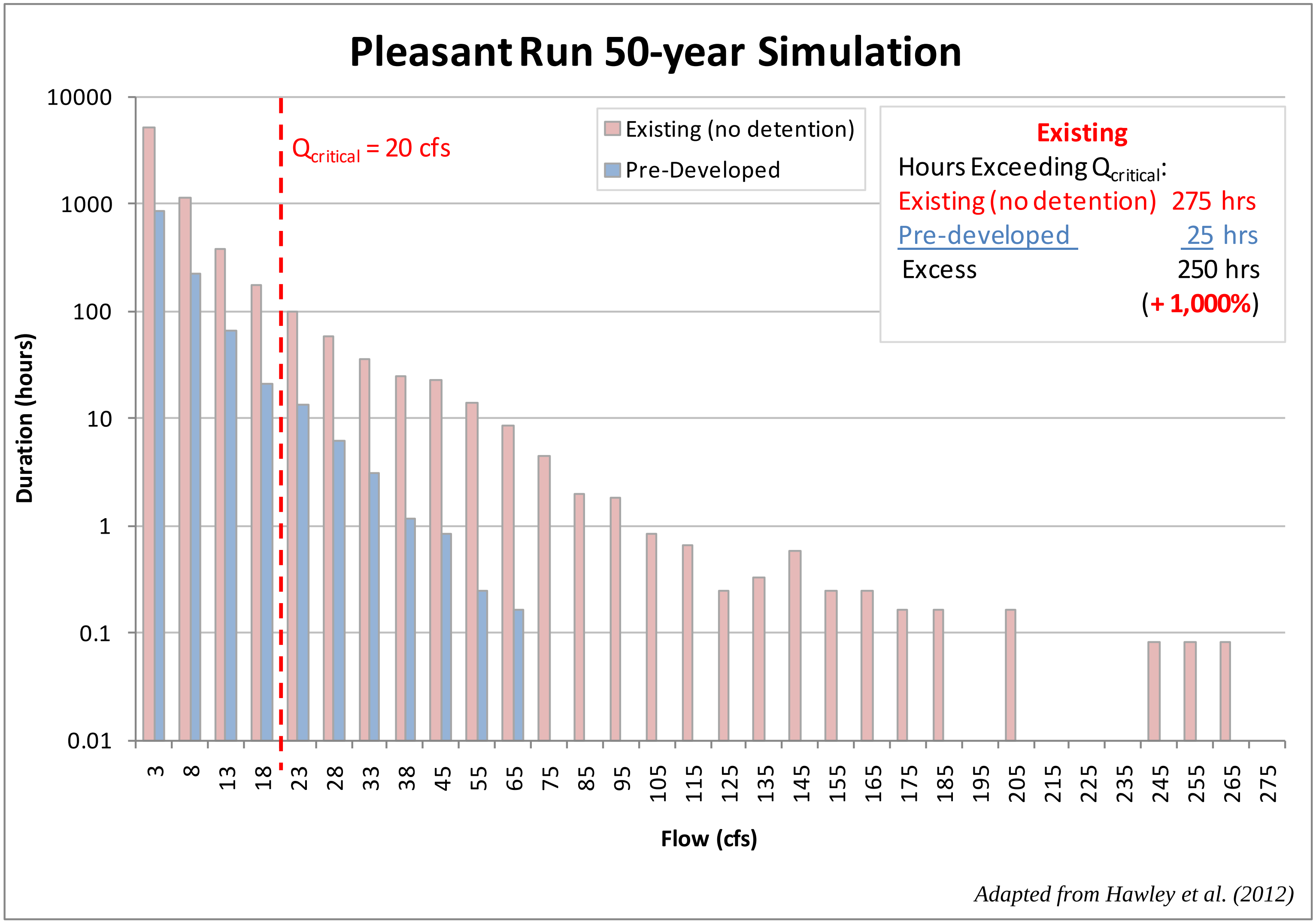


Adapted from Hawley (2012)

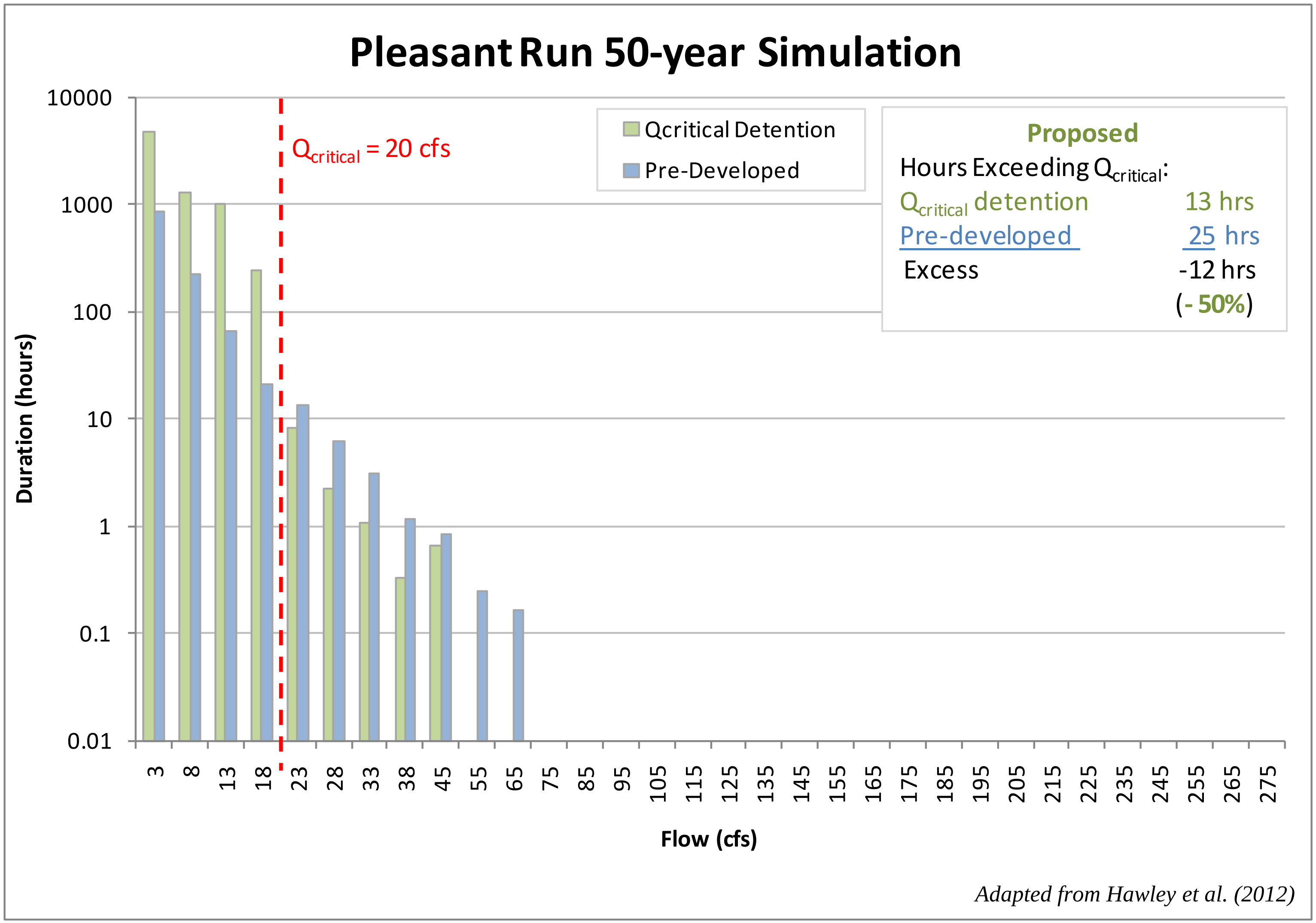
Consider All Storms > $Q_{critical}$



$Q_{critical}$ Design Target = "Safe Release Rate"

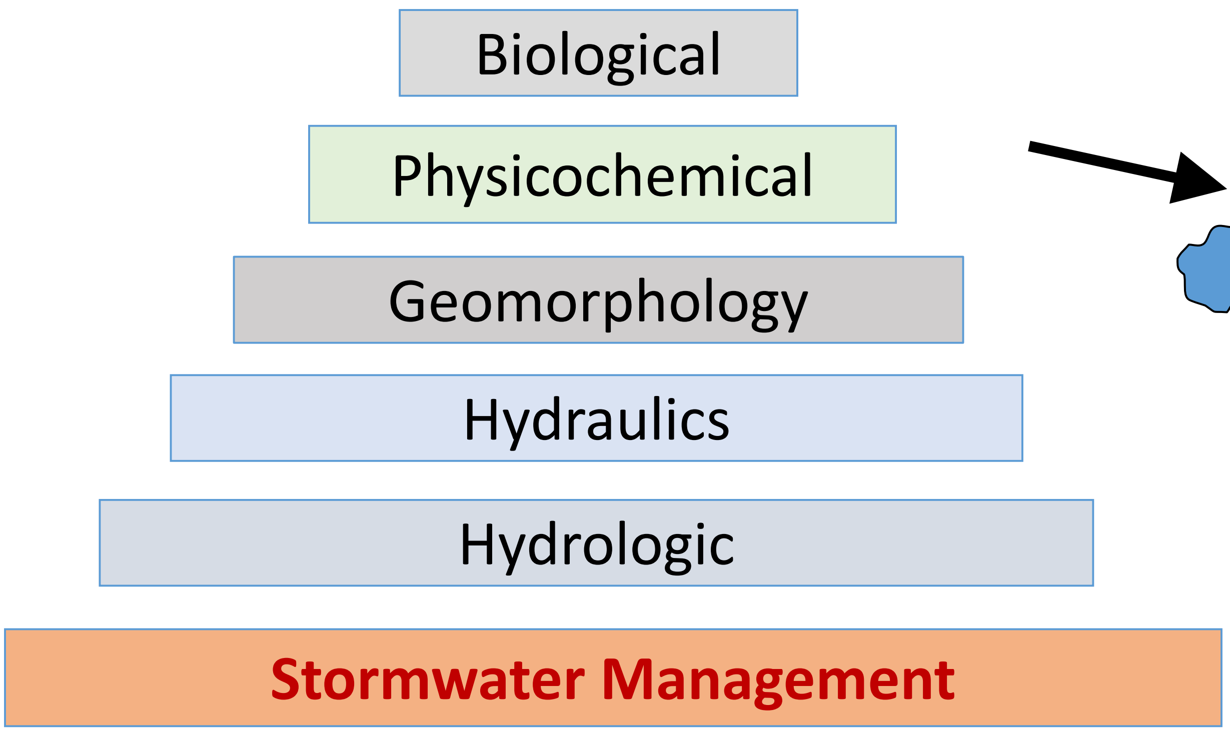


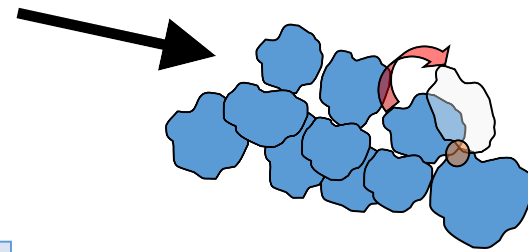
If Excess Volume Is Released Below $Q_{critical}$ → No Excess Erosive Flows



Stormwater-based Management Strategies

Reduce the erosive power of stormwater runoff (potentially in conjunction with stream restoration)



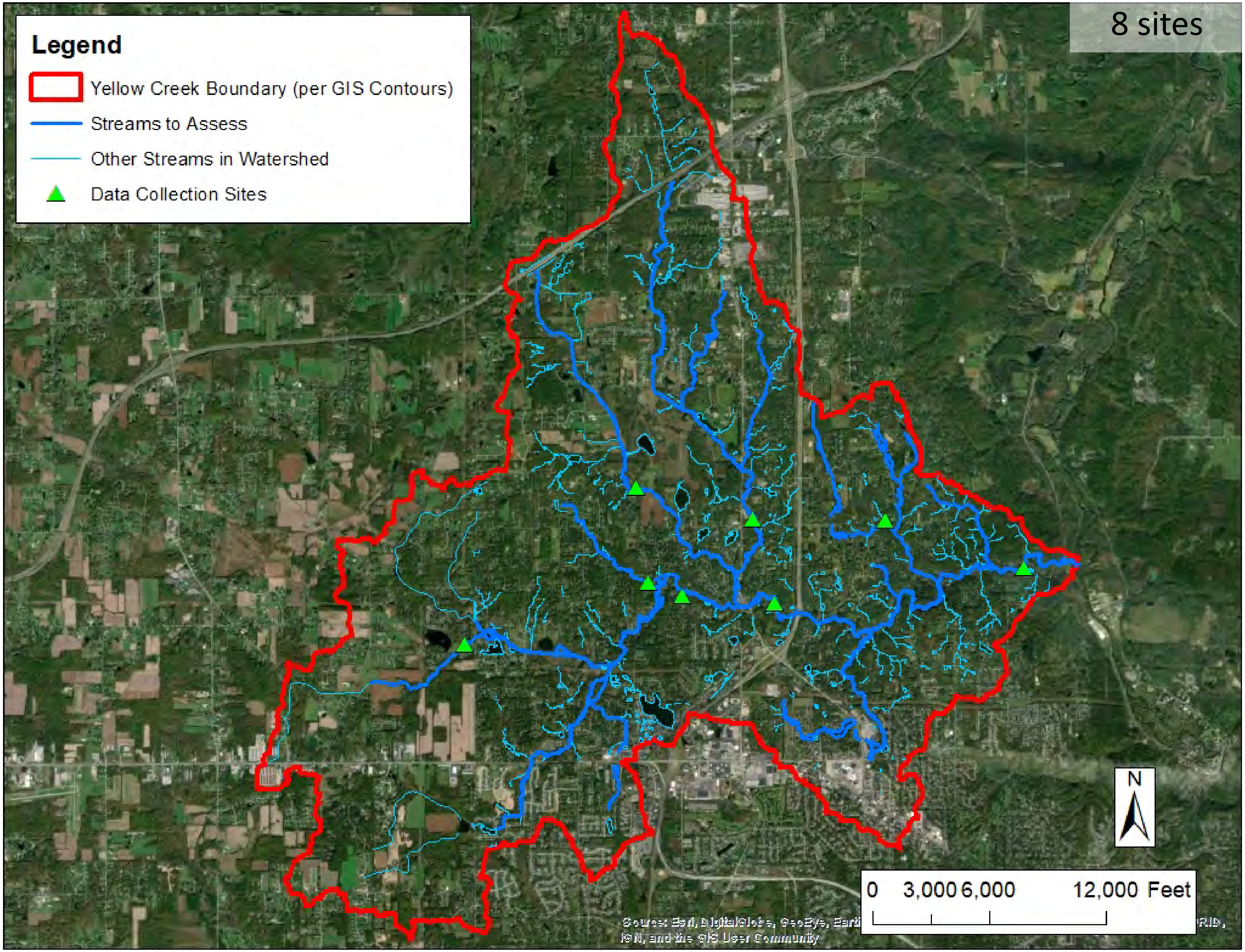


$Q_{critical}$

It all starts here

Channel Evolution Sequence in Response to Increased Flows from Urbanization, Adapted from Schumm et al. (1984) and Hawley et al. (2012)

What is $Q_{critical}$ for Yellow Creek?



Hydrogeomorphic Data Collection

Hydrogeomorphic Data Collection

$Q_{critical}$ ~ 40-50% of Q_2

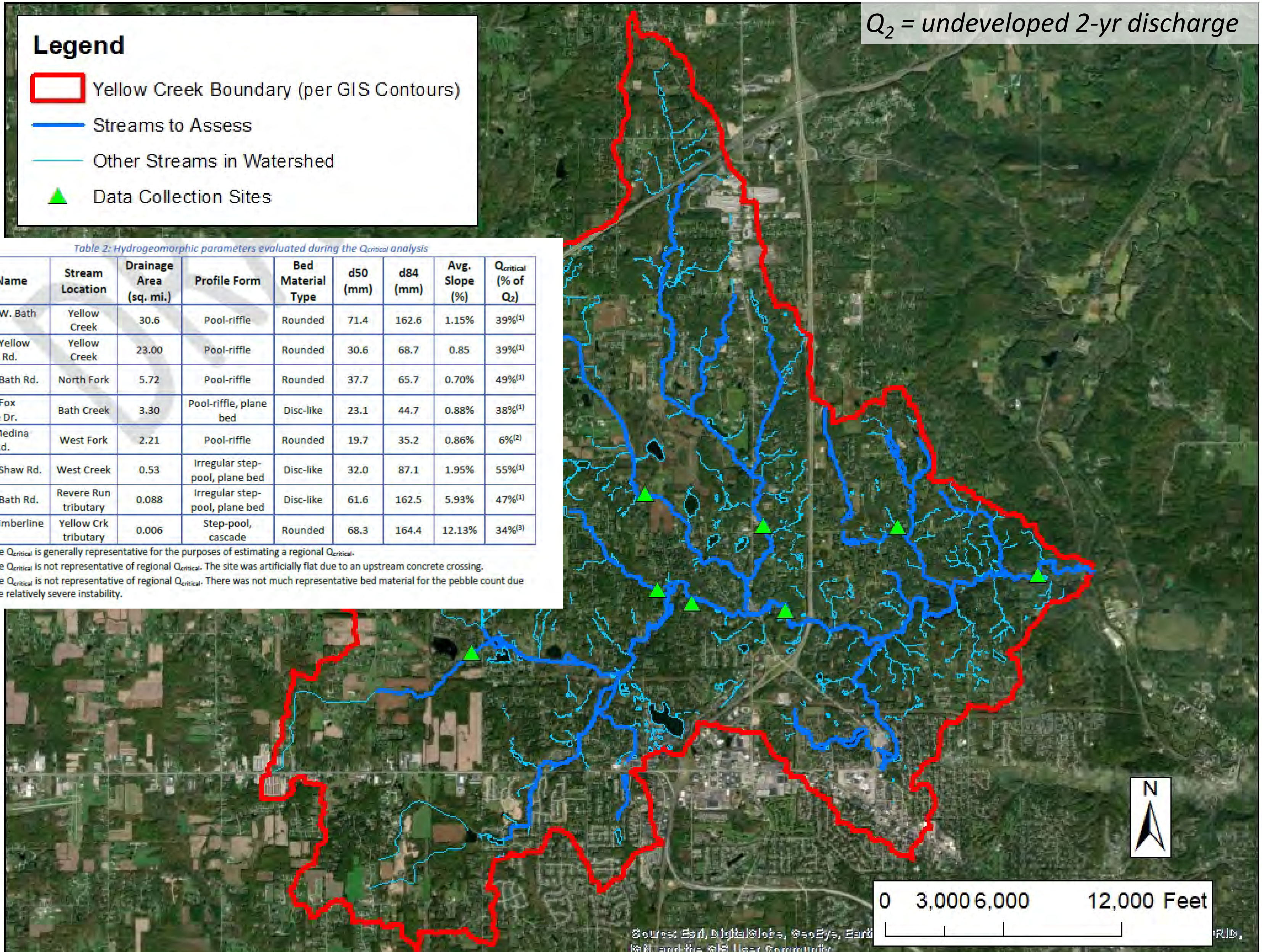


Table 2: Hydrogeomorphic parameters evaluated during the $Q_{critical}$ analysis

Site Name	Stream Location	Drainage Area (sq. mi.)	Profile Form	Bed Material Type	d50 (mm)	d84 (mm)	Avg. Slope (%)	$Q_{critical}$ (% of Q_2)
2226 W. Bath Rd.	Yellow Creek	30.6	Pool-riffle	Rounded	71.4	162.6	1.15%	39%(1)
3495 Yellow Creek Rd.	Yellow Creek	23.00	Pool-riffle	Rounded	30.6	68.7	0.85	39%(1)
3757 Bath Rd.	North Fork	5.72	Pool-riffle	Rounded	37.7	65.7	0.70%	49%(1)
1405 Fox Chase Dr.	Bath Creek	3.30	Pool-riffle, plane bed	Disc-like	23.1	44.7	0.88%	38%(1)
588 Medina Line Rd.	West Fork	2.21	Pool-riffle	Rounded	19.7	35.2	0.86%	6%(2)
4023 Shaw Rd.	West Creek	0.53	Irregular step-pool, plane bed	Disc-like	32.0	87.1	1.95%	55%(1)
3139 Bath Rd.	Revere Run tributary	0.088	Irregular step-pool, plane bed	Disc-like	61.6	162.5	5.93%	47%(1)
901 Timberline Dr.	Yellow Crk tributary	0.006	Step-pool, cascade	Rounded	68.3	164.4	12.13%	34%(3)

(1) Site $Q_{critical}$ is generally representative for the purposes of estimating a regional $Q_{critical}$.

(2) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. The site was artificially flat due to an upstream concrete crossing.

(3) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. There was not much representative bed material for the pebble count due to the relatively severe instability.

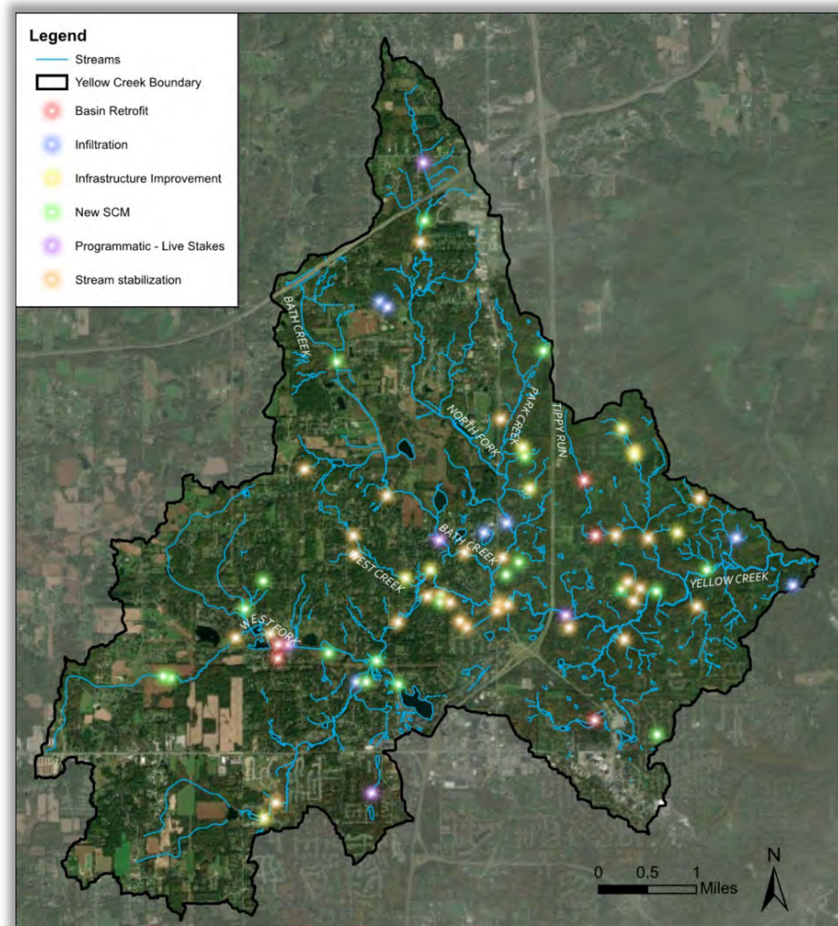
Mitigation Strategies

Stormwater Strategies

In-Stream Restoration

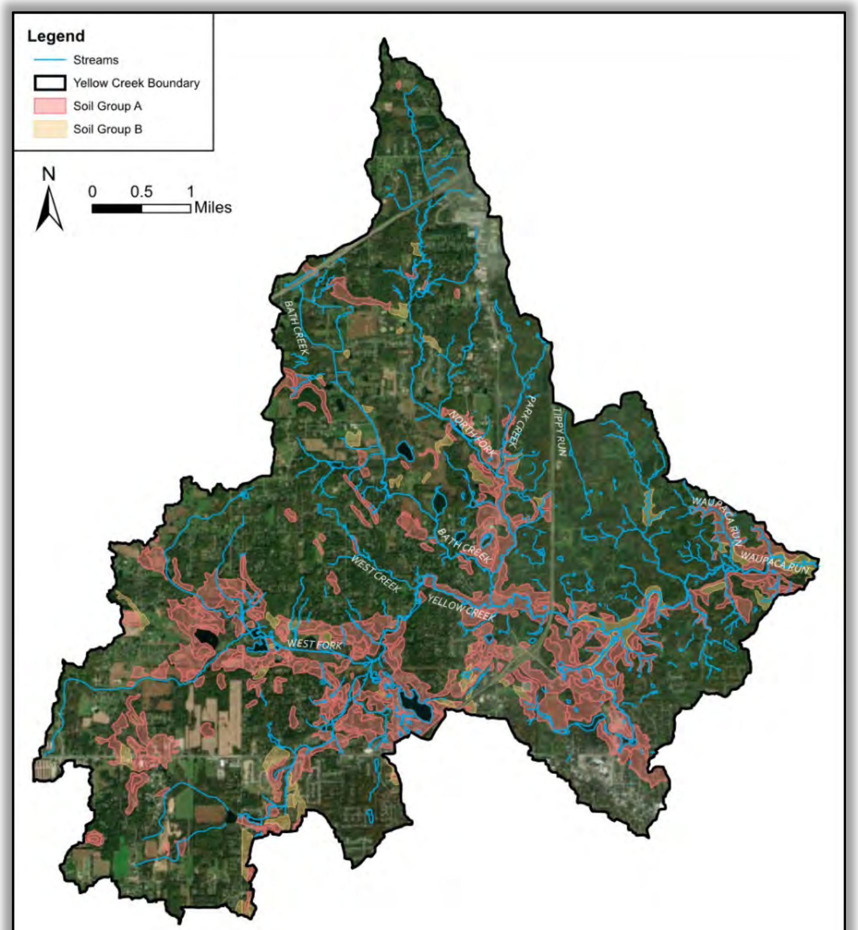
Conceptual Strategies

1. Preserve/enhance high infiltration areas
2. Infrastructure improvements
3. Optimize existing SCMs
4. Install new SCMs
5. Mitigate instability in “seasonal channels”
6. Bank protection projects that could potentially be within the scope of the SWMD
7. Partial bank protection projects that could potentially be within the scope of the SWMD
8. Programmatic/non-structural improvements



“SCM” = Stormwater Control Measure

1. Preserve/Enhance High Infiltration Areas

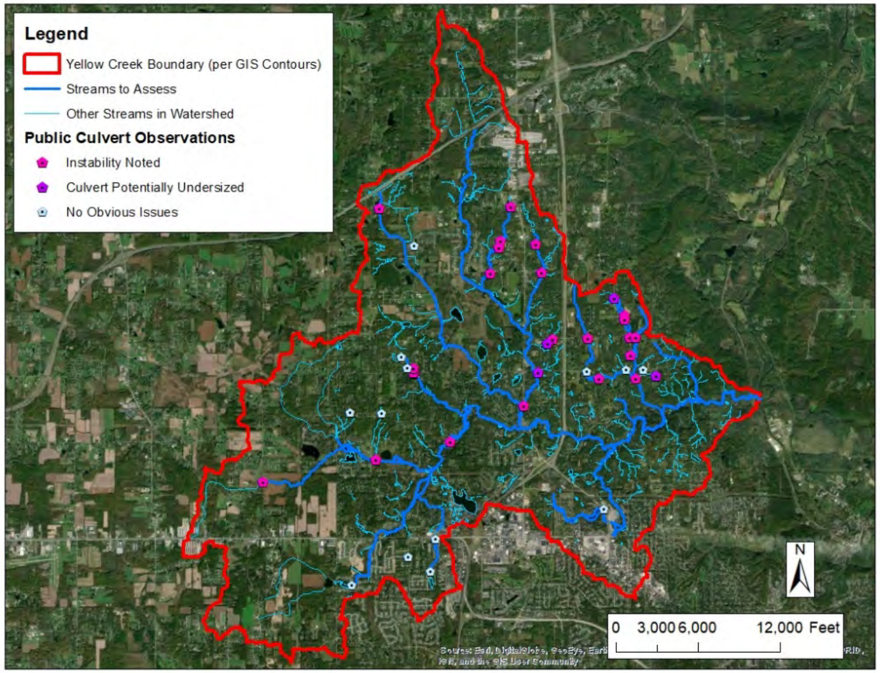


Locations of Type A and Type B soils in Yellow Creek watershed

- Undeveloped Type A or Type B soils
- Public parcel forest preservation and/or SCM infiltration optimization
- Private parcels could also promote preservation and optimize SCMs for high infiltration

Example of a forested area with Type A soil

2. Infrastructure Improvements



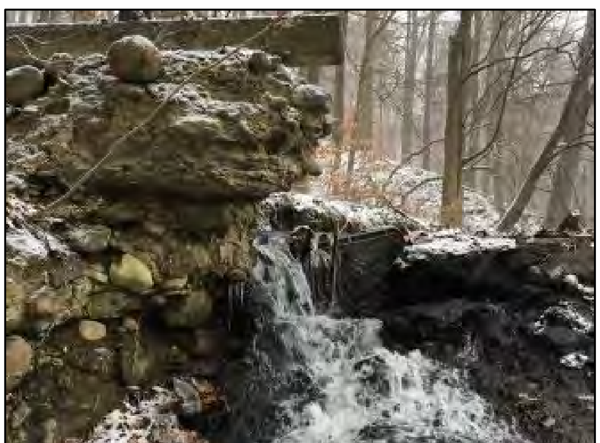
- Culvert maintenance
- Stabilization of outfalls
- Storm sewer repairs, etc.

Outlet would benefit from additional armoring and stabilization

→ *Notifications to Other Responsible Parties*

Cracked bridge abutment

- Many areas of potential concern do not fall under SWMD jurisdiction



Dam is patched with a piece of plywood & chain-link fence

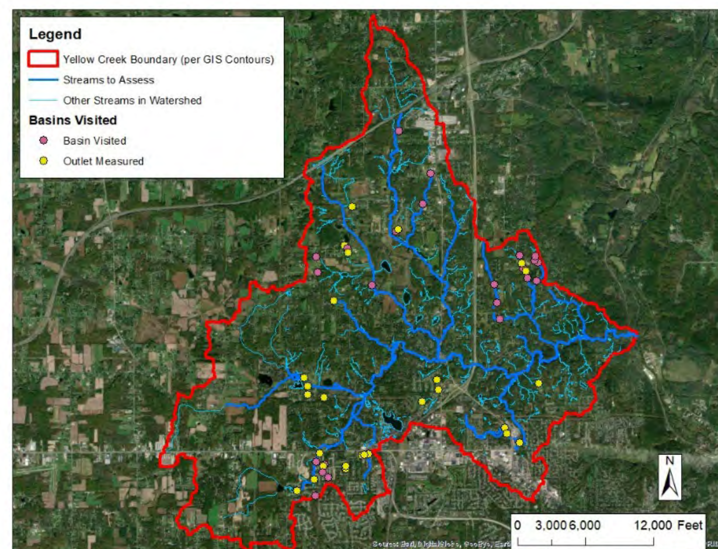
Slumping gabions next to road

3. Optimization of Existing SCMs

Existing outlet structure that could potentially be optimized to reduce downstream erosion.

Example of private pond that could benefit from Stream/Wetland complex construction.

- 50 existing detention basins visited
- Preliminary analysis suggests that cost-effective retrofits could partially mitigate excess erosive power at several basins
- Armoring, potential spillway improvements, etc. could be included

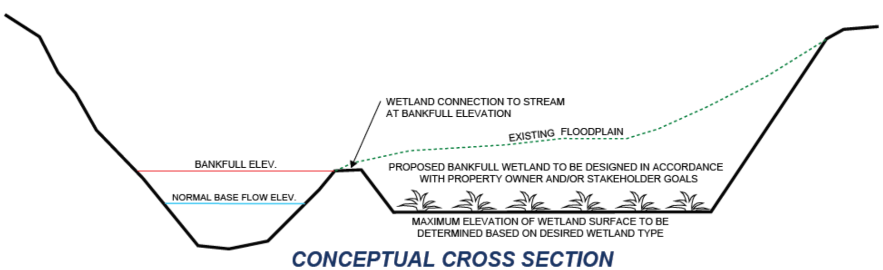


Locations of existing SCMs in Yellow Creek watershed

4. Install New SCMs

Conceptual contours of bankfull wetlands

- Add new storage specifically designed to offload erosive flows
- ~40+ acre-feet of potential new storage could be created in undevelopable floodplain areas
- Could be optimized to reduce the erosive power of the 1-year discharge, particularly during summer storms



Bankfull wetland conceptual cross section

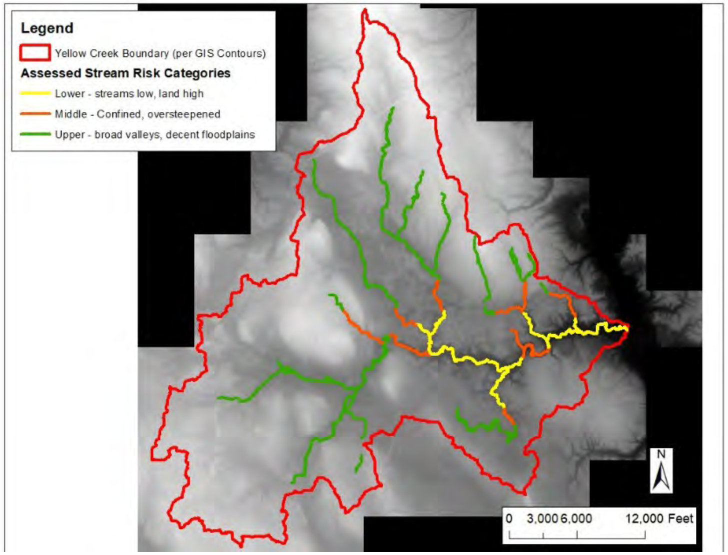
Constructed Bankfull Wetland in Northern KY

5. Rehabilitation in "Seasonal Channels"

Eroded ravine downstream of driveway.

~4-ft headcut in tributary

- Primarily address localized instability
- Chronic erosion creates relatively high sediment loads to downstream waters
- Conceptual examples include swale and tributary stabilization and headcut repair



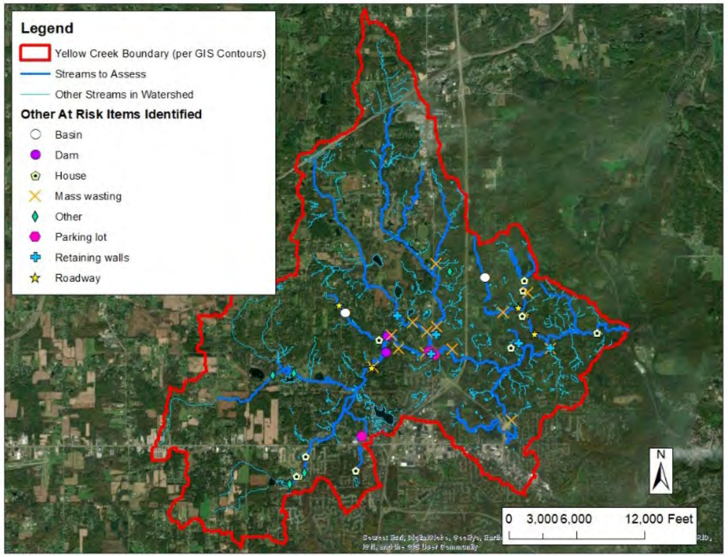
Relative stream instability risk throughout Yellow Creek watershed

6. Bank Protection Potentially within the Scope of the SWMD

Stream erosion undermining parking lot → public safety risk

Exposed pipes in bank show extents of bank erosion near Wastewater Facility

- Stream instability on private parcels that might have risks to public infrastructure
- Streams with relatively short banks
- Not adjacent to excessively large/ steep hillslopes



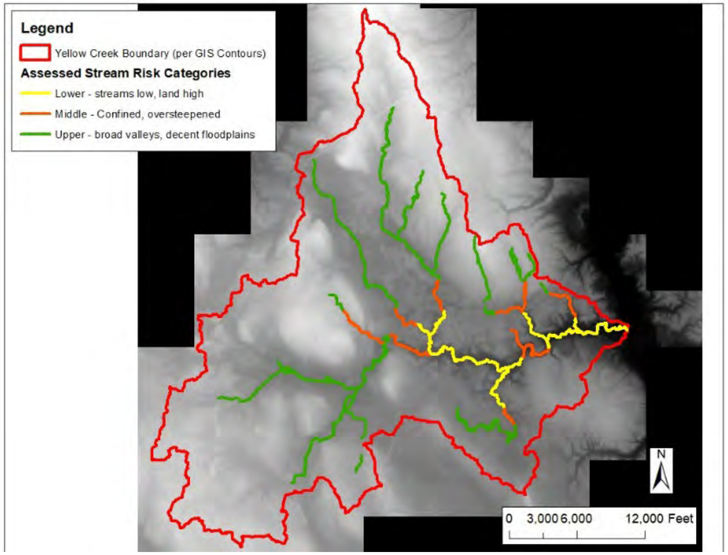
Various at-risk items in Yellow Creek watershed

7. Partial Bank Protection Potentially within the Scope of the SWMD

Mass wasting along ~70-ft tall bank

~40-foot tall, near vertical bank with mass wasting and tree loss

- Adjacent to tall, unstable hillslopes
- Public/private division along toe of slope
- Moving stream off toe of slope would reduce the risk of future undercutting
- Full geotechnical stabilization (e.g. retaining walls, etc.) likely outside the scope of the SWMD



Stream instability risk throughout Yellow Creek watershed

8. Programmatic/Non-Structural Improvements

- Optimization of stormwater design targets for new development
- Staff training/support
- Homeowner outreach/education
- Routine inspections and maintenance

Streambank Workshop

October 4, 2017
City of Florence & Sustainable Streams, LLC

What is stream erosion? *Northern Kentucky has many streams that are adjusting to increased stormwater runoff from impervious surfaces such as rooftops, roads, and driveways. Streams become larger to accommodate more water just as a human body becomes larger when the input calories exceed the expended calories. The increased erosive flows cause streams to become deeper and wider.*

Stream erosion may start as a tension crack along the bank (left) that eventually leads to bank collapse and widening (right)

Examples of erosion prevention practices:

- *Establish native riparian vegetation*
- *Remove invasive species such as Honeysuckle*
- *Do not regularly mow to the edge of the bank*
- *Do not dump yard waste into the stream*
- *Harvest and plant livestakes*
- *Anchor logs or rocks along the bank*
- *Re-grade the bank to a 4:1 slope (or gentler)*

NOTE: Do not use equipment in streams without approval from regulatory agencies

Before — *Vertical banks mowed to edge*
After — *Re-graded, vegetated banks*

Stabilized bank with re-graded 4:1 slopes and riparian vegetation

Native plants can provide bank stability and polinator habitat

Virginia Spiderwort — *Lance-leaved Coreopsis* — *Wild Bergamot*

Invasive honeysuckle shades out stablizing ground cover

Avoid mowing to the edge of streams

Sustainable Streams
FLORENCE

Literature from a workshop that addresses streambank instability

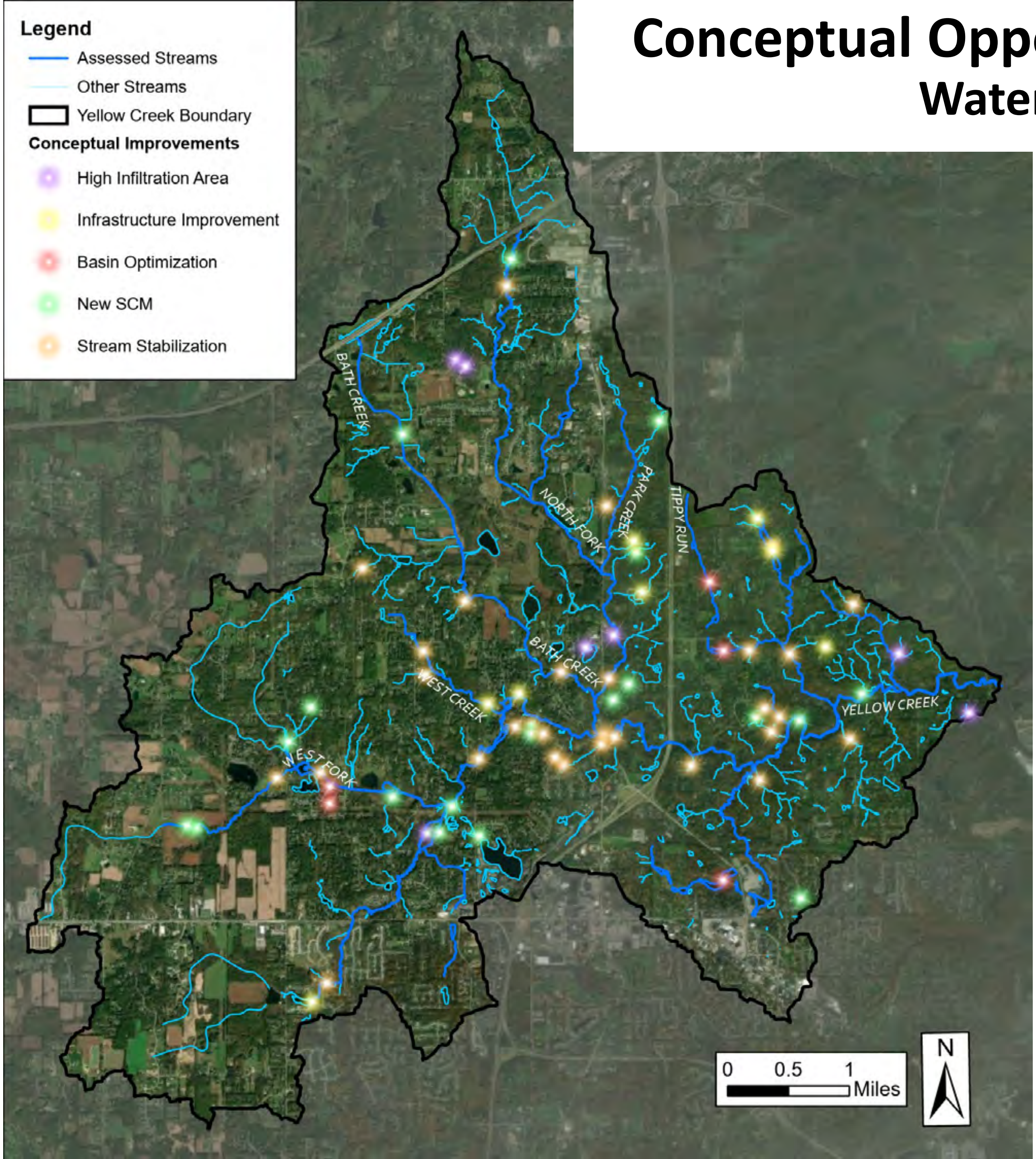
Septic tank maintenance is important to watershed health

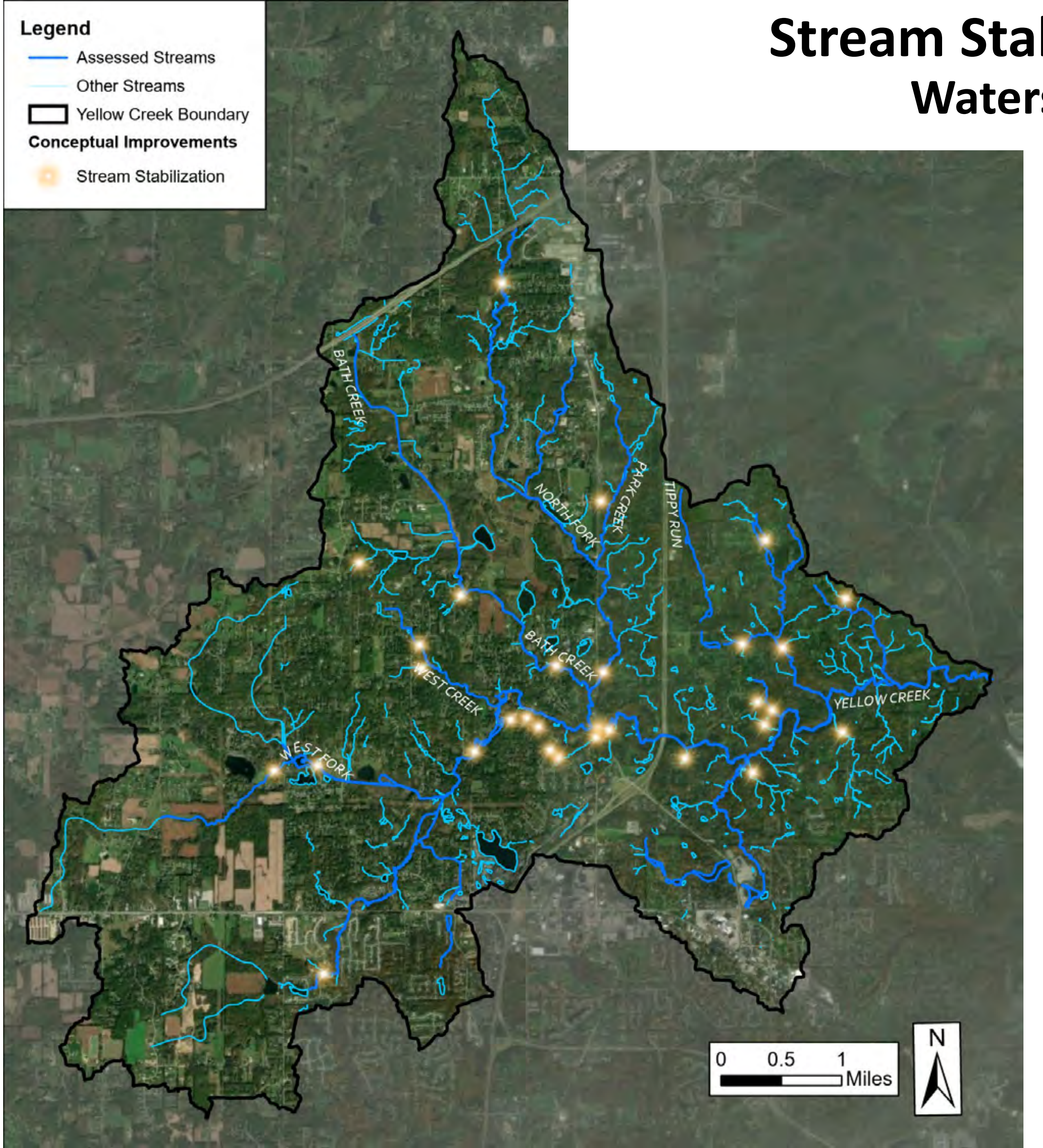
Home-Owner Protection Examples
(from this watershed)

High Priority Concepts

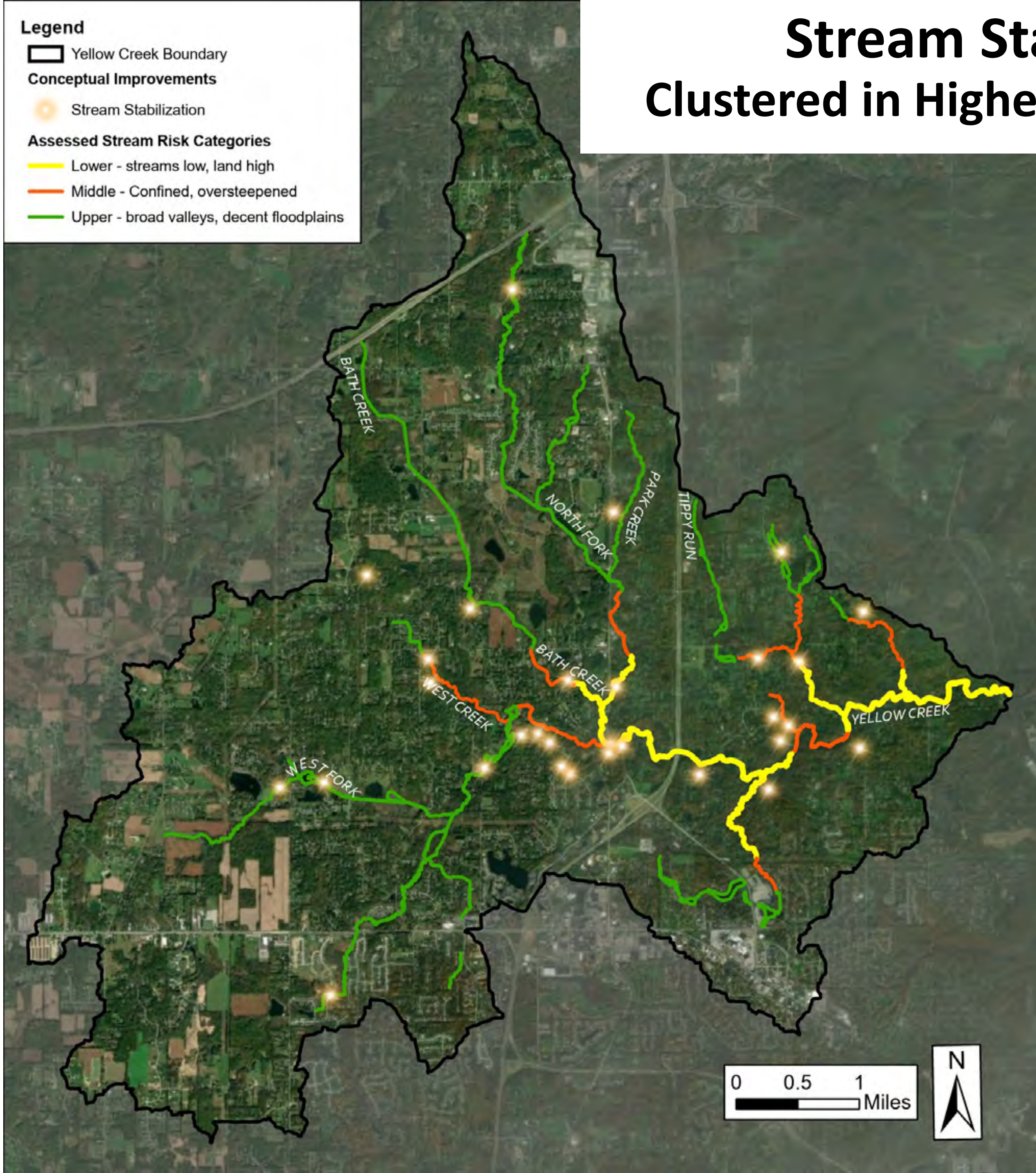
Conceptual Opportunities
Watershed Wide



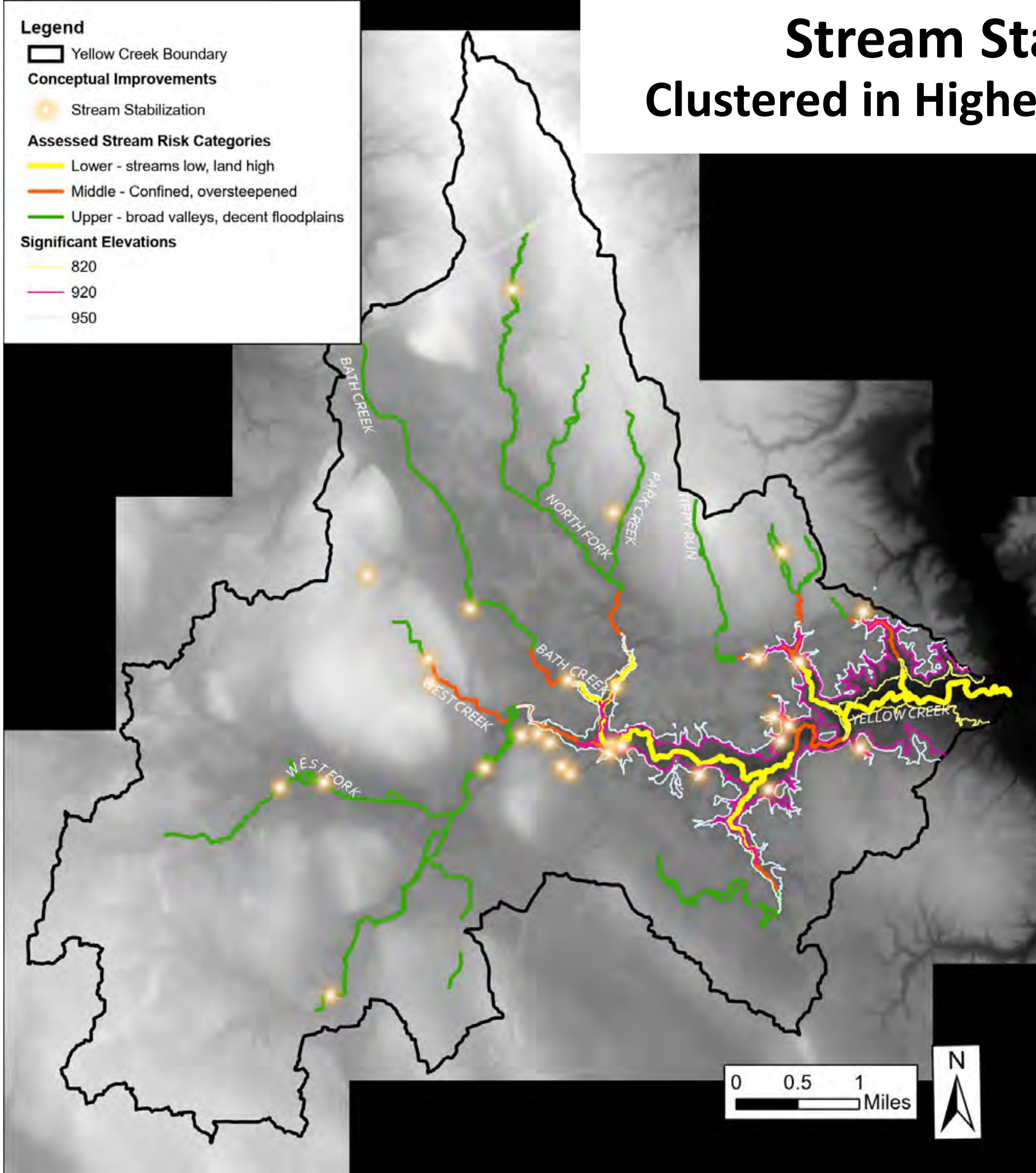
Stream Stabilization
Watershed Wide



Stream Stabilization
Clustered in Higher Risk Areas



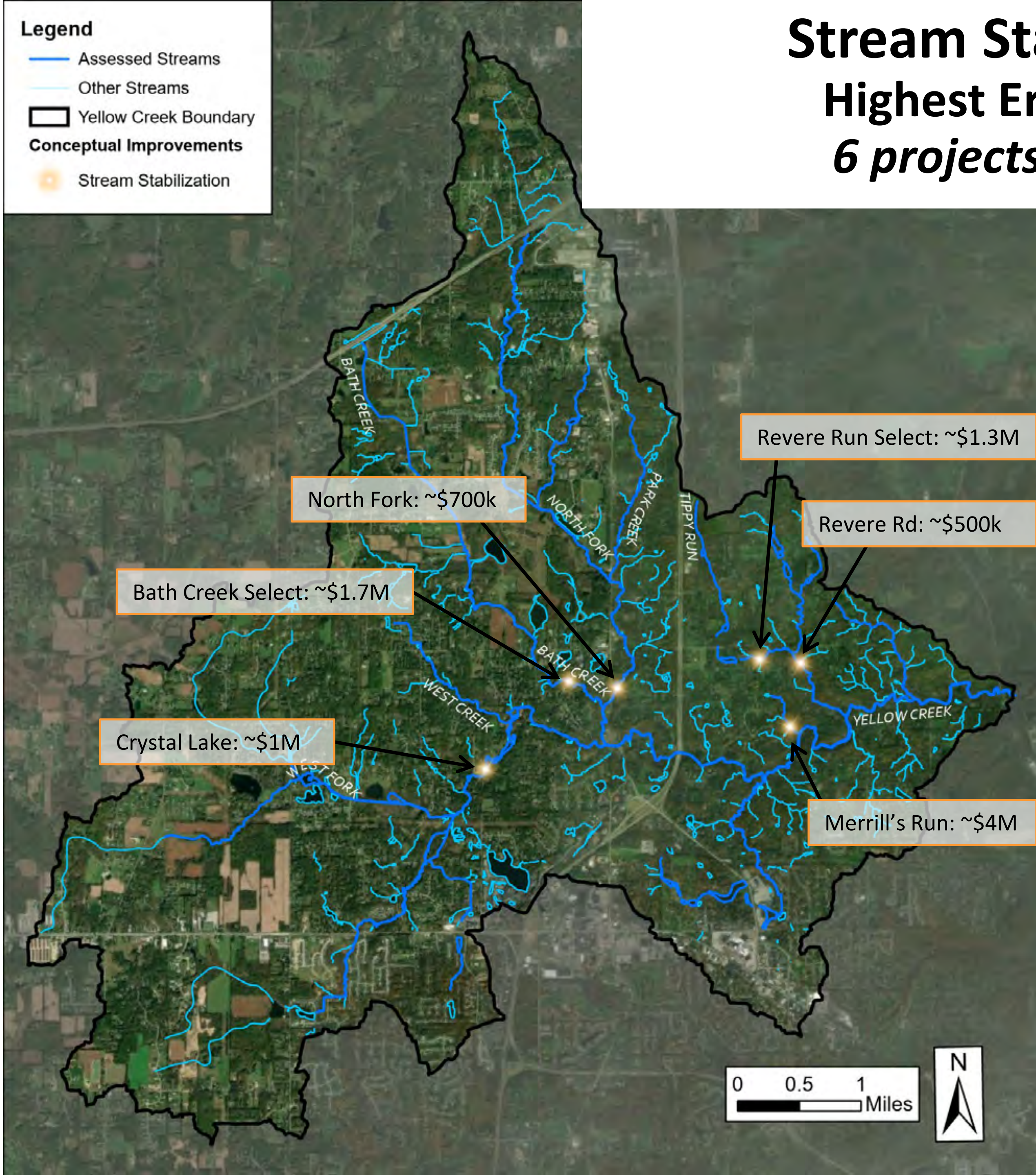
Stream Stabilization
Clustered in Higher Risk Areas



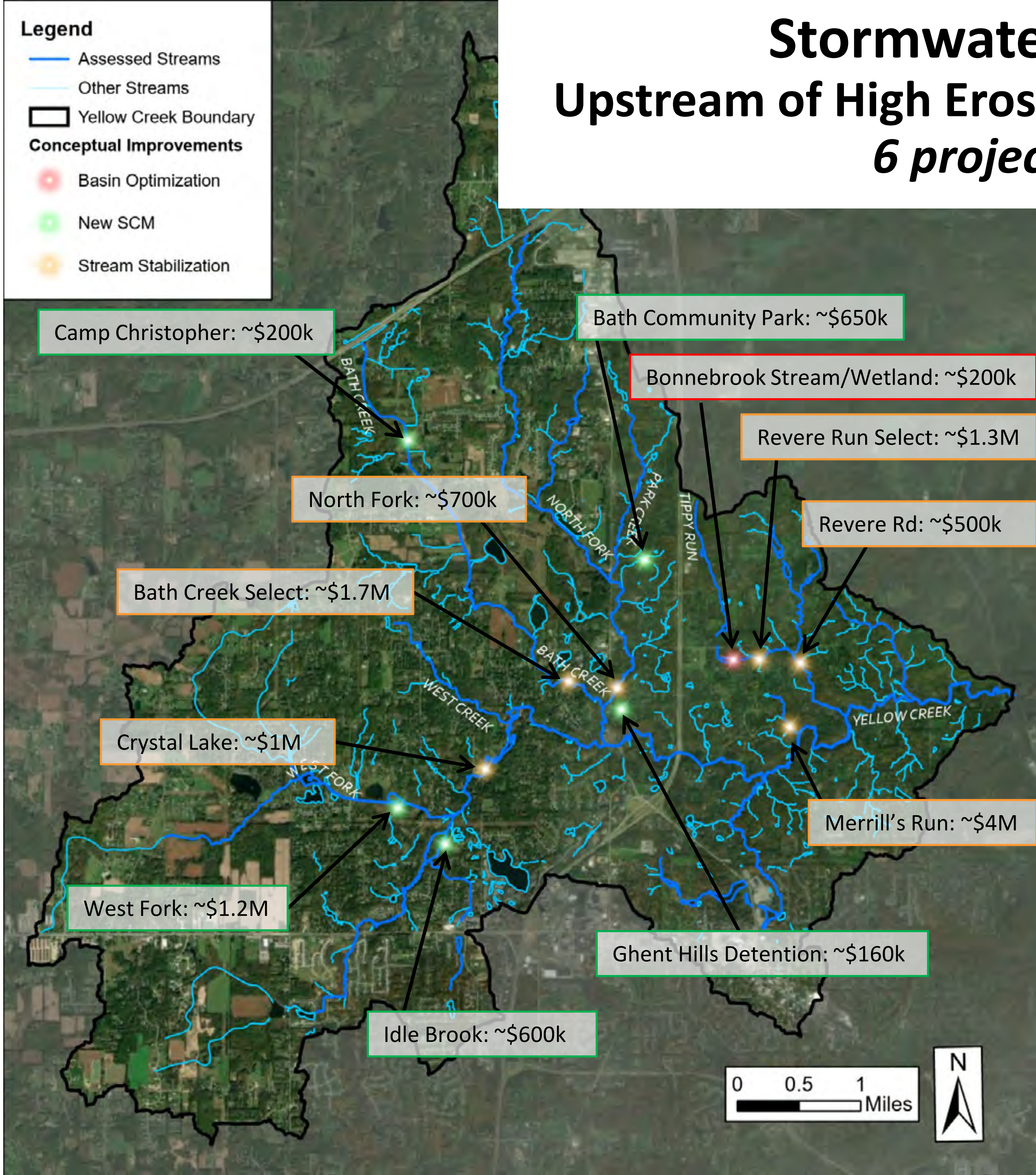
Stream Stabilization

Highest Erosion Areas

6 projects for ~$9.2M



Stormwater Controls
Upstream of High Erosion Streams
6 projects for ~$3M



Stormwater Control Projects*

- <u>**Bonnebrook Dr Stream/Wetland Complete w/ Wet Weather Detention (~$200k)**</u>
  - Surface area of ~2.5 acres & assumed avg. depth of ~4-5 ft, corresponds to ~10-12 ac-ft of new storage
  - Upstream of **Revere Run Select Stream Stabilization concept (~$1.3M)** & **Revere Rd Stabilization (~$500k)**
- <u>**Bath Community Park (~$650k)**</u>
  - Amended swales intercept undetained runoff from parking lot and bankfull wetland in soccer field could potentially create ~7 ac-ft
  - Upstream of **North Fork Stream Re-alignment concept (~$700k)**
- <u>**Camp Christopher Bankfull Wetland (~$200k)**</u>
  - Could create up to ~4 ac-ft of storage in Bath Creek headwaters
  - Upstream of **Bath Creek Select Stream Stabilization concept (~$1.7M)**
- <u>**Ghent Hills Detention (~$160k)**</u>
  - Intercepts ~9 acres of undetained runoff in a ~1 ac-ft detention basin immediately upstream of a ravine with extensive erosion
- <u>**Idle Brook Bankfull Wetland (~$600k)**</u>
  - Could create ~4 ac-ft of highly optimized storage on a public parcel in Idle Brook
  - (*Nester Bankfull wetland is a similar opportunity right downstream but it's not on a public parcel*)
    - Both are upstream of **Crystal Lake Stream Re-alignment ($1M)**
- <u>**West Fork Bankfull Wetland (~$1.2M)**</u>
  - Could create up to ~<u>18 ac-ft</u> of new storage in the headwaters of Yellow Creek
  - Upstream of **Crystal Lake Stream Re-alignment ($1M)**

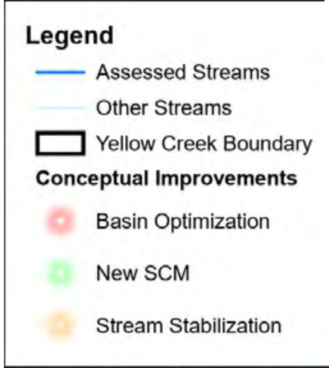
Stream Stabilization Projects*

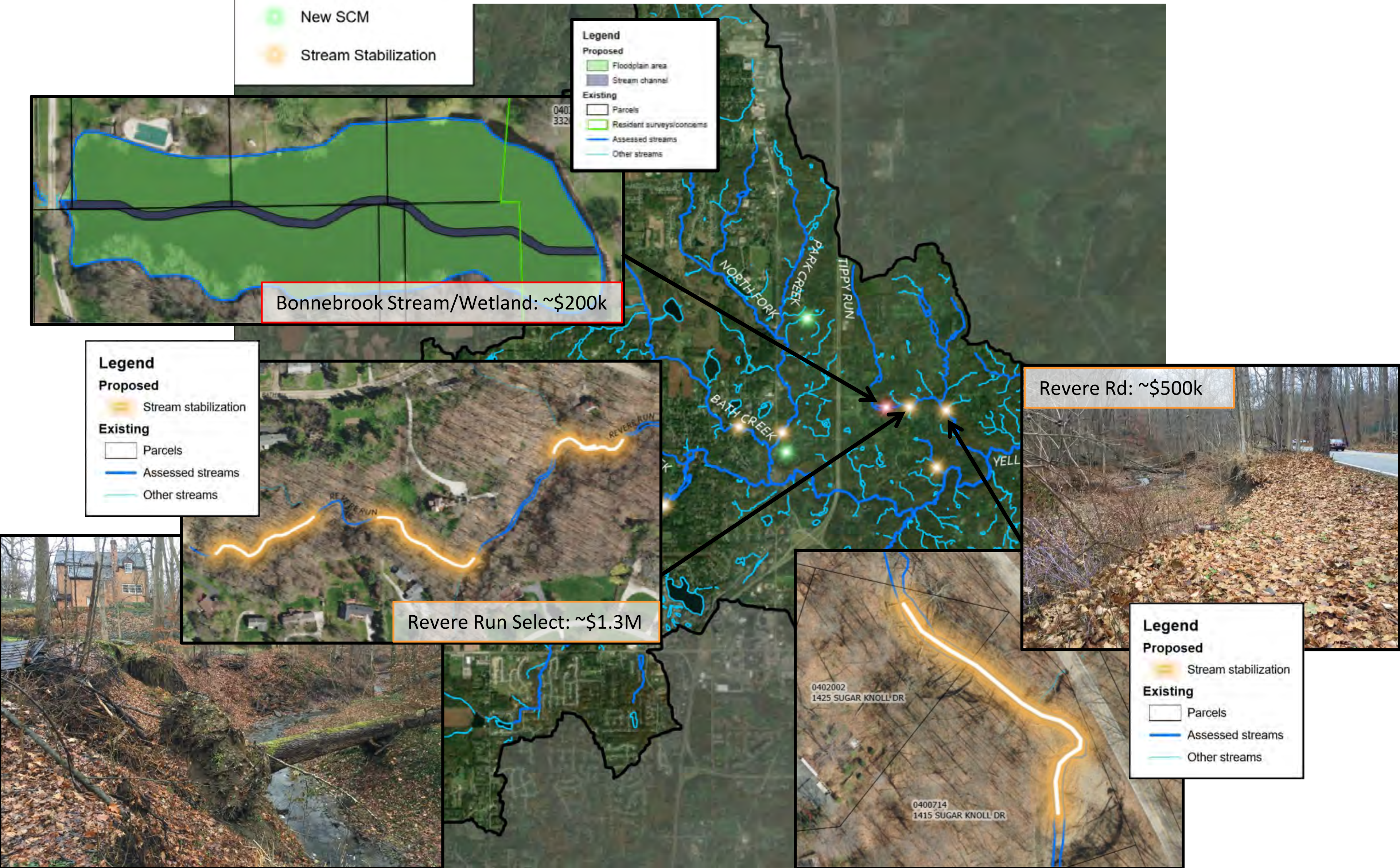
- **Bath Creek Select Stream Stabilization (~$1.7M)**
  - ~1,400 ft of up to ~45 ft tall banks
  - Downstream of **Camp Christopher Bankfull Wetland (~$200k)**
- **Merrill's Run Stabilization (~$4M)**
  - ~1,500 ft of up to ~60 ft tall banks
- **North Fork Stream Re-alignment (~$700k)**
  - ~550 ft of up to ~60 ft tall banks
  - Downstream of **Bath Community Park (~$650k)**
- **Revere Run Select (~$1.3M)**
  - ~1,100 ft of up to ~65 ft tall banks
  - Downstream of **Bonnebrook Dr Stream/Wetland Complex ($200k)**

- Above projects (except Merrill's Run) have SCM opportunities upstream.
  - Bonnebrook Dr & Camp Christopher show highest potential for improvements relative to their scale.

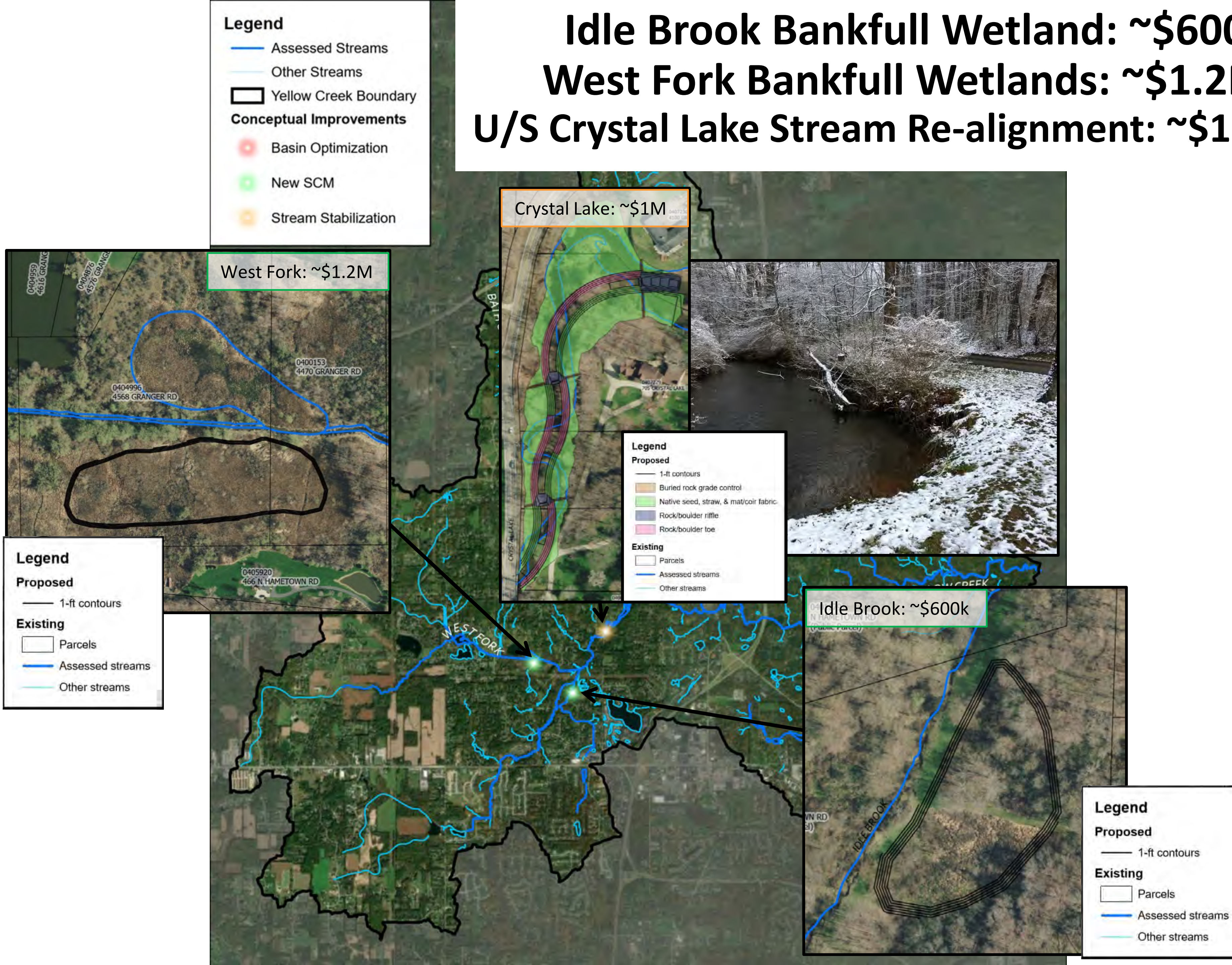
* *These lists focus on biggest opportunities for reducing stream erosion. Other factors (infrastructure protection, public safety aspects, etc.) can affect feasibility and prioritization.*

Bonnebrook Stream/Wetland: ~$200k
U/S of Revere Run Select Stabilization: ~$1.3M
U/S of Revere Rd. Stabilization: ~$500k

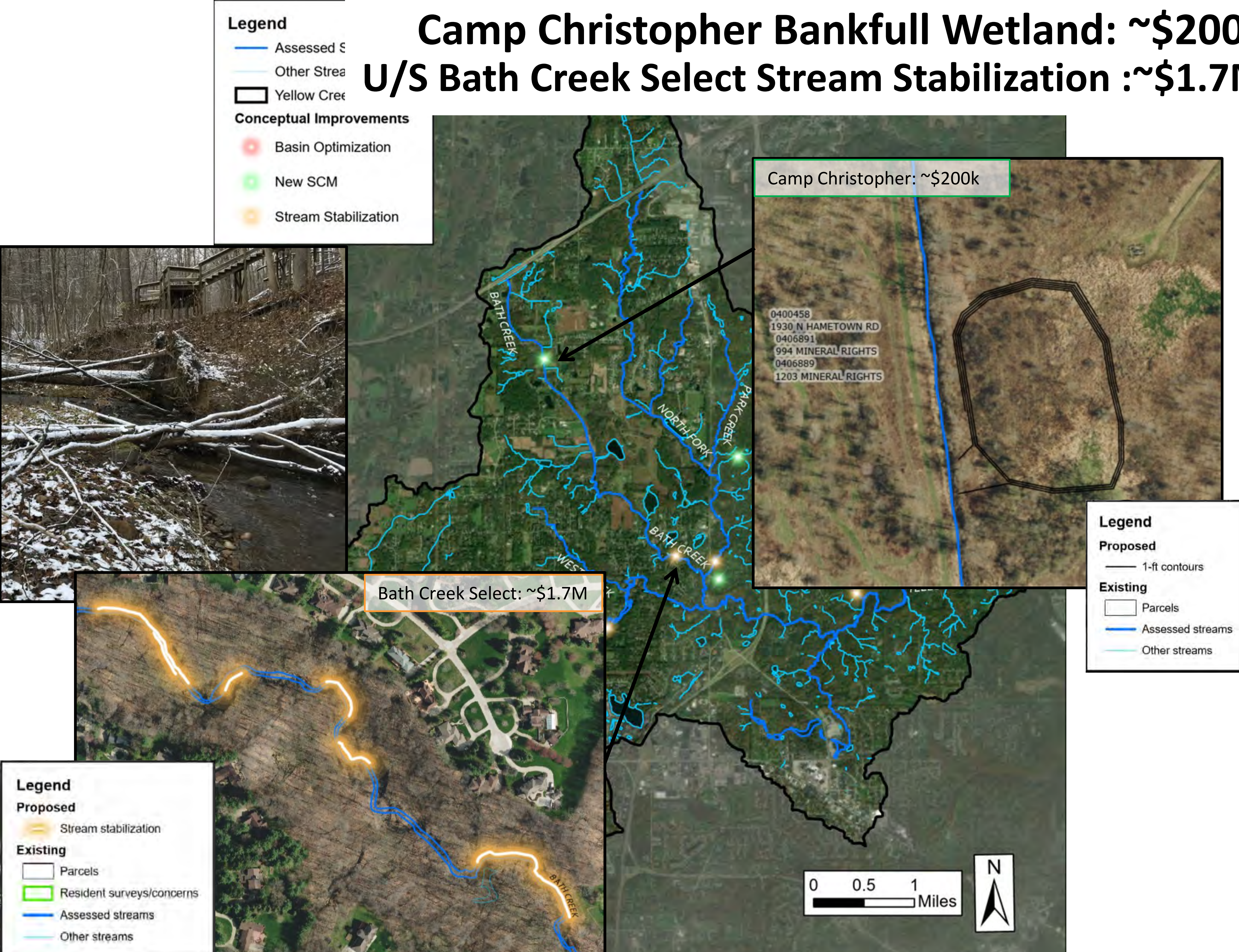




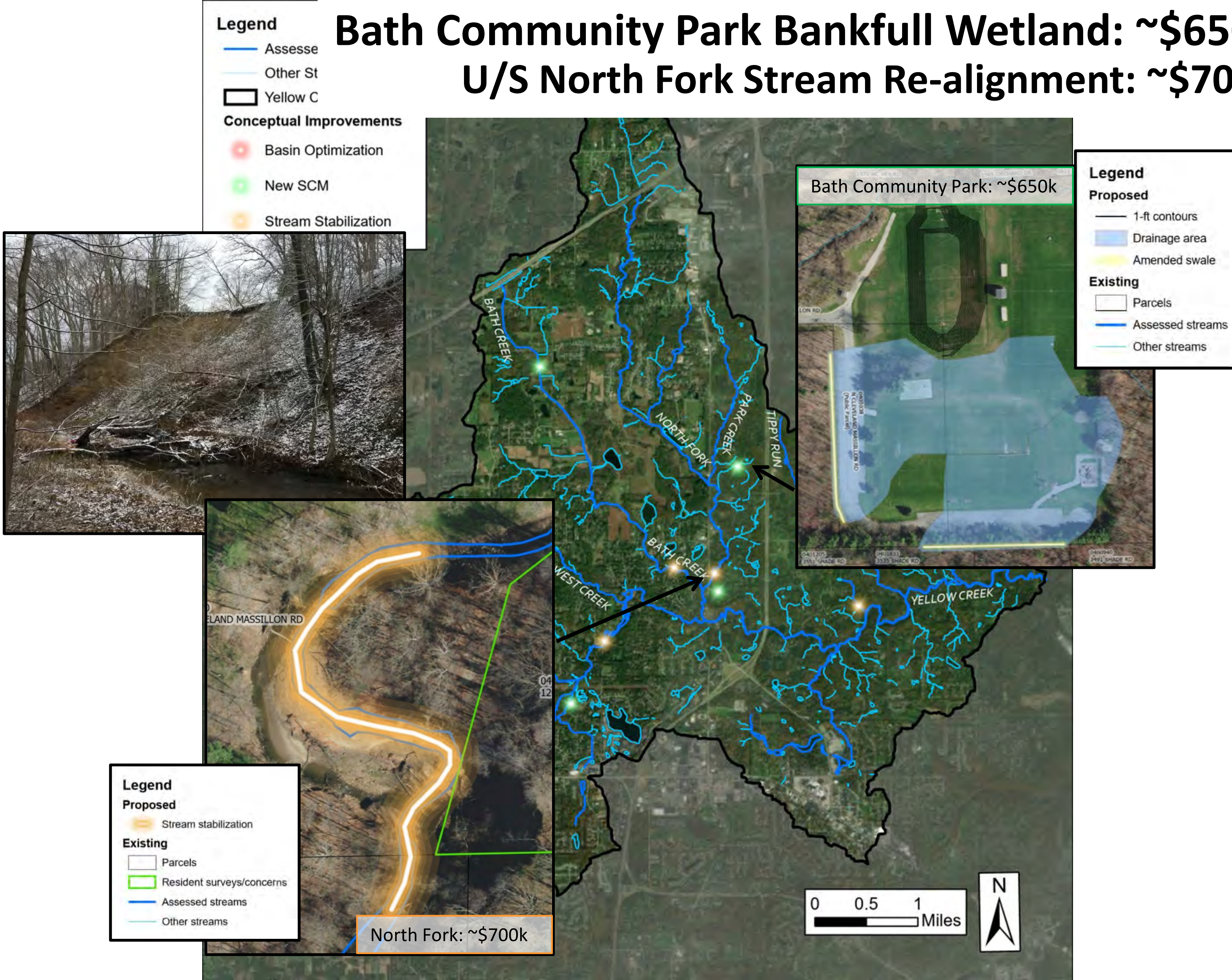
Idle Brook Bankfull Wetland: ~$600k
West Fork Bankfull Wetlands: ~$1.2M
U/S Crystal Lake Stream Re-alignment: ~$1M



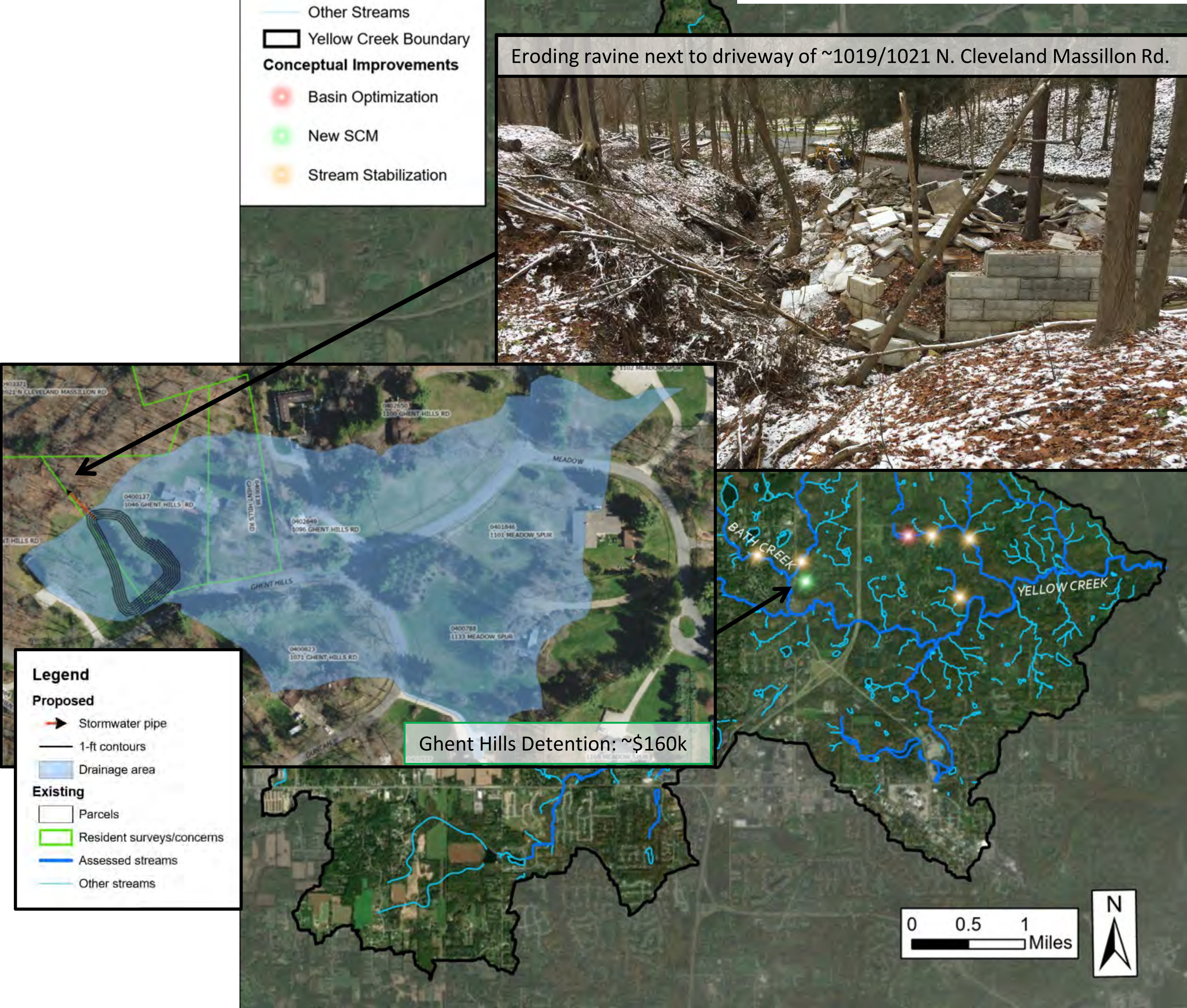
Camp Christopher Bankfull Wetland: ~$200k
U/S Bath Creek Select Stream Stabilization :~$1.7M



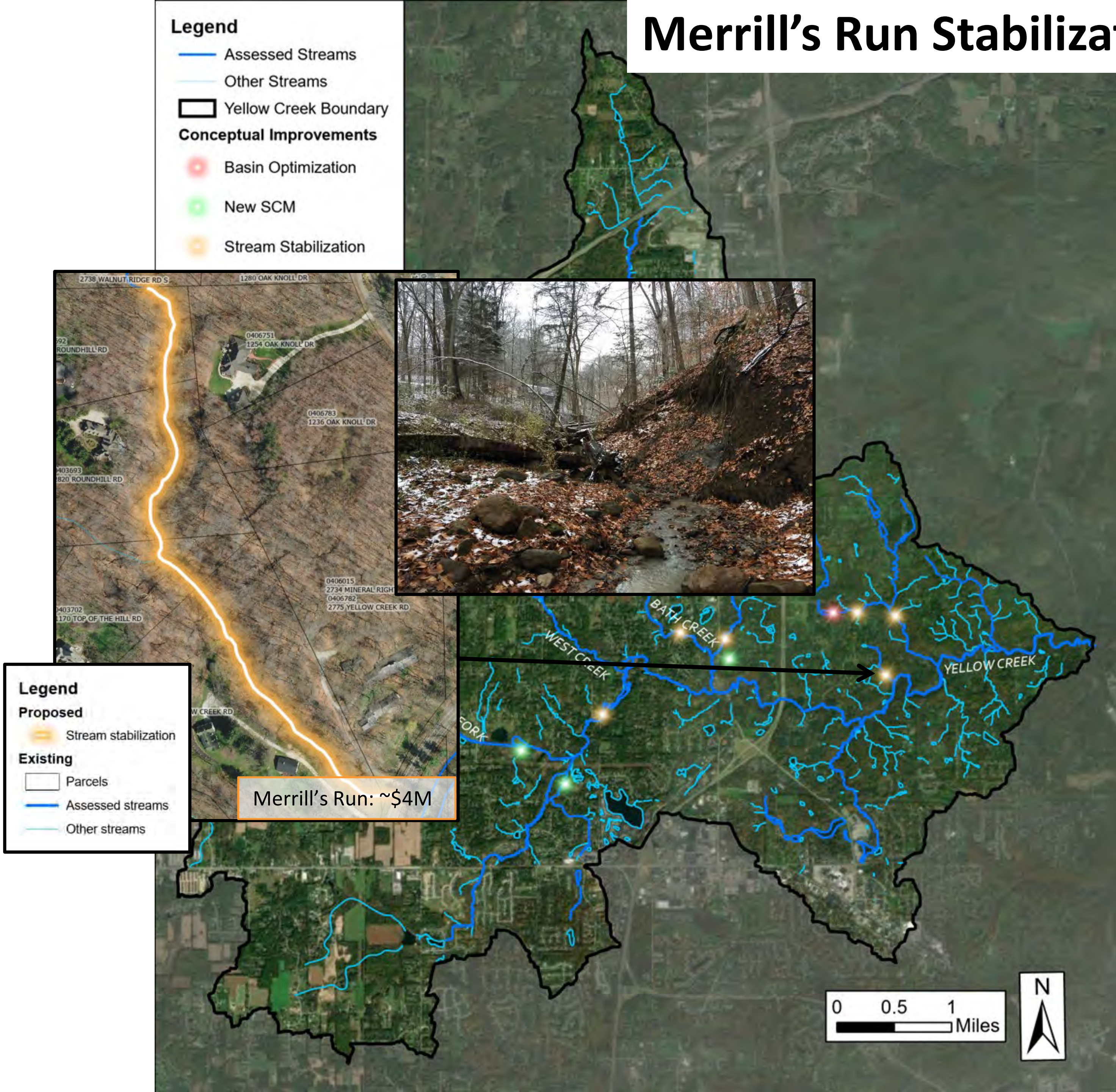
Bath Community Park Bankfull Wetland: ~$650k
U/S North Fork Stream Re-alignment: ~$700k



Ghent Hills Detention: ~$160k



Merrill's Run Stabilization: ~$4M



Conclusions

Stormwater projects

- typically **greater network benefits** (flow, sediment, & erosion reduction)
- will not 'fix' a geotechnically unstable bank (especially in the near-term)

Stream restoration projects

- typically lower network benefits
- can reduce sediment loads from **high-priority banks**, protect imperiled infrastructure, etc.

Integrated projects

- can have **greater combined benefits** than individual stream restoration/ stormwater projects

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SYSTEM-LEVEL NUTRIENT POLLUTION CONTROL STRATEGIES

Integrating Stormwater Management and Stream Restoration Strategies for Greater Water Quality Benefits

Roderick W. Lammers,* Tyler A. Dell, and Brian P. Bledsoe

Abstract

Urbanization alters the delivery of water and sediment to receiving streams, often leading to channel erosion and enlargement, which increases loading of sediment and nutrients, degrades habitat, and harms sensitive biota. Stormwater control measures (SCMs) are constructed in an attempt to mitigate some of these effects. In addition, stream restoration practices such as bank stabilization are increasingly promoted as a means of improving water quality by reducing downstream sediment and pollutant loading. Each unique combination of SCMs and stream restoration practices results in a novel hydrologic regime and set of geomorphic characteristics that interact to determine stream condition, but in practice, implementation is rarely coordinated due to funding and other constraints. In this study, we examine links between watershed-scale implementation of SCMs and stream restoration in Big Dry Creek, a suburban watershed in the Front Range of northern Colorado. We combine continuous hydrologic model simulations of watershed-scale response to SCM design scenarios with channel evolution modeling to examine interactions between stormwater management and stream restoration strategies for reducing loading of sediment and adsorbed phosphorus from channel erosion. Modeling results indicate that integrated design of SCMs and stream restoration interventions can result in synergistic reductions in pollutant loading. Not only do piecemeal and disunited approaches to stormwater management and stream restoration miss these synergistic benefits, they make restoration projects more prone to failure, wasting valuable resources for pollutant reduction. We conclude with a set of recommendations for integrated planning of SCMs and stream restoration to simultaneously achieve water quality and channel protection goals.

Core Ideas

- Stormwater control measures (SCM) and stream restoration can reduce channel erosion.
- SCMs alone reduced sediment and phosphorus loading more than stream restoration alone.
- Coordinating SCMs and restoration has the greatest positive impact.

THE negative effect of urbanization on stream systems, the so-called "urban stream syndrome," is well known (Walsh et al., 2005b). A dominant cause of urban stream degradation is hydrologic alteration—larger runoff volumes and higher and more frequent peak flows all lead to channel bed and bank erosion (Leopold, 1968; Booth, 1990). Channel erosion threatens valuable infrastructure, degrades aquatic habitat, and can contribute significant amounts of pollution to streams, including eroded fine sediment and bound constituents such as phosphorus (Fox et al., 2016). This is in addition to the pollutants carried directly from urban runoff to the stream. Managing urban runoff to reduce hydrologic alteration, improve water quality, and prevent stream channel degradation is a significant challenge.

Stormwater management can mitigate some of urbanization's effects on hydrology, potentially increasing channel stability. In addition, urban stream restoration can directly improve channel stability by increasing erosion resistance. These two management approaches are tightly linked, but they are often designed and implemented independently.

Many urban stormwater management programs focus specifically on maintaining pre-development peak flow rates of large, less frequent storms (to reduce flood risk) and removing pollutants such as totals suspended solids, nitrogen, and phosphorus through the use of stormwater control measures (SCMs) (Burns et al., 2012). Properly designed, watershed-scale SCMs can restore pre-development in-stream hydraulics (Anim et al., 2019); however, few management programs specifically focus on controlling the frequency and duration of flows that most contribute to stream erosion potential. In mobile, sand bed streams, the critical discharge for bed sediment movement is low (Tillinghast et al., 2011), meaning controlling smaller, more frequent events is essential for limiting channel incision (Bledsoe, 2002). Furthermore, because of increased runoff volumes in urban watersheds, it may not be possible to control erosion in these sensitive stream types if runoff volumes are not reduced (Rohrer and Roesner, 2006; Pomeroy et al., 2008; Elliott et al., 2010; Tillinghast et al., 2012; Anim et al., 2019). These previous studies showed that urban stream channels are sensitive to changes in a variety of flows across the flow duration curve, but they primarily looked at bed material transport as an indicator of channel stability. In fact, urban channels

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Abbreviations: BSTEM, Bank Stability and Toe Erosion Model; DEM, digital elevation model; EURV, excess urban runoff volume; REM, River Erosion Model; SCM, stormwater control measures; SWMM, Storm Water Management Model.

Next Steps

- CONCEPTUAL DESIGN
- STAKEHOLDER INPUT
- PUBLIC/PRIVATE COORDINATION
- FINANCING
- IMPLEMENTATION PLAN

Questions