

Fore to Forest for Fins and Feathers: *Transforming Acacia Country Club*



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Source: Cleveland Memory Project. Accessed 9/21/17

- 155 Acres
- Operated as a Donald Ross designed course for 90 years (1922-2012)
- Purchased by Conservation Fund \$14.75M
- Donated to Cleveland Metroparks 2012
- Deed Restrictions
- Restoration / Passive Open Space Focus

Phase 1: Community Outreach & Baseline Data

- Public Meetings
- BioBlitz
- Annual Day in the Life of Euclid Creek
- Academic research partners



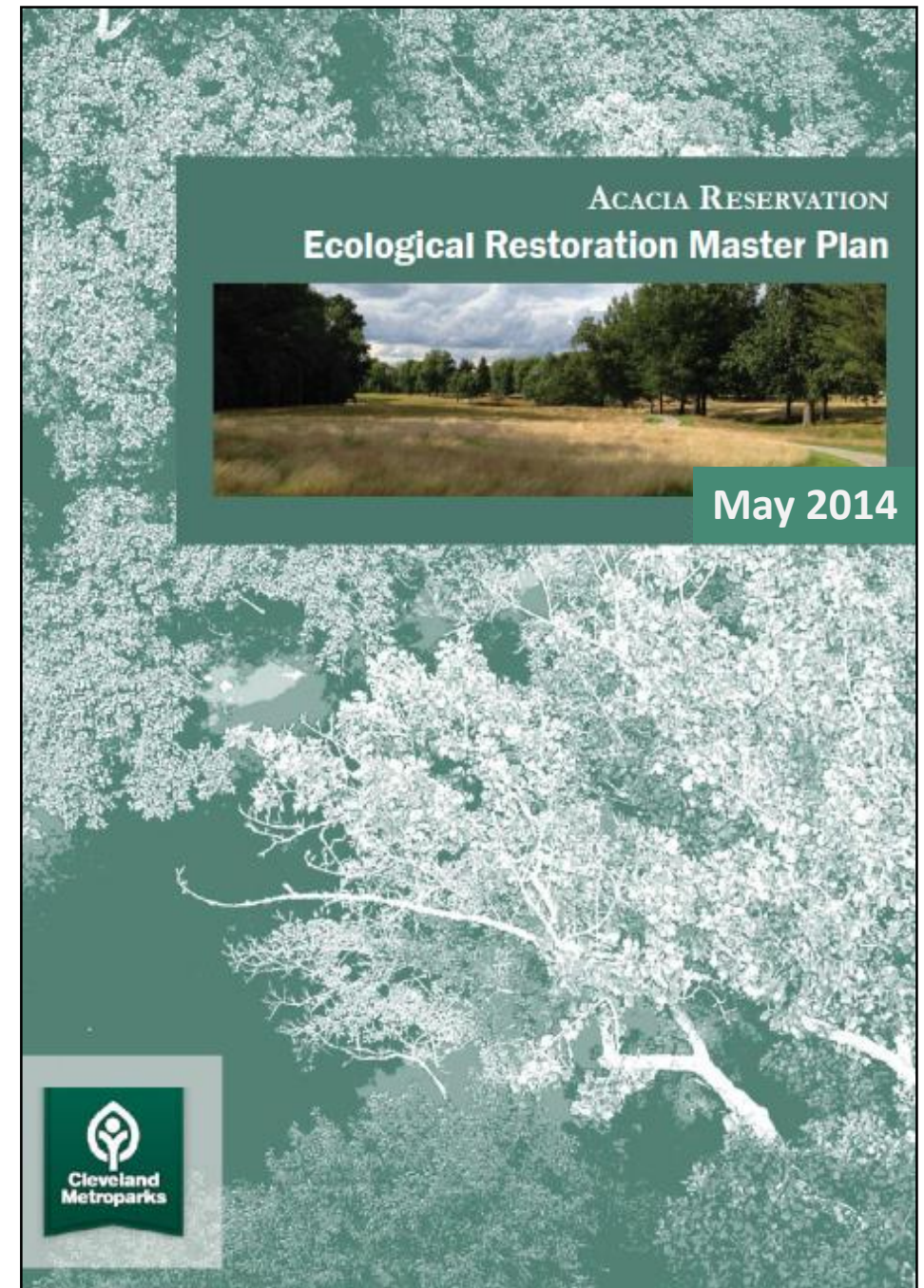


Baseline data collection

- Vegetation plots
- Stream surveys
- Water level loggers
- Flow meters
- Deer spotlighting
- Soil mapping

Phase 2: Planning

- Ecological Restoration Master Plan
- Acacia Reservation Master Plan



Restoration Goals

1. Restore the natural hydrological function
2. Establish native forest and wetland communities
3. Develop adaptive management that incorporates scientific research and stewardship
4. Integrate public use and social reflection to connect people with habitat restoration





Phase 3: Implementation

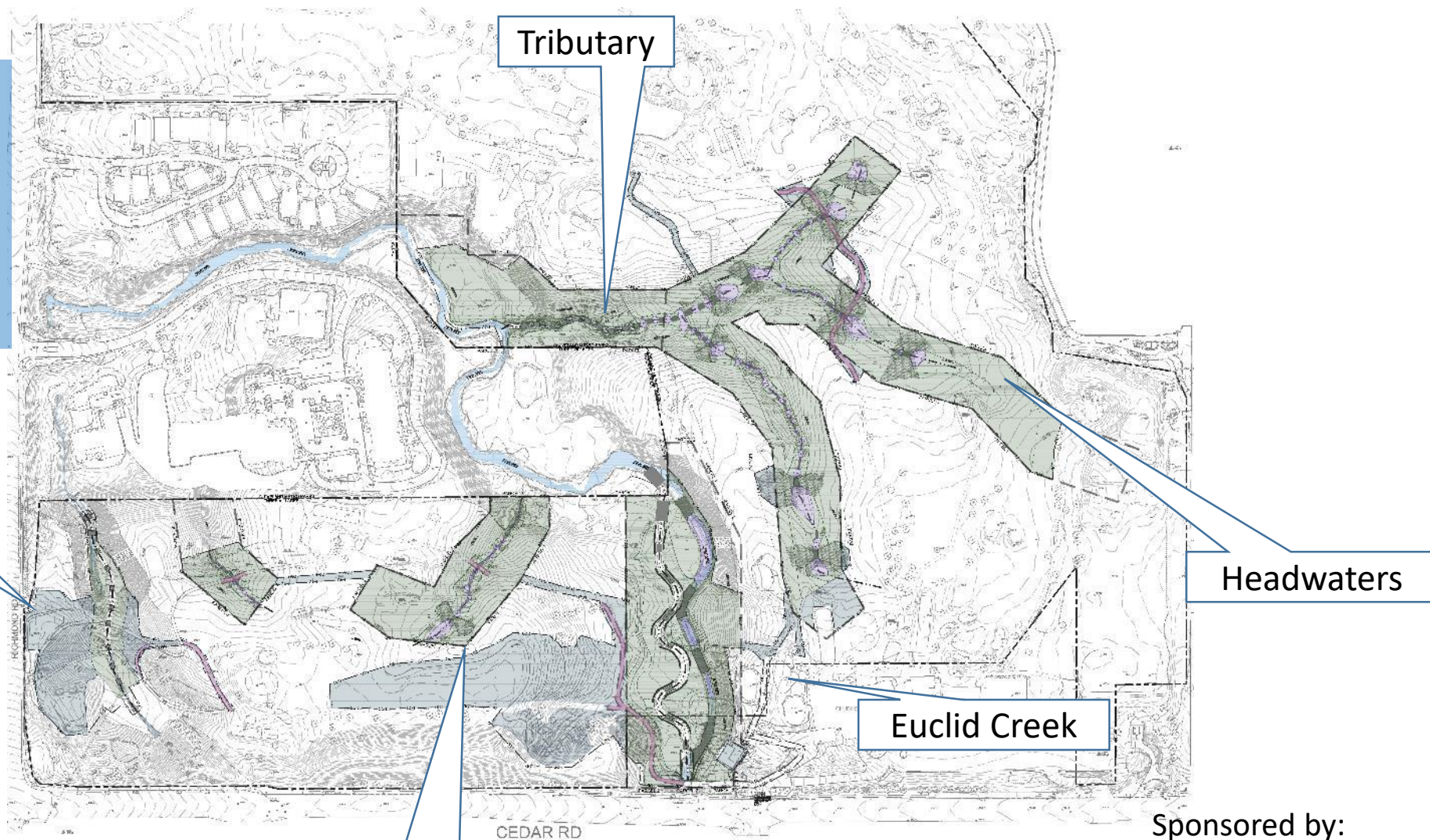
2015

- Invasive plant mgt
- Tile breaking
- Meadow establishment
- Reforestation
(Tree planting & seedling protection)
- Deer management

Euclid Creek, Tributaries & Headwaters

Designer/Contractor:
Biohabitats

Construction
Subcontractor: Meadville
Land Service, Inc.



Headwaters

Funded by:



Sponsored by:

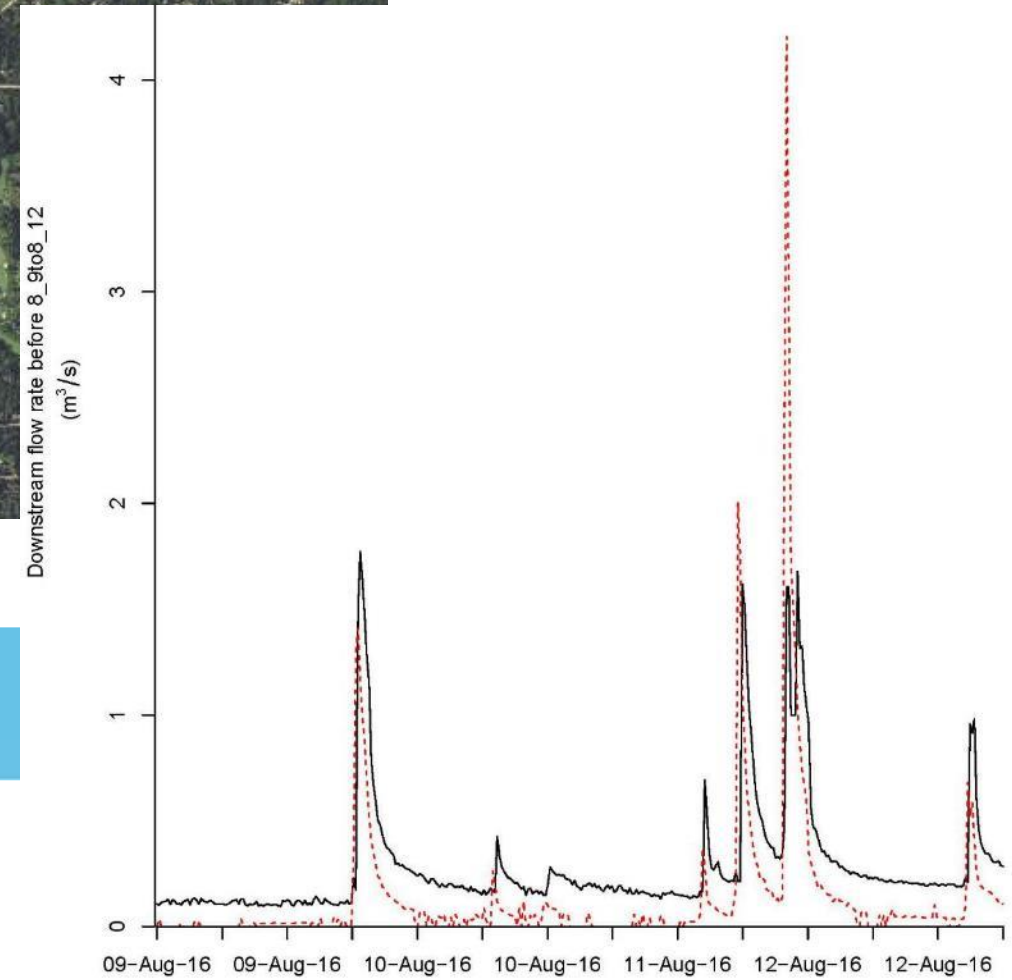
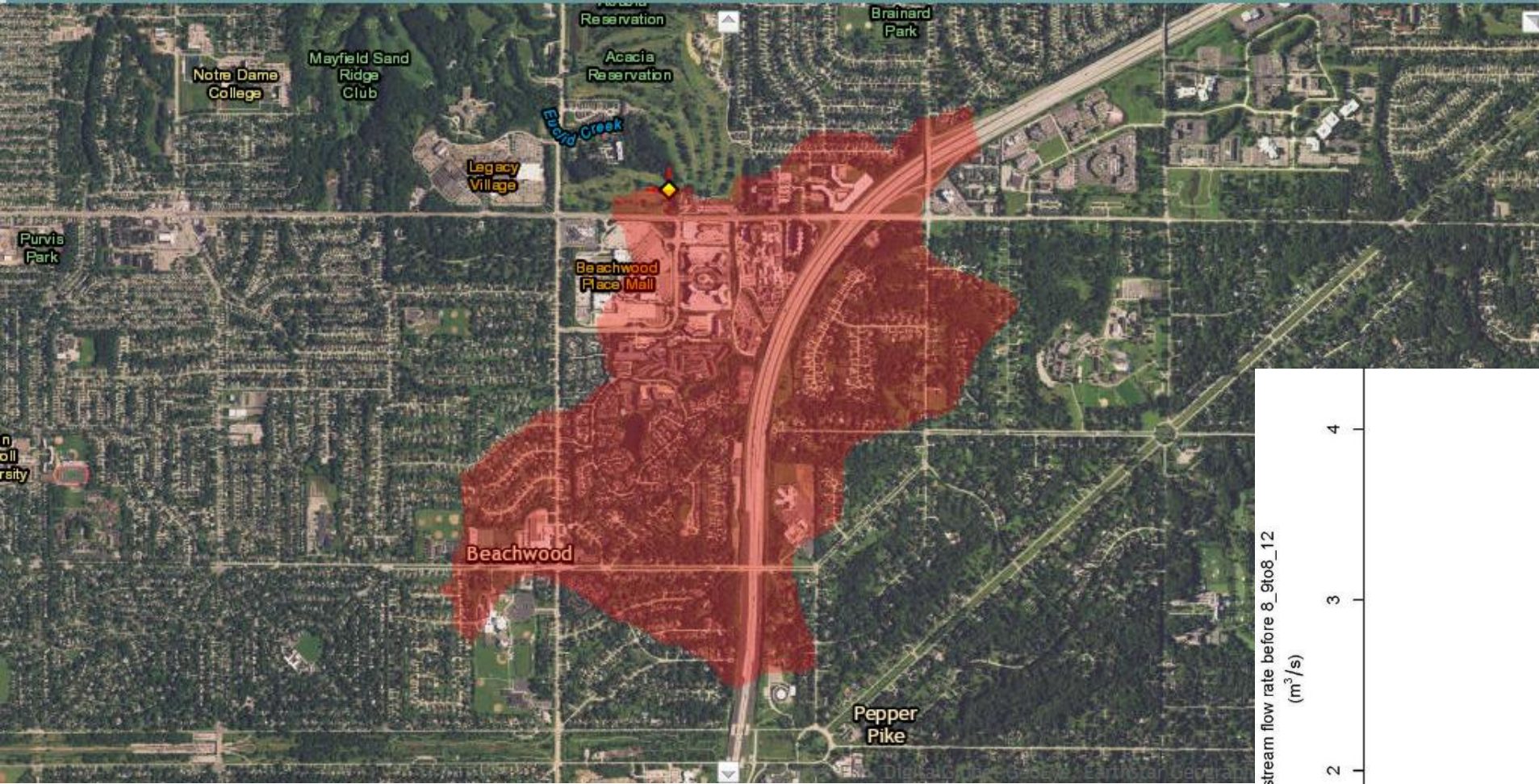


Stream Functions Pyramid

A Guide for Assessing & Restoring Stream Functions » OVERVIEW



FIGURE 1



1 HYDROLOGY » *Transport of water from the watershed to the channel*

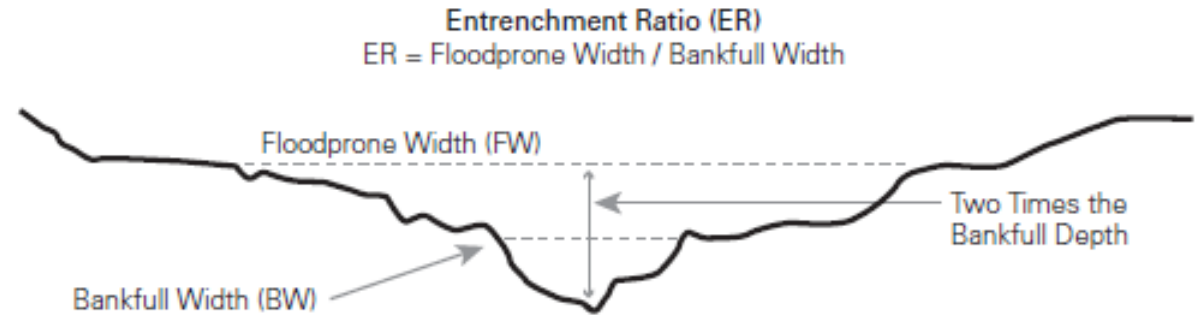
Functioning at Risk

Photo attribution: StreamStats

2 HYDRAULIC » *Transport of water in the channel, on the floodplain, and through sediments*

Entrenchment Ratio

- ER = Flood-prone width/bankfull width
- ER < 2 represent narrow floodplain valley



Entrenchment Ratio = 1.6

Not Functioning

3

GEOMORPHOLOGY » *Transport of wood and sediment to create diverse bed forms and dynamic equilibrium*

- Lateral Stability
 - Modified Bank Erosion Hazard Index & Near Bank Stress
- Qualitative Habitat Evaluation Index (QHEI)
- Large Woody Debris
- Riparian Assessment

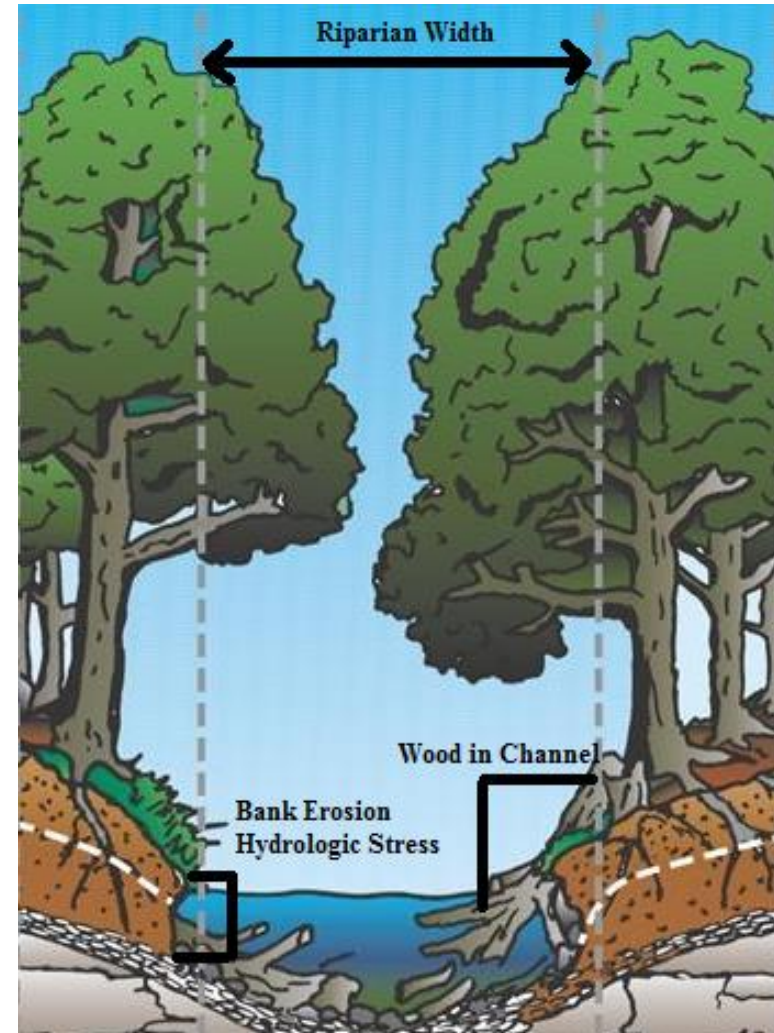
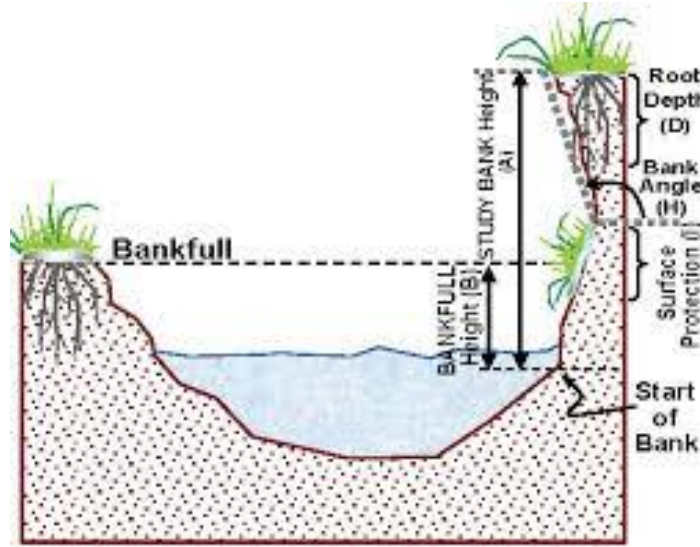


Photo attribution: Stroud Water
Resource Center, PA

LATERAL STABILITY

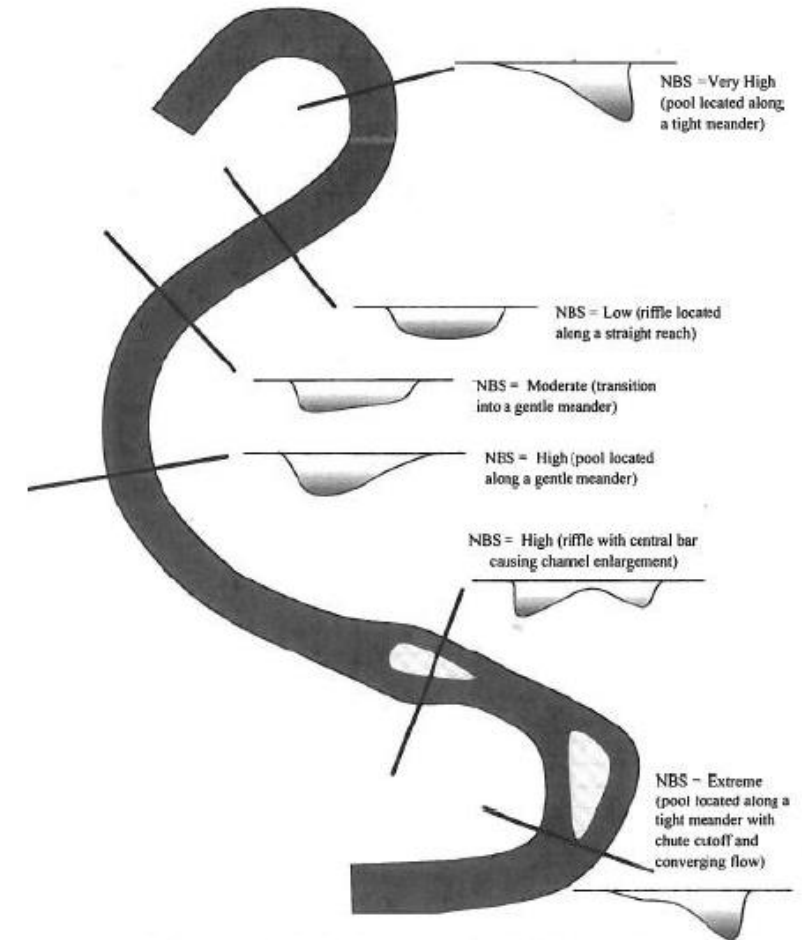
Bank Erosion Hazard Index (BEHI)

- Bank Length/Height
- Substrate
- Stratification
- Root Density/Depth
- Surface Protection
- Bank Angle



Near Bank Stress (NBS)

- Position relative to thalweg
- Riffles
- Pools
- Mid-channel bars and channel enlargement

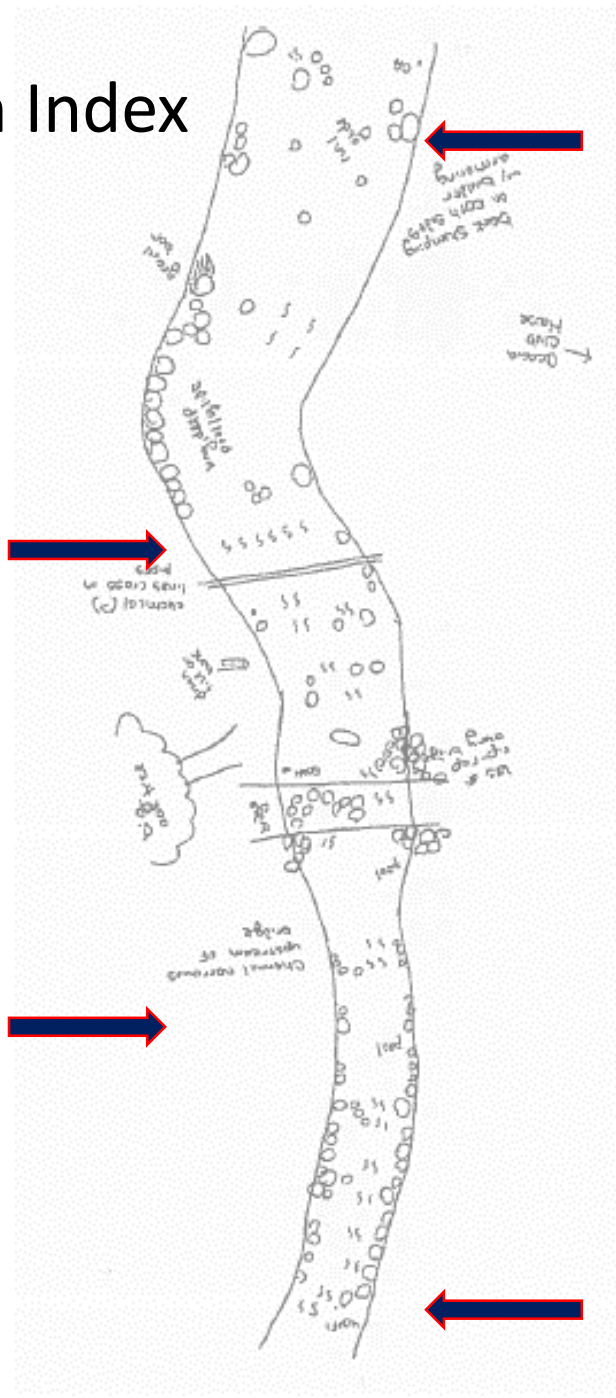


Near-bank stress estimation based on channel pattern, depositional features, and cross-section shape (Level I Reconnaissance) (Rosgen 2003).

Moderate BEHI/Moderate NBS

Functioning-At-Risk

Qualitative Habitat Evaluation Index



Qualitative Habitat Evaluation Index



OhioEPA Qualitative Habitat Evaluation Index and Use Assessment Field Sheet **QHEI Score: 56.0**

Stream & Location: Erie Creek @ Hope-a-Restoration (pre-restoration) RM: 2.9 Date: 6/18/15
Scorers Full Name & Affiliation: Dunlap / Montgomery Office verified location: ☐

River Code: 19-041-890 STORET #: Lat/Long: 41.50220 181.49132

1) **SUBSTRATE** Check ONLY Two substrate TYPE BOXES; estimate % or note every type present

BEST TYPES	POOL RIFFLE	OTHER TYPES	POOL RIFFLE	ORIGIN	QUALITY
<input type="checkbox"/> BEDROCK SLABS (10)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> HARD PAN (4)	<input type="checkbox"/> POOL RIFFLE	<input checked="" type="checkbox"/> LIMESTONE (1)	<input type="checkbox"/> HEAVY (2)
<input type="checkbox"/> BOULDER (8)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> DETRITUS (3)	<input type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> TILLS (1)	<input checked="" type="checkbox"/> MODERATE (1)
<input checked="" type="checkbox"/> COBBLE (8)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> MUCK (2)	<input type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> WETLANDS (0)	<input checked="" type="checkbox"/> NORMAL (0)
<input type="checkbox"/> GRAVEL (7)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> SILT (2)	<input type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> HARD PAN (0)	<input type="checkbox"/> FREE (1)
<input type="checkbox"/> SAND (6)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> ARTIFICIAL (0)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> SANDSTONE (0)	<input checked="" type="checkbox"/> EXTENSIVE (2)
<input type="checkbox"/> BEDROCK (5)	<input checked="" type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> (Score natural substrates, ignore sludge from point-sources)	<input type="checkbox"/> POOL RIFFLE	<input type="checkbox"/> RIP/RAR (0)	<input checked="" type="checkbox"/> MODERATE (1)

NUMBER OF BEST TYPES: 2 (Maximum 2)

Comments: Score natural substrates, ignore sludge from point-sources

2) **INSTREAM COVER** Indicate presence 0 to 3: 0-Absent; 1-Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large cobbles in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

COVER	AMOUNT
<input type="checkbox"/> UNDERCUT BANKS (1)	<input checked="" type="checkbox"/> EXTENSIVE 25% (1)
<input type="checkbox"/> OVERHANGING VEGETATION (1)	<input type="checkbox"/> MODERATE 25-75% (7)
<input type="checkbox"/> SHADOWS (UNSEGWATER) (1)	<input checked="" type="checkbox"/> SPARSE 5-25% (5)
<input type="checkbox"/> ROOTWADS (2)	<input type="checkbox"/> NEARLY ABSENT 0-5% (1)
<input type="checkbox"/> BOULDERS (4)	<input type="checkbox"/> COVER
<input type="checkbox"/> ROOTWADS (2)	<input type="checkbox"/> AMOUNT

Comments: Score natural substrates, ignore sludge from point-sources

3) **CHANNEL MORPHOLOGY** Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
<input type="checkbox"/> HIGH (4)	<input checked="" type="checkbox"/> EXCELLENT (7)	<input type="checkbox"/> NONE (6)	<input type="checkbox"/> HIGH (3)
<input type="checkbox"/> MODERATE (3)	<input type="checkbox"/> GOOD (5)	<input checked="" type="checkbox"/> RECOVERED (4)	<input checked="" type="checkbox"/> MODERATE (2)
<input type="checkbox"/> LOW (2)	<input type="checkbox"/> FAIR (3)	<input type="checkbox"/> RECOVERING (3)	<input type="checkbox"/> LOW (1)
<input type="checkbox"/> NONE (1)	<input type="checkbox"/> POOR (1)	<input type="checkbox"/> RECENT OR NO RECOVERY (1)	

Comments: Score natural substrates, ignore sludge from point-sources

4) **BANK EROSION AND RIPARIAN ZONE** Check ONE in each category for EACH BANK (Or 2 per bank & average)

EROSION	RIPARIAN WIDTH	FLOOD PLAIN QUALITY
<input type="checkbox"/> NONE (1)	<input type="checkbox"/> WIDE (60m) (4)	<input type="checkbox"/> FOREST SWAMP (3)
<input type="checkbox"/> MODERATE (2)	<input type="checkbox"/> MODERATE (10-50m) (3)	<input type="checkbox"/> SHRUB OR OPEN FIELD (2)
<input checked="" type="checkbox"/> HEAVY / SEVERE (4)	<input type="checkbox"/> VERY NARROW < 10m (1)	<input type="checkbox"/> RESIDENTIAL / AGRICULTURE (1)
	<input type="checkbox"/> NONE (0)	<input type="checkbox"/> FENCED PASTURE (1)
		<input type="checkbox"/> OPEN PASTURE / ROW CROP (0)

Comments: Score natural substrates, ignore sludge from point-sources

5) **POOL / GLIDE AND RIFFLE / RUN QUALITY**

MAXIMUM DEPTH	CHANNEL WIDTH	CURRENT VELOCITY
<input type="checkbox"/> SHALLOW (1)	<input checked="" type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (2)	<input type="checkbox"/> TORRENTIAL (1)
<input checked="" type="checkbox"/> 0.7-1.0m (4)	<input type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (1)	<input type="checkbox"/> VERY FAST (1)
<input type="checkbox"/> 0.4-0.7m (2)	<input type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (0)	<input type="checkbox"/> INTERMITTENT (1)
<input type="checkbox"/> 0.2-0.4m (0)	<input type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (0)	<input type="checkbox"/> FAST (1)
<input type="checkbox"/> 0.1-0.2m (0)	<input type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (0)	<input checked="" type="checkbox"/> MODERATE (2)
<input type="checkbox"/> 0.0-0.1m (0)	<input type="checkbox"/> POOL WIDTH / RIFFLE WIDTH (0)	<input type="checkbox"/> EDDIES (1)

Comments: Score natural substrates, ignore sludge from point-sources

6) **GRADIENT** (50 ft/mi) ☐ VERY LOW (LOW 2-4) ☐ MODERATE (6-10) ☒ HIGH (VERY HIGH 10-6)

7) **DRAINAGE AREA** (1.48 m²) ☐ VERY LOW (LOW 2-4) ☐ MODERATE (6-10) ☒ HIGH (VERY HIGH 10-6)

8) **% POOL**: 20 **% GLIDE**: 0 **% RUN**: 30 **% RIFFLE**: 50

9) **GRADIENT** (Maximum 10) 4

10) **RECREATION POTENTIAL** Primary Contact Secondary Contact (circle one and comment on bank)

11) **POOL / RIFFLE / RUN EMBEDDEDNESS** ☐ NONE (2) ☐ LOW (1) ☒ MODERATE (0) ☐ EXTENSIVE (1)

12) **RIFLE / RUN** ☐ NONE (2) ☐ LOW (1) ☒ MODERATE (0) ☐ EXTENSIVE (1)

13) **Channel** Maximum 10

14) **Cover** Maximum 46

15) **Substrate** Maximum 18

16) **Bank Erosion and Riparian Zone** Maximum 25

17) **Pool / Glide and Riffle / Run Quality** Maximum 9

18) **Gradient** Maximum 4

19) **Recreation Potential** Maximum 9

20) **Embeddedness** Maximum 6

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355) **Recreation Potential** Maximum 9

356) **Embeddedness** Maximum 6

357) **Channel Morphology** Maximum 10

358) **Bank Erosion and Riparian Zone** Maximum 25

359) **Pool / Glide and Riffle / Run Quality** Maximum 9

360) **Gradient** Maximum 4

361) **Recreation Potential** Maximum 9

362) **Embeddedness** Maximum 6</

Large Woody Debris

- >10cm diameter, >1m length
- Structural control
- Boundary roughness
- Flow resistance
- Can increase localized erosion
- Can increase substrate diversity



6 pcs / 100 m

Functioning-At-Risk

Rapid Riparian Assessment



- Avg. Riparian Width 30 ft. – 100 ft.
- Human impact
- Different vegetation zones
- Sheet flow v. concentrated flow
- Hillslope
- Presence of wetlands, floodplain
ponding, debris

Marginal

Functioning-At-Risk

4 PHYSIOCHEMICAL » Temperature and oxygen regulation; processing of organic matter and nutrients

Parameters *(Water Sentinel, 07/15)*

- Temperature 20.3 C
- pH 8.4
- Salinity 1420 mg/L
- Conductivity 2.4 mS
- Turbidity 35"??
- Total Dissolved Solids 1910 mg/L
- Nitrate 0
- Phosphate 10

All results were within EPA standards for water quality



???

Headwater IBI (fish) calculation

Includes 12 metrics from three categories that exhibit predictable gradients in quality:

- Species composition: total native, darter/sculpins, headwater, minnows, sensitive, and % tolerant
- Trophic composition: % pioneering, % omnivores, and % insectivores
- Fish condition: % DELT anomalies, relative number (minus tolerants), and simple lithophils

Headwater IBI (fish) calculation



Very Poor

Not Functioning

Headwater IBI Calculation

River Code: 19-041 River Mile 8.90 Date: 4/16/2015
River: Euclid Creek Location: Acadia Reservation (pre-restoration)
Drainage Area (sq mi): 1.48 Collectors: M.D. C. O. G. B. A.

IBI Metric	Value	Score	Low-End
Number of Native Species	4	1	1
Number of Minnow Species	2	1	1
Number of Headwater Species	0	1	1
Number of Sensitive Species	0	1	1
Number of Darter & Sculpin Species	0	1	1
Number of Simple Lithophilic Species	0	1	1
Proportion as Tolerant	62.5%	1	1
Proportion as Omnivores	6.25%	5	1
Proportion as Pioneering Species	62.5%	1	1
Proportion as Insectivores	37.5%	5	1
Proportion with DELT Anomalies	0.0%	5	1
Relative Number minus Tolerants	12.0	1	1

Total IBI Score (Unadjusted): 24.0

Total IBI Score (Low-End Adjusted): 12.0

"VERY POOR"
- LOWEST POSSIBLE IBI SCORE

Summary of Pre-restoration Results

5 **BIOLOGY** » *Biodiversity and the life histories of aquatic and riparian life*

Not Functioning

4 **PHYSIOCHEMICAL** » *Temperature and oxygen regulation; processing of organic matter and nutrients*

???

3 **GEOMORPHOLOGY** » *Transport of wood and sediment to create diverse bed forms and dynamic equilibrium*

Functioning at Risk

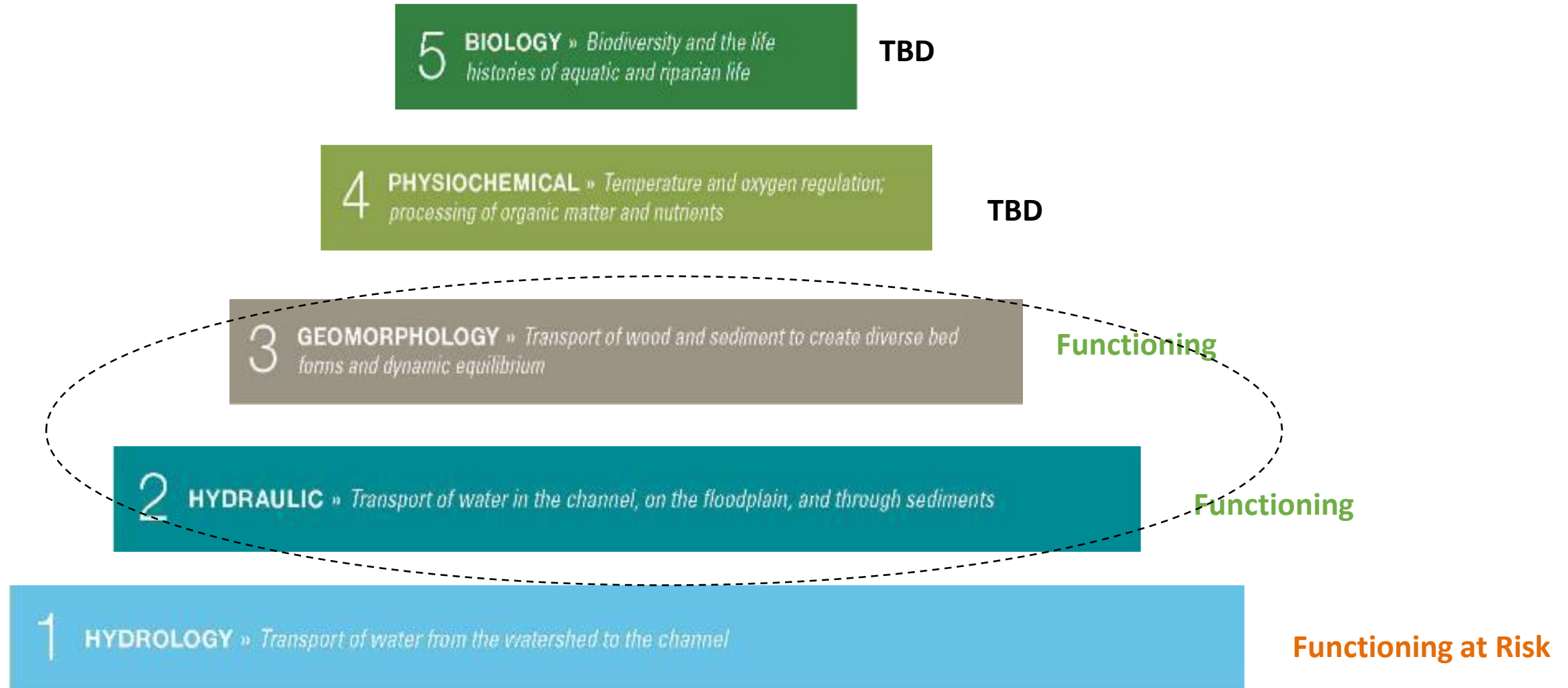
2 **HYDRAULIC** » *Transport of water in the channel, on the floodplain, and through sediments*

Not Functioning

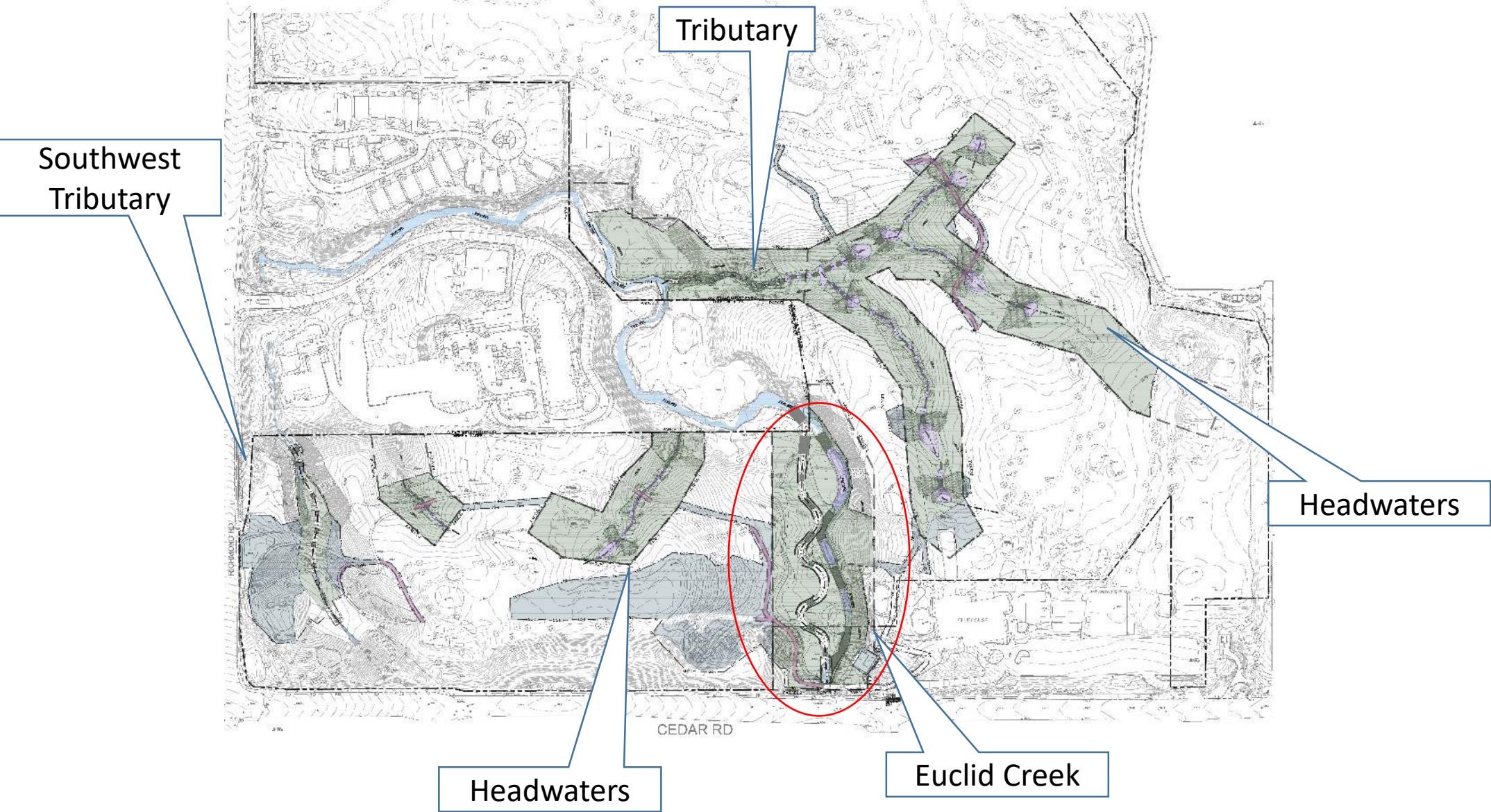
1 **HYDROLOGY** » *Transport of water from the watershed to the channel*

Functioning at Risk

Ecological Uplift Goals



Euclid Creek, Tributaries & Headwaters



Goal 1: Restore ± 900 linear feet of Euclid Creek and bring it into attainment of its WWH aquatic life use designation.

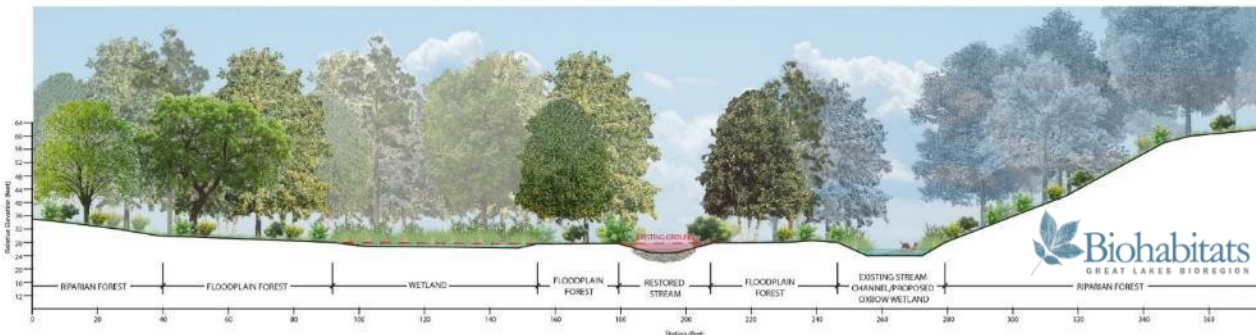
- Indicator: QHEI scores ≥ 60 for segments of Euclid Creek within Acacia Reservation within 10 years of restoration.
 - *Objective A* – Change **geomorphic parameters** that influence stream habitat (large woody debris and bed form diversity) from “Functioning-At-Risk” to “Functioning” along the ± 900 linear feet stretch of Euclid Creek.
 - *Objective B* – Change **floodplain connectivity** from “Not Functioning” to “Functioning” along ± 800 linear feet of the segment of Euclid Creek. This includes raising the streambed where incised.

Goal 2: To restore ± 3.5 acres of floodplain habitat to buffer the effects of stormwater inputs, increase infiltration capacity, and decrease erosion.

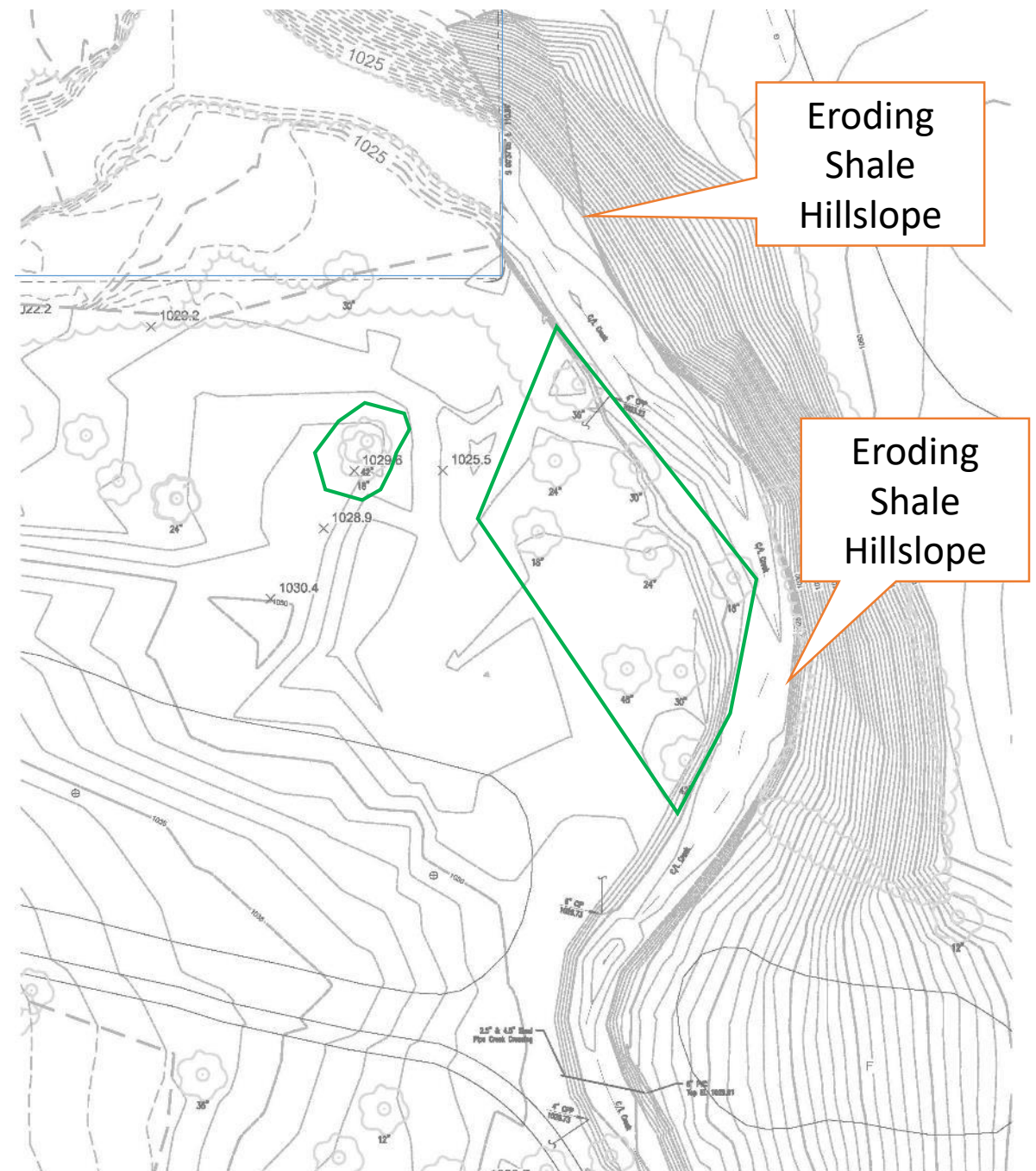
- Indicator: QHEI scores ≥ 60 for segments of Euclid Creek within Acacia Reservation within 10 years of restoration.
 - Change riparian vegetation from “Functioning-At-Risk” to “Functioning” by restoring ± 3.5 acres of riparian zone and floodplain. This includes disrupting historic drain tiles to achieve more natural hydrology and planting native trees, shrubs, and herbaceous plugs. The addition of an intact floodplain will reduce the impact of peak flows on the system.

Euclid Creek Plan

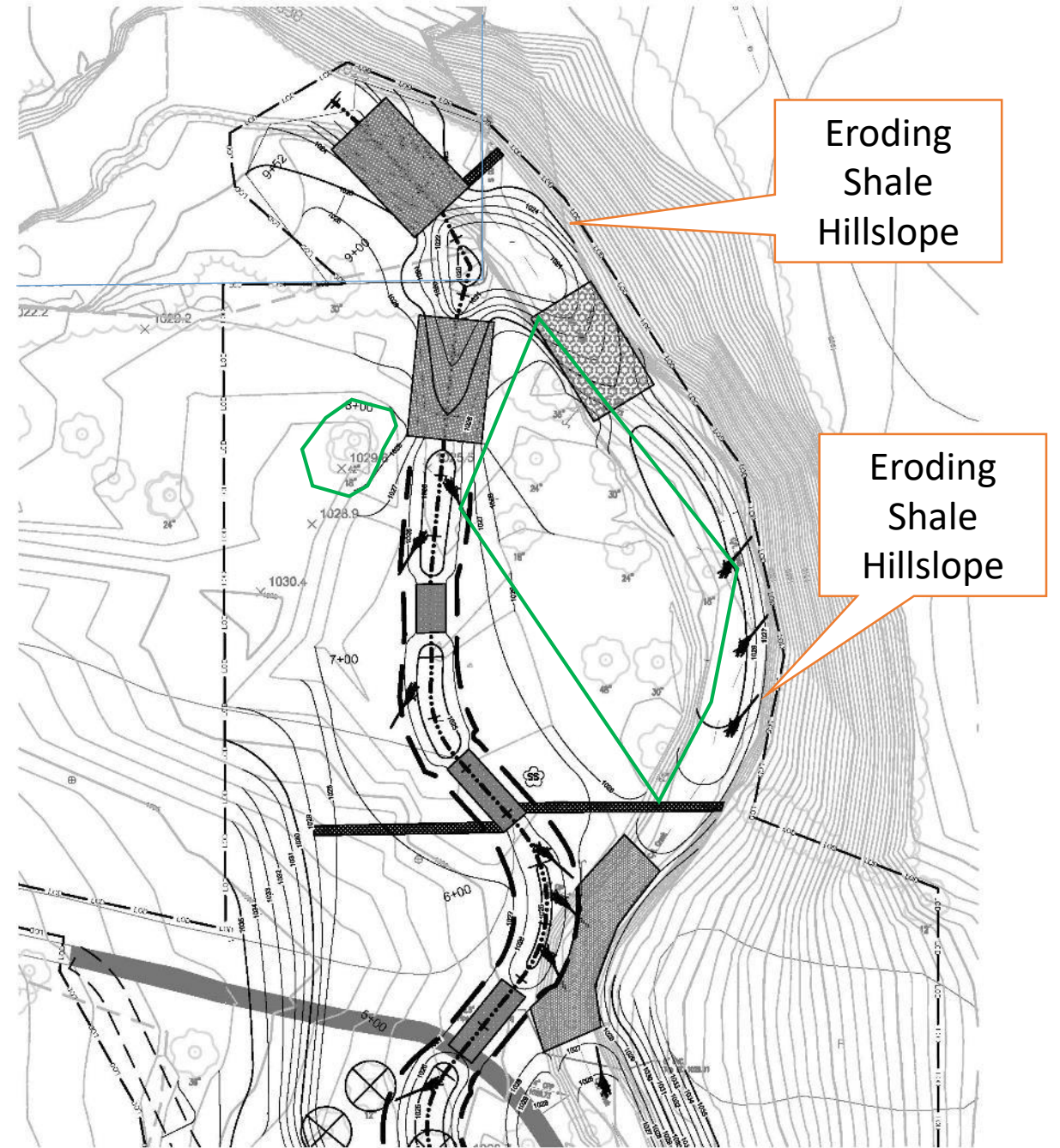
- Floodplain reconnection of Euclid Creek by raising streambed and excavating new floodplain
- Shift creek away from failing hillslope
- Construct riffles and pools to slow storm events and reduce downstream sediment supply
- Create floodplain and riparian forest in former fairways
- Create wetlands in old stream channel
- Install large woody debris and standing snag habitat features in floodplain



Euclid Creek Design



Euclid Creek Design



Euclid Creek Design



Euclid Creek Design



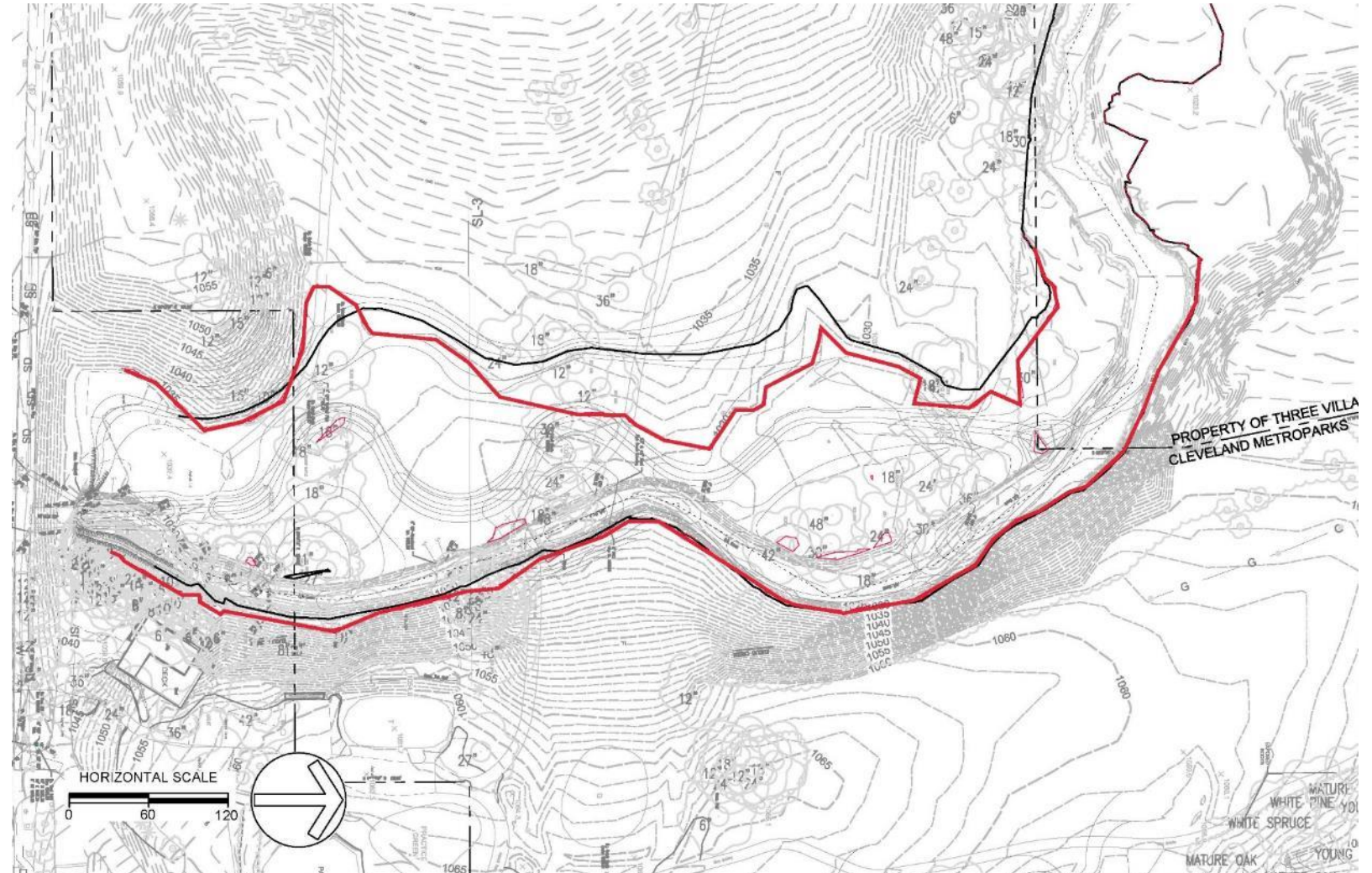
Cobble Sills – 425 LF

- help to prevent new channel from forming during high/heavy flow events
- approximately 4 feet wide by depth of thalweg



Euclid Creek Design

- Floodplain reconnection of Euclid Creek by raising streambed and excavating new floodplain
- Create floodplain and riparian forest in former fairways



Euclid Creek Design



Euclid Creek Design



Euclid Creek Construction

- 950 LF of channel construction/restoration
- 12,000 CY of excavation
- 950 tons of cobble – 37 loads
- 930 cy of mulch
- 930 cy of mulch
- 780 tons of imbricated rock – 36 loads



Erosion Control Matting

- Provides temporary stabilization until the establishment of vegetation
- 3,600 SY of coconut fiber matting and 2,280 SY of coir fiber matting



Post Construction



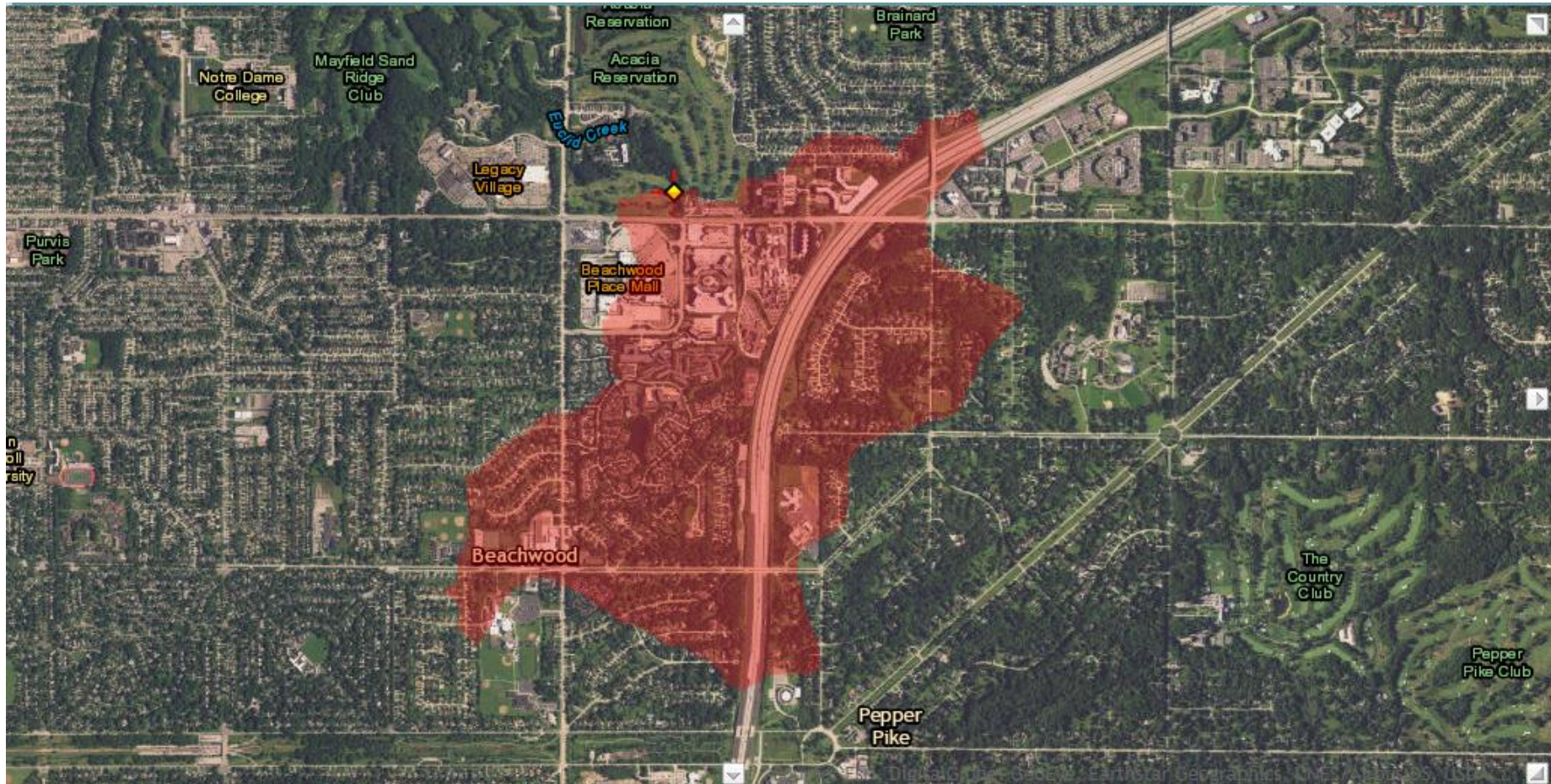
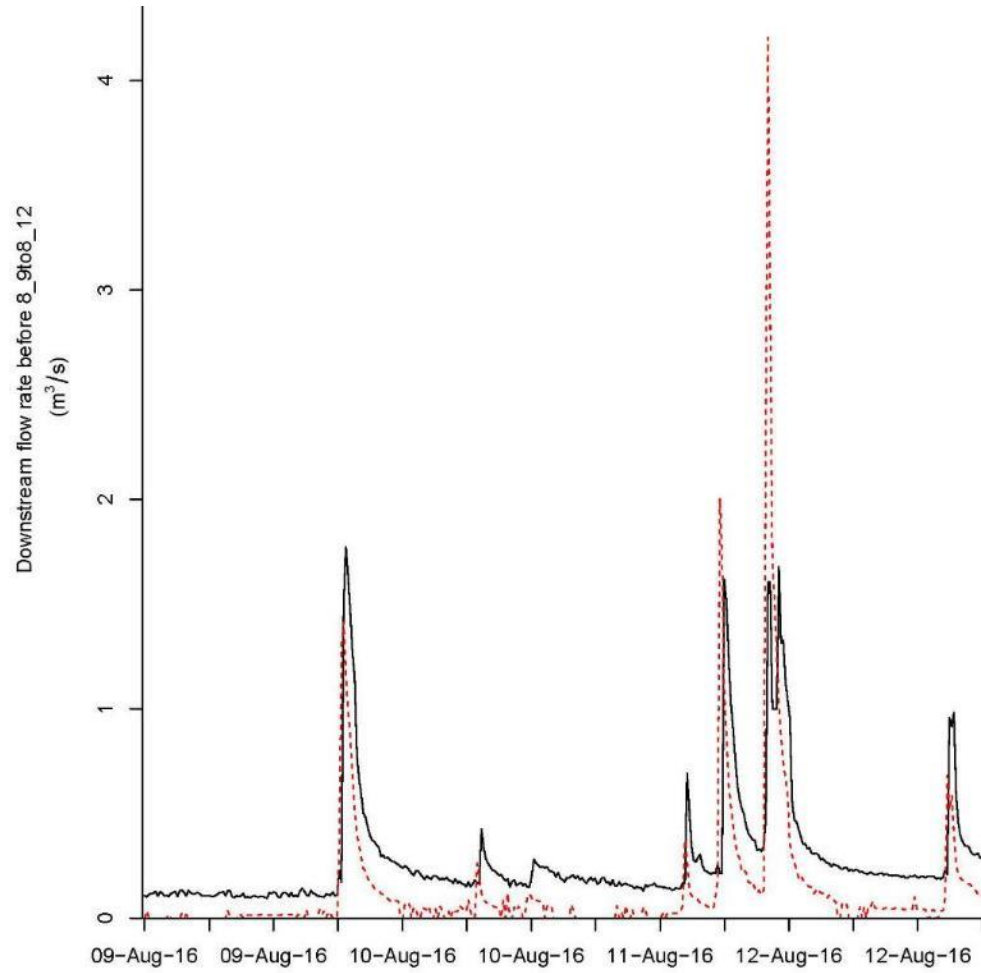


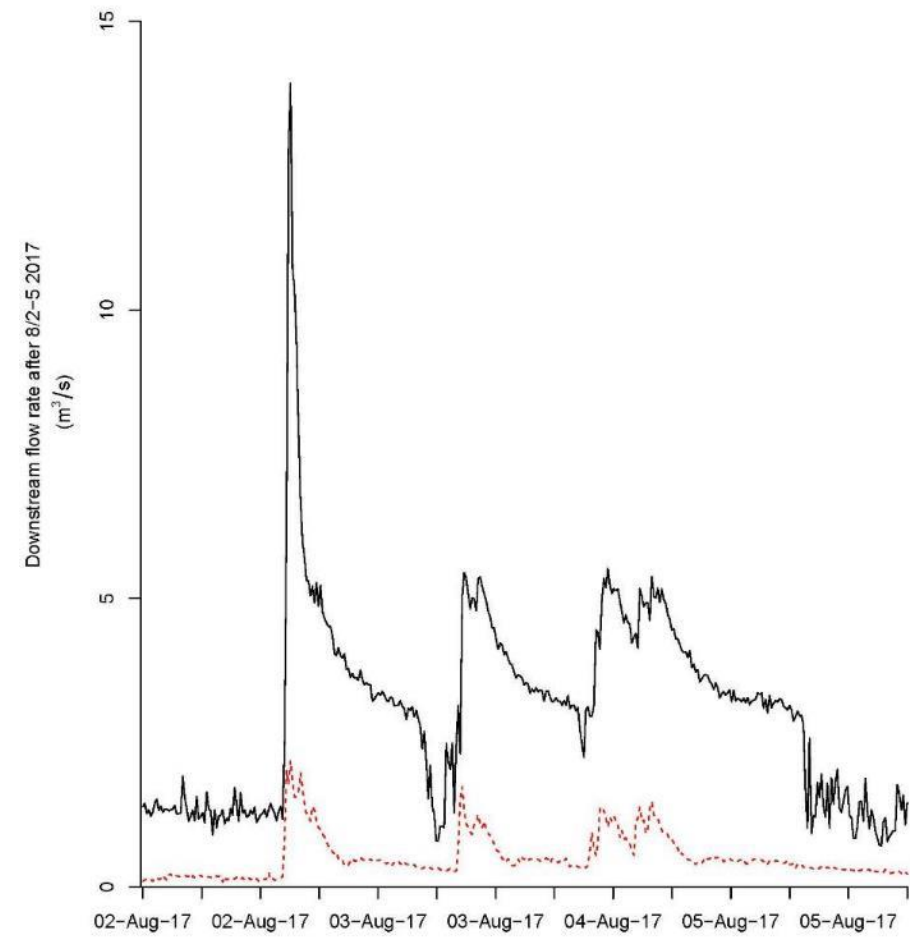
Photo attribution: StreamStats

No Change - Functioning at Risk

Before



After



2 HYDRAULIC » *Transport of water in the channel, on the floodplain, and through sediments*



New ER = 16.38

Functioning

3

GEOMORPHOLOGY » *Transport of wood and sediment to create diverse bed forms and dynamic equilibrium*

- BEHI – Primarily Low to Moderate
- Near Bank Stress - Varies



Functioning

Qualitative Habitat Evaluation Index



QHEI = 59 (Good)
Functioning

OhioEPA Qualitative Habitat Evaluation Index and Use Assessment Field Sheet **QHEI Score: 59**

Stream & Location: Eucaly Creek @ Acadia Reservation (Post-restoration) RM: 6.9 Date: 7/24/17

Scorers Full Name & Affiliation: Max Dwyer (Cleveland Metropoli)

River Code: 19-041-89 STORET #: Lat/Long: 41.50283 / 81.49140 Office verified location ☒

1] **SUBSTRATE** Check ONLY Two substrate TYPE BOXES; estimate % or note every type present

BEST TYPES	POOL RIFFLE	OTHER TYPES	POOL RIFFLE	ORIGIN	QUALITY
<input type="checkbox"/> BLDR / SLABS [10]	<input checked="" type="checkbox"/>	<input type="checkbox"/> HARDPAN [4]	<input checked="" type="checkbox"/>	<input type="checkbox"/> LIMESTONE [1]	<input type="checkbox"/> HEAVY [-2]
<input type="checkbox"/> BOULDER [9]	<input checked="" type="checkbox"/>	<input type="checkbox"/> DETRITUS [3]	<input checked="" type="checkbox"/>	<input type="checkbox"/> TILLS [1]	<input checked="" type="checkbox"/> MODERATE [-1]
<input checked="" type="checkbox"/> COBBLE [8]	<input checked="" type="checkbox"/>	<input type="checkbox"/> MUCK [2]	<input checked="" type="checkbox"/>	<input type="checkbox"/> WETLANDS [0]	<input type="checkbox"/> NORMAL [0]
<input type="checkbox"/> GRAVEL [7]	<input checked="" type="checkbox"/>	<input type="checkbox"/> SILT [2]	<input checked="" type="checkbox"/>	<input type="checkbox"/> HARDPAN [0]	<input type="checkbox"/> FREE [1]
<input type="checkbox"/> SAND [6]	<input checked="" type="checkbox"/>	<input type="checkbox"/> ARTIFICIAL [0]	<input checked="" type="checkbox"/>	<input type="checkbox"/> SANDSTONE [0]	<input type="checkbox"/> EXTENSIVE [-2]
<input type="checkbox"/> BEDROCK [5]	<input checked="" type="checkbox"/>	<input type="checkbox"/> (Score natural substrates; ignore)	<input checked="" type="checkbox"/>	<input type="checkbox"/> RIP/RAP [0]	<input checked="" type="checkbox"/> MODERATE [-1]
NUMBER OF BEST TYPES: <input type="checkbox"/> 4 or more [2] <input checked="" type="checkbox"/> 3 or less [0]				<input type="checkbox"/> LACUSTURINE [0]	<input type="checkbox"/> NORMAL [0]
Comments				<input checked="" type="checkbox"/> SHALE [-1]	<input type="checkbox"/> NONE [1]
				<input type="checkbox"/> COAL FINES [-2]	

2] **INSTREAM COVER** Indicate presence 0 to 3. 0-Absent; 1-Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

UNDERCUT BANKS [1]	POOLS > 70cm [2]	OXBOWS, BACKWATERS [1]	AMOUNT
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Check ONE (Or 2 & average)
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> EXTENSIVE >75% [1]
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> MODERATE 25-75% [7]
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> SPARSE 5-25% [3]
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> NEARLY ABSENT <5% [1]
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Cover Maximum 20
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	13

3] **CHANNEL MORPHOLOGY** Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
<input checked="" type="checkbox"/> HIGH [4]	<input checked="" type="checkbox"/> EXCELLENT [7]	<input type="checkbox"/> NONE [6]	<input checked="" type="checkbox"/> HIGH [3]
<input checked="" type="checkbox"/> MODERATE [3]	<input checked="" type="checkbox"/> GOOD [5]	<input type="checkbox"/> RECOVERED [4]	<input type="checkbox"/> MODERATE [2]
<input type="checkbox"/> LOW [2]	<input type="checkbox"/> FAIR [3]	<input checked="" type="checkbox"/> RECOVERING [3]	<input type="checkbox"/> LOW [1]
<input type="checkbox"/> NONE [1]	<input type="checkbox"/> POOR [1]	<input type="checkbox"/> RECENT OR NO RECOVERY [1]	
Comments			
Channel Maximum 20			
17.5			

4] **BANK EROSION AND RIPARIAN ZONE** Check ONE in each category for EACH BANK (Or 2 per bank & average)

EROSION	RIAPARIAN WIDTH	FLOOD PLAIN QUALITY
<input checked="" type="checkbox"/> NONE / LITTLE [3]	<input checked="" type="checkbox"/> WIDE > 50m [4]	<input type="checkbox"/> FOREST, SWAMP [3]
<input type="checkbox"/> MODERATE [2]	<input checked="" type="checkbox"/> MODERATE 10-50m [3]	<input type="checkbox"/> SHRUB OR OLD FIELD [2]
<input type="checkbox"/> HEAVY / SEVERE [1]	<input checked="" type="checkbox"/> NARROW 5-10m [2]	<input checked="" type="checkbox"/> RESIDENTIAL, PARK, NEW FIELD [1]
	<input type="checkbox"/> VERY NARROW < 5m [1]	<input type="checkbox"/> FENCED PASTURE [1]
	<input type="checkbox"/> NONE [0]	<input type="checkbox"/> OPEN PASTURE, ROWCROP [0]
		<input type="checkbox"/> CONSERVATION TILLAGE [1]
		<input type="checkbox"/> URBAN OR INDUSTRIAL [0]
		<input type="checkbox"/> MINING / CONSTRUCTION [0]
		Indicate predominant land use(s) past 100m riparian.
		Riparian Maximum 10
		6.5

5] **POOL / GLIDE AND RIFFLE / RUN QUALITY**

MAXIMUM DEPTH	CHANNEL WIDTH	CURRENT VELOCITY	Recreation Potential
Check ONE (ONLY)	Check ONE (Or 2 & average)	Check ALL that apply	Primary Contact
<input type="checkbox"/> > 1m [6]	<input checked="" type="checkbox"/> POOL WIDTH > RIFFLE WIDTH [2]	<input type="checkbox"/> TORRENTIAL [-1]	Secondary Contact
<input type="checkbox"/> 0.7-1m [4]	<input type="checkbox"/> POOL WIDTH = RIFFLE WIDTH [1]	<input type="checkbox"/> VERY FAST [1]	(circle one and comment on back)
<input checked="" type="checkbox"/> 0.4-0.7m [2]	<input type="checkbox"/> POOL WIDTH < RIFFLE WIDTH [0]	<input type="checkbox"/> FAST [1]	
<input type="checkbox"/> 0.2-0.4m [1]		<input checked="" type="checkbox"/> MODERATE [1]	
<input type="checkbox"/> < 0.2m [0]		<input type="checkbox"/> INTERMITTENT [-2]	
		<input type="checkbox"/> EDDIES [1]	
		Indicate for reach - pools and riffles	
		Pool / Current Maximum 12	
		6	

6] **GRADIENT** (5.0 f/mi) ☐ VERY LOW - LOW [2-4] ☐ MODERATE [6-10] ☒ HIGH - VERY HIGH [10-6]

DRAINAGE AREA (1.4% mi²) ☐ VERY LOW - LOW [2-4] ☐ MODERATE [6-10] ☒ HIGH - VERY HIGH [10-6]

%POOL: 65 %GLIDE: 0 %RUN: 35 %RIFFLE: 35

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
<input type="checkbox"/> BEST AREAS > 10cm [2]	<input type="checkbox"/> MAXIMUM > 50cm [2]	<input checked="" type="checkbox"/> STABLE (e.g., Cobble, Boulder) [2]	<input type="checkbox"/> NONE [2]
<input checked="" type="checkbox"/> BEST AREAS 5-10cm [1]	<input checked="" type="checkbox"/> MAXIMUM < 50cm [1]	<input type="checkbox"/> MOD. STABLE (e.g., Large Gravel) [1]	<input type="checkbox"/> LOW [1]
<input type="checkbox"/> BEST AREAS < 5cm [metric=0]		<input type="checkbox"/> UNSTABLE (e.g., Fine Gravel, Sand) [0]	<input checked="" type="checkbox"/> MODERATE [0]
			<input type="checkbox"/> EXTENSIVE [-1]
			Riffle / Run Maximum 8
			4

7] **GRADIENT** (5.0 f/mi) ☐ VERY LOW - LOW [2-4] ☐ MODERATE [6-10] ☒ HIGH - VERY HIGH [10-6]

DRAINAGE AREA (1.4% mi²) ☐ VERY LOW - LOW [2-4] ☐ MODERATE [6-10] ☒ HIGH - VERY HIGH [10-6]

%POOL: 65 %GLIDE: 0 %RUN: 35 %RIFFLE: 35

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

NO RIFFLE [metric=0]

Gradient Maximum 10

4

Large Woody Debris

- 3 pieces of Large Woody Debris



Not Functioning



Rapid Riparian Assessment

- **USEPA RBP**
 - Avg. buffer width = 185 ft.
- **USFWS Stream Assessment Ranking**
 - No zones well represented.
 - Distance from stream to hillside, 50-100 ft.
 - Hill slope is 4%.
 - Sheet run-off. Ponding well represented.

Functioning / Functioning –At-Risk

4 **PHYSIOCHEMICAL** » *Temperature and oxygen regulation; processing of organic matter and nutrients*



???

5

BIOLOGY » *Biodiversity and the life histories of aquatic and riparian life*





Headwater IBI Calculation

River Code: 19-041 River Mile: 8.90 Date: 4/18/2015
 River: Euclid Creek Location: Acacia Reservation (pre-restoration)
 Drainage Area (sq mi): 1.48 Collectors: M. Surber, C. Weldon, P. Ford

IBI Metric	Value	Score	Low-End
Number of Native Species	4	1	1
Number of Minnow Species	2	1	1
Number of Headwater Species	0	1	1
Number of Sensitive Species	0	1	1
Number of Darter & Sculpin Species	0	1	1
Number of Simple Lithophilic Species	0	1	1
Proportion as Tolerant	62.5%	1	1
Proportion as Omnivores	6.25%	5	1
Proportion as Pioneering Species	62.5%	1	1
Proportion as Insectivores	37.5%	5	1
Proportion with DELT Anomalies	0.0%	5	1
Relative Number minus Tolerants	12.0	1	1

Total IBI Score (Unadjusted): 24.0

Total IBI Score (Low-End Adjusted): 12.0

Very poor

"VERY POOR"
- LOWEST POSSIBLE IBI SCORE

Restoration

Headwater IBI Calculation

River Code: 19-041 River Mile: 8.90 Date: 7/24/17
 River: Euclid Creek Location: Acacia Reservation
 Drainage Area (sq mi): 1.48 Collectors: M. Surber, C. Weldon, P. Ford

IBI Metric	Value	Score	Low-End
Number of Native Species	3	1	N/A
Number of Minnow Species	2	1	N/A
Number of Headwater Species	0	1	N/A
Number of Sensitive Species	0	1	N/A
Number of Darter & Sculpin Species	0	1	N/A
Number of Simple Lithophilic Species	0	1	N/A
Proportion as Tolerant	93.33%	1	N/A
Proportion as Omnivores	1.43%	5	N/A
Proportion as Pioneering Species	81.9%	1	N/A
Proportion as Insectivores	16.67%	3	N/A
Proportion with DELT Anomalies	0	5	N/A
Relative Number minus Tolerants	70	3	N/A

Poor

Total IBI Score (Unadjusted): 24.0

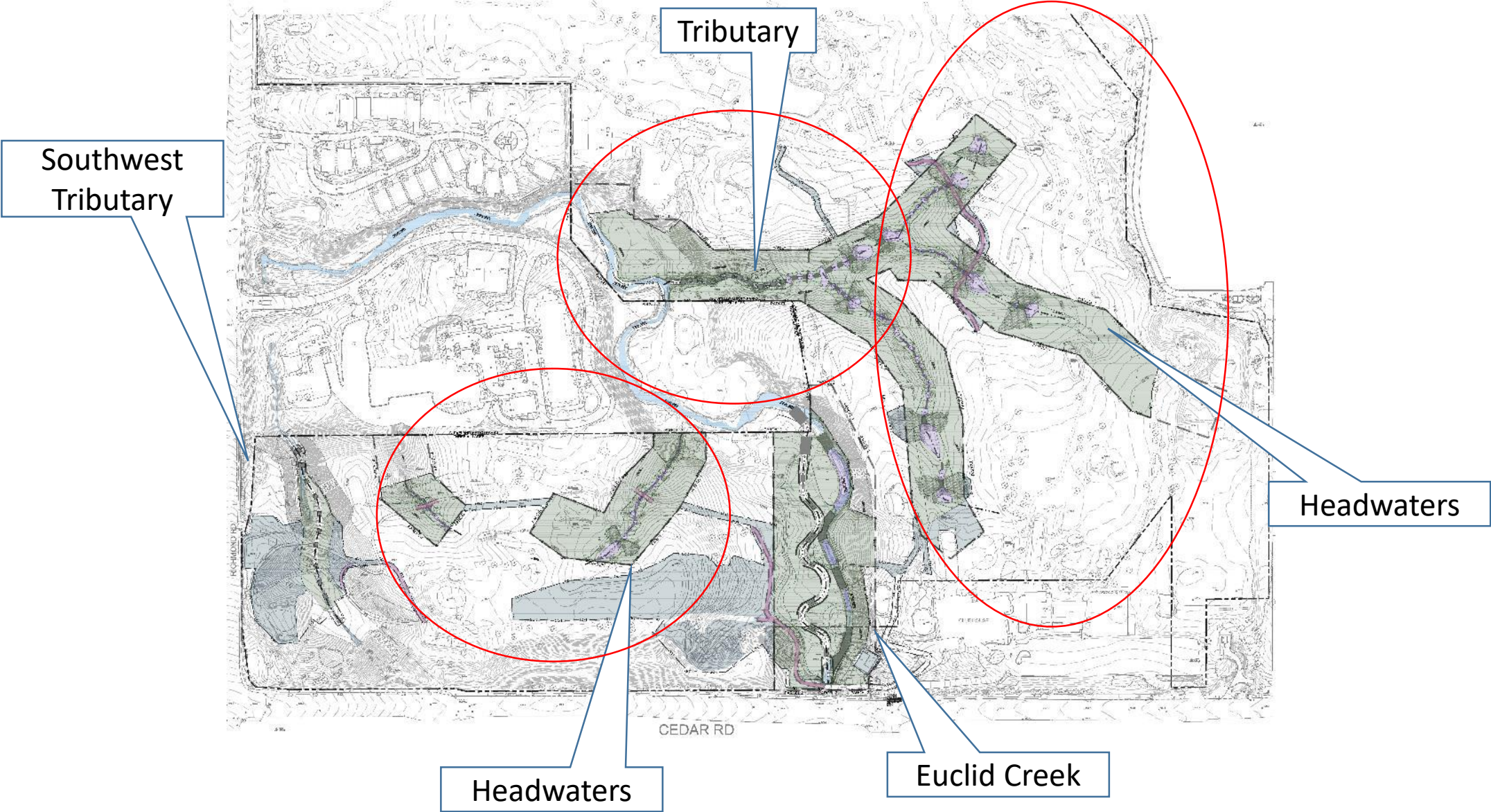
Total IBI Score (Low-End Adjusted): N/A

Not Functioning... yet

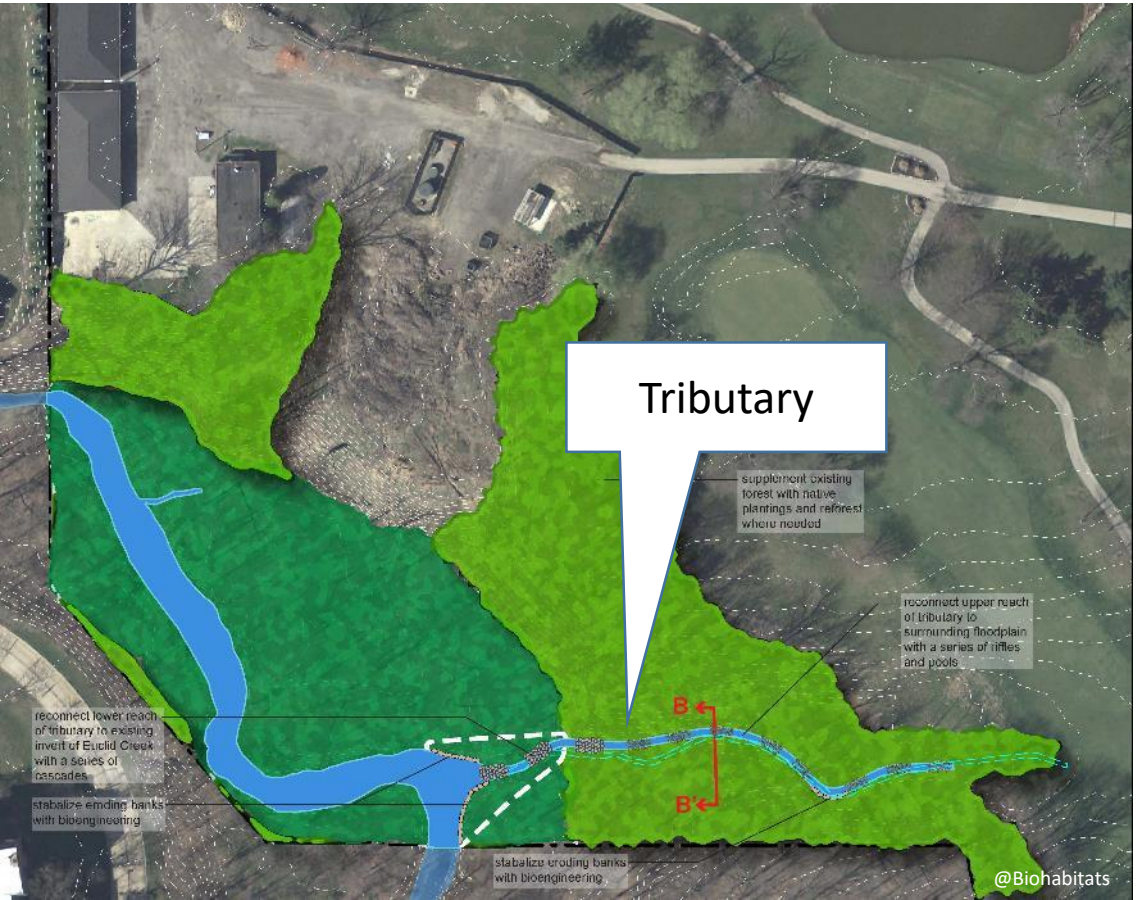
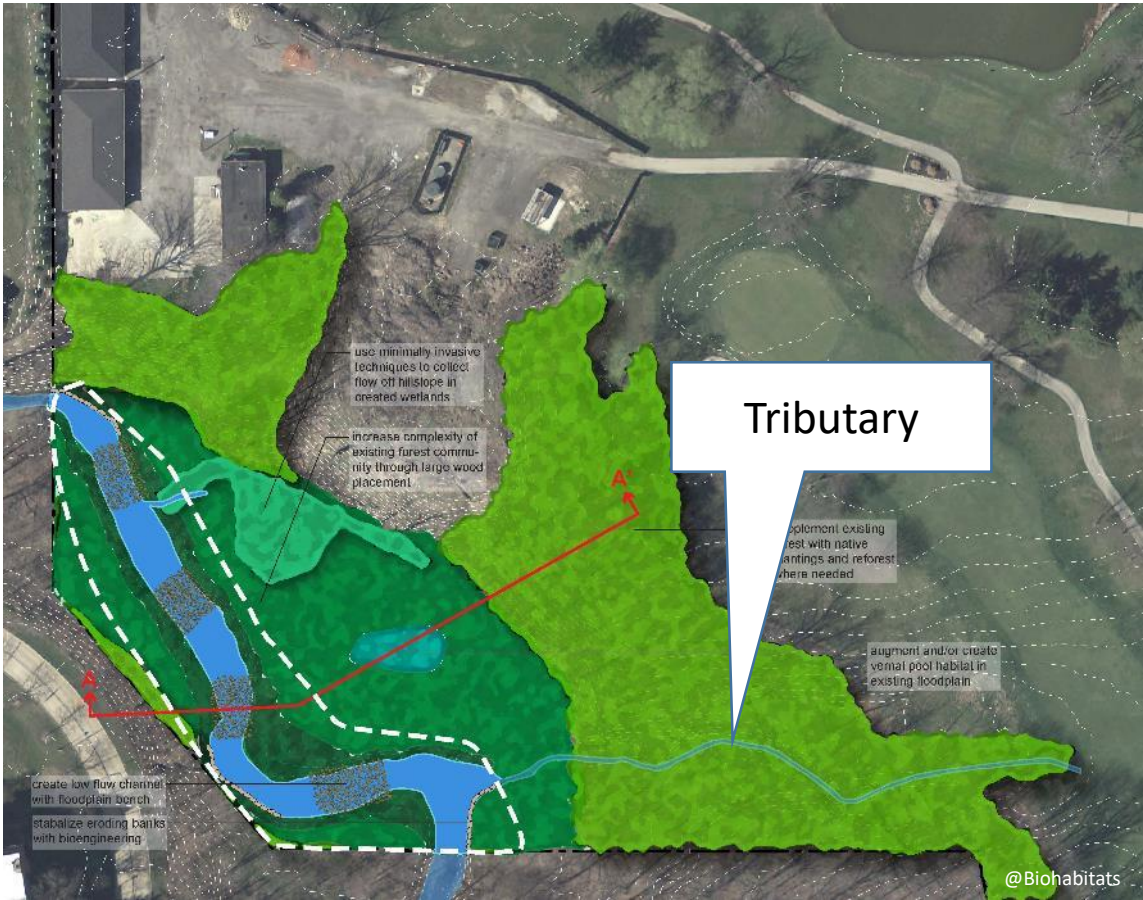
"POOR"

	Parameter	Before Restoration (2013-2016)	Recently After Restoration (summer 2017)	
				
Biological		NF	NF	↑
Physiochemical		?	?	
Geomorphology	BEHI/NBS	F-A-R	F	↑
	QHEI	F-A-R	F	↑
	Large Woody Debris	F	NF	↓
	Riparian Health	F-A-R	F-A-R	↑
Hydraulics	Entrenchment Ratio	NF	F	↑
Hydrology		F-A-R	F-A-R	—

Euclid Creek, Tributaries & Headwaters



Euclid Creek, Tributaries & Headwaters



Tributary

Goal: To restore 372± linear feet of intermittent tributary to Euclid Creek to reduce sediment loadings and provide for stable channel.

- *Objective A:* Change lateral stability parameter to address erosion and siltation from “Not Functioning” to “Functioning” for 372± linear feet of intermittent stream restoration.
- *Objective B:* Change geomorphic parameters that influence stream habitat (bed form diversity) from “Not Functioning” to “Functioning” along 372± linear feet of intermittent channel.

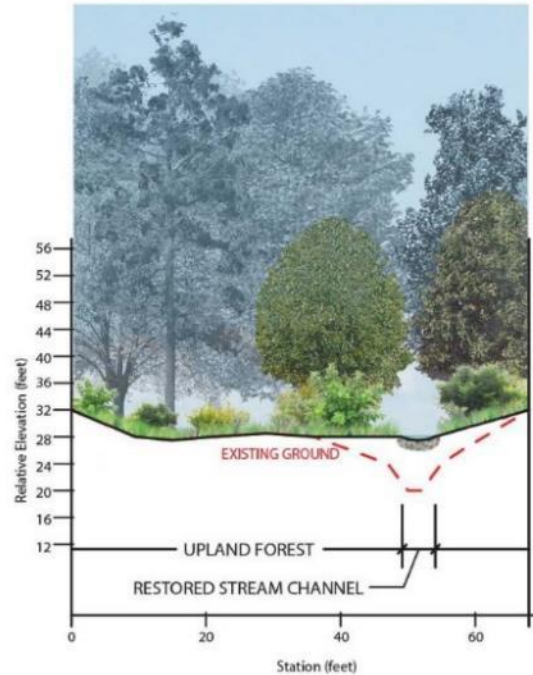
Headwaters

Goal 1: To restore approx. 14.3 acres of wetland swales along existing drainage network to further increase infiltration capacity, decrease sediment and pollutant loads, increase native habitat, and contribute to a more resilient watershed.

- *Objective 1:* Remove invasive plant material and debris from swales.
- *Objective 2:* Re-established surface drainage and promote infiltration by removing/plugging/breaking drainage tile within the 75 foot buffer.
- *Objective 3:* Restore wetlands through use of sand seepage beds and other soil saturation techniques and provide for stable channel through use of cascades and other techniques in steeper locations where restoration/creation may not be possible.
- *Objective 4:* Provide habitat for wildlife by incorporating habitat features such as woody debris piles and standing snags.
- *Objective 5:* Include a 75-foot buffer around the identified drainage corridor.

Headwaters and Tributary Plan

- Break & remove tile drainage network
- Create stream channels to convey flows
- Create berms to slow and filter storm flows
- Restore “rough” to forest and wetlands
- Supplement existing forest



Headwaters Existing Conditions



Headwaters and Tributary Design

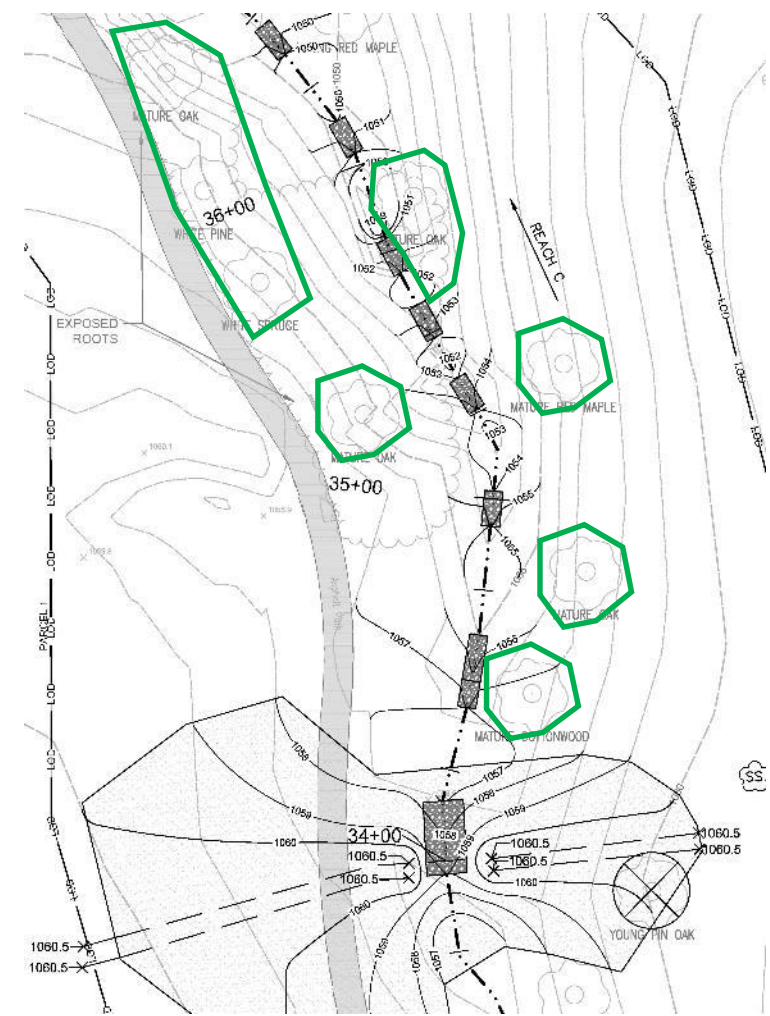
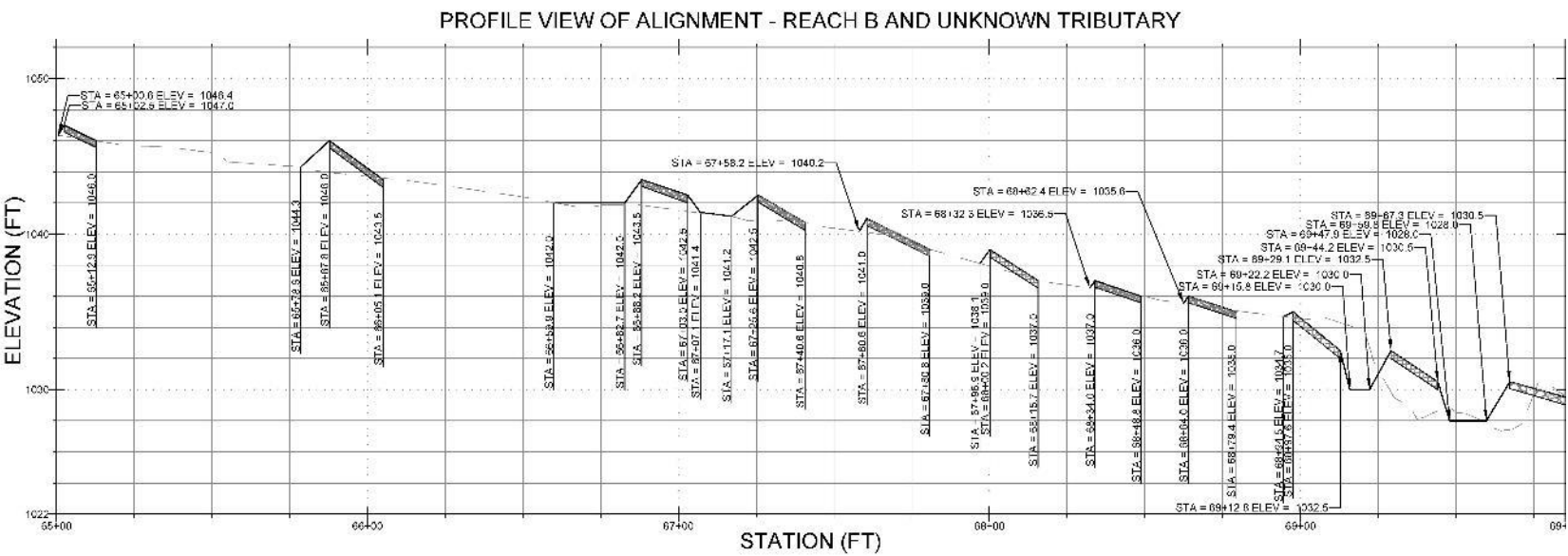
	Area A			Area B			Area C			Area A+B			Area A+B+C		
	Existing Conditions	Proposed Conditions	Future Conditions	Existing Conditions	Proposed Conditions	Future Conditions	Existing Conditions	Proposed Conditions	Future Conditions	Existing Conditions	Proposed Conditions	Future Conditions	Existing Conditions	Proposed Conditions	Future Conditions
Storm Event															
1	2.6	2.2	1.5	4.5	3.3	2.7	5.7	4.1	2	7.4	5.4	4.1	10.2	8.4	6
2	2.9	2.5	1.7	5.1	3.7	3.1	6.3	4.6	2.3	8.3	6.1	4.7	11.5	9.4	6.8
5	5.6	4.9	3.5	9.8	7.5	6.5	12	9	5	16	12.4	9.8	22.5	19.3	14.4
10	7	6.2	4.4	12.4	9.7	8.4	15	11.4	6.4	20.3	15.9	12.7	28.6	24.7	18.6
25	8.9	7.9	5.7	15.8	12.5	11	19	14.5	8.4	25.7	20.5	16.5	36.4	31.8	24.3
50	10.8	9.7	7.1	19.3	15.4	13.6	23.2	17.8	10.4	31.4	25.2	20.5	44.7	39.2	30.1
100	11.6	10.4	7.6	20.7	16.6	14.7	24.8	19.2	11.2	33.7	27.2	22.1	48	42.2	32.5

Headwaters and Tributary Design

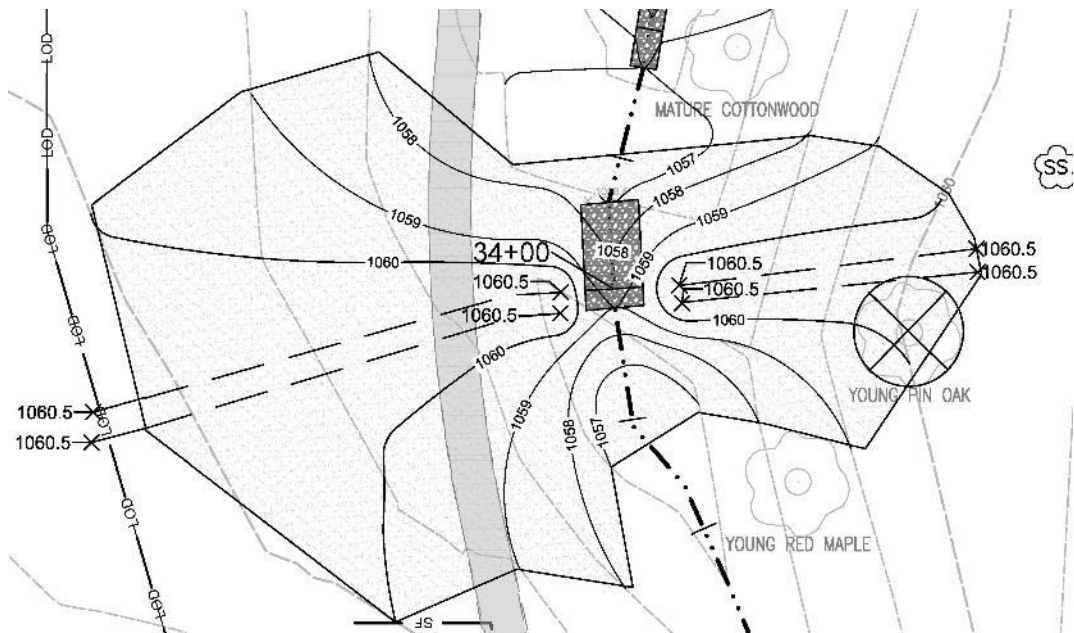
Stress Conditions	τ_{fp} (psf)
Low Stress- Channel doesn't need to conform to floodplain alignment. If space allows, channel can be highly sinuous.	< 1.0
Medium Stress -Channel planform is highly dependent floodplain planform and curvature	1.0-1.5
High Stress -Erosion in floodplain will cause floodplain channels to form and the potential development of an anabranching channel network. Provide grade control and plan for anabranching channel network	1.5-2.0
Very High Stress - Need to protect high stress regions of the floodplain with rock or other vertical control to prevent degradation unless floodplain is covered with mature brushy vegetation that has a complete coverage of the high stress regions of the floodplain.	>2.0



Headwaters and Tributary Design



Headwaters Design



Cleveland Metroparks

Sand Seepage Wetland



© Biohabitats, Inc.

Headwaters Design



Tributary Design



Headwaters and Tributary Design



Headwater Construction

- Construction of 5 separate headwater ephemeral channels totaling 2,535 LF
- 3,000 CY of fill from Euclid Creek floodplain excavation
- 374 tons of sand (processed river sediment) – 17 loads
- 1,218 cubic yards of mulch



Tributary Construction

- 325 LF of channel restoration of Unnamed Tributary to Euclid Creek
- 640 tons of cobble – 25 loads
- 154 tons of imbricated rock – 7 loads



Tributary Post Construction



Apr. 2017



Aug. 2017

Headwaters Post Construction



Headwaters Post Construction



Before



After



Headwaters Post Construction

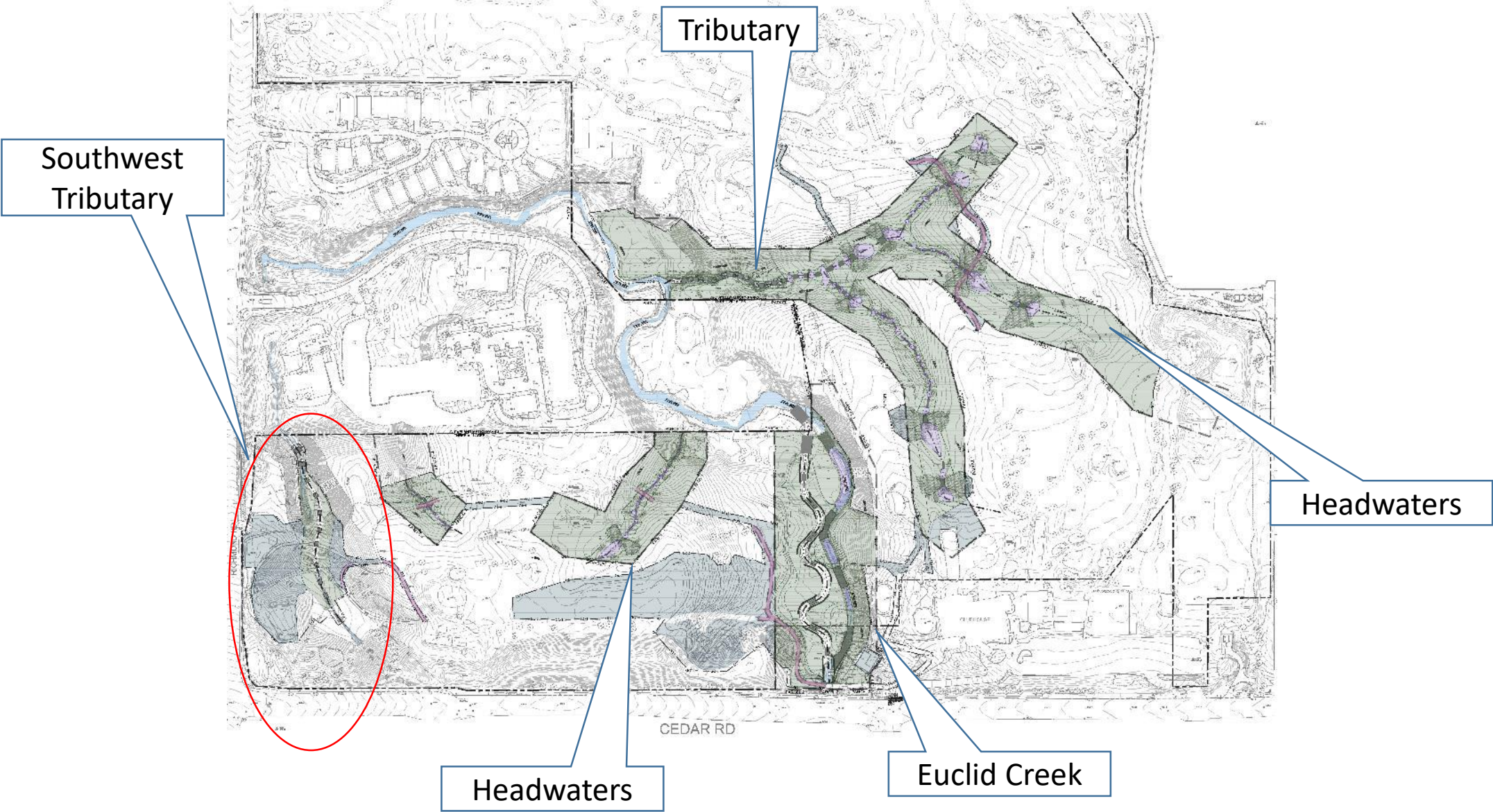


Euclid Creek, Tributary & Headwaters

- approximately \$1,300,000 in base contract for construction
- 9 months for construction - October 2016 to June 2017
- planting at end of April 2017 and beginning of June 2017
- 2,687 trees
- 1,210 shrubs
- 4,174 herbaceous
- 150 live stakes
- 15 acres of seeding



Euclid Creek, Tributaries & Headwaters



Southwest Tributary

Goal: Daylight 150 feet of intermittent stream.

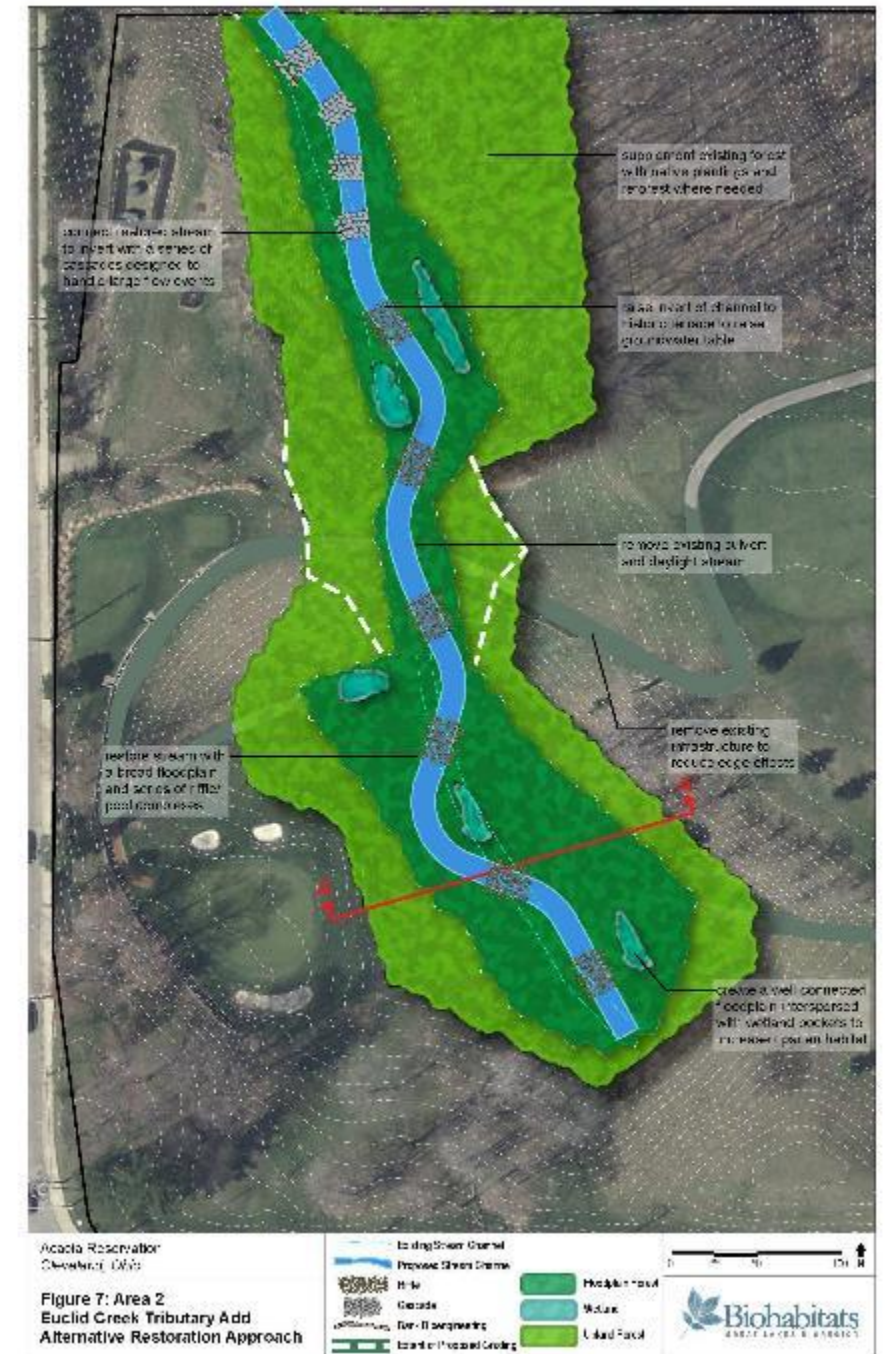
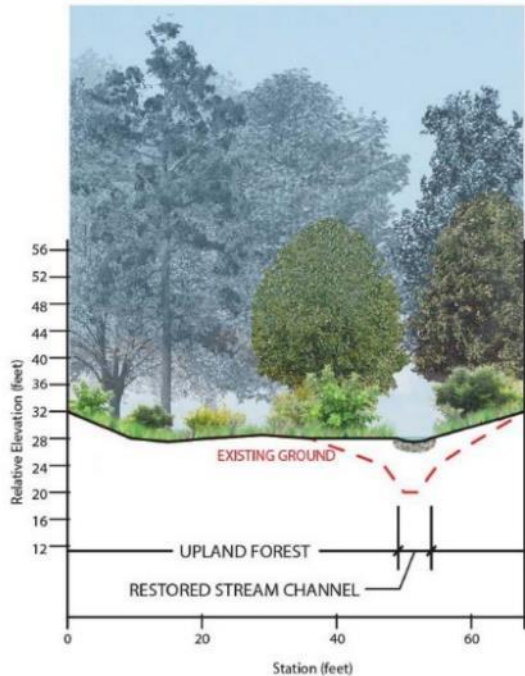
Objective A: Address habitat and flow alteration by removing culvert, daylighting/restoring 150 LF of stream, and provide for stable transitions with existing daylighted stream sections (upstream and downstream).

Objective B: Reverse in-stream and riparian habitat alteration associated with former channelization to the extent possible by establishing grade controls and plantings to stabilize existing stream banks.

Objective C: Expand riparian vegetation by restoring riparian zone and disrupt historic drain tiles to achieve more natural hydrology

Southwest Tributary Plan

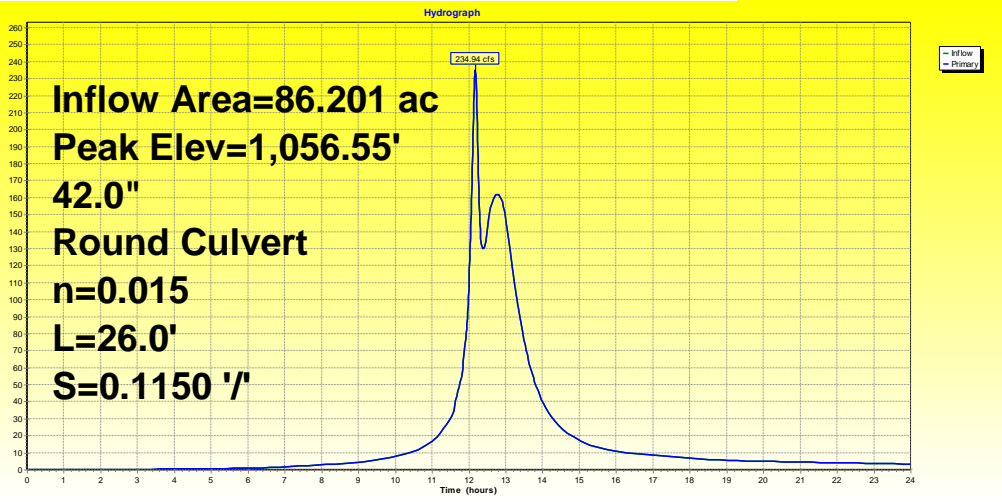
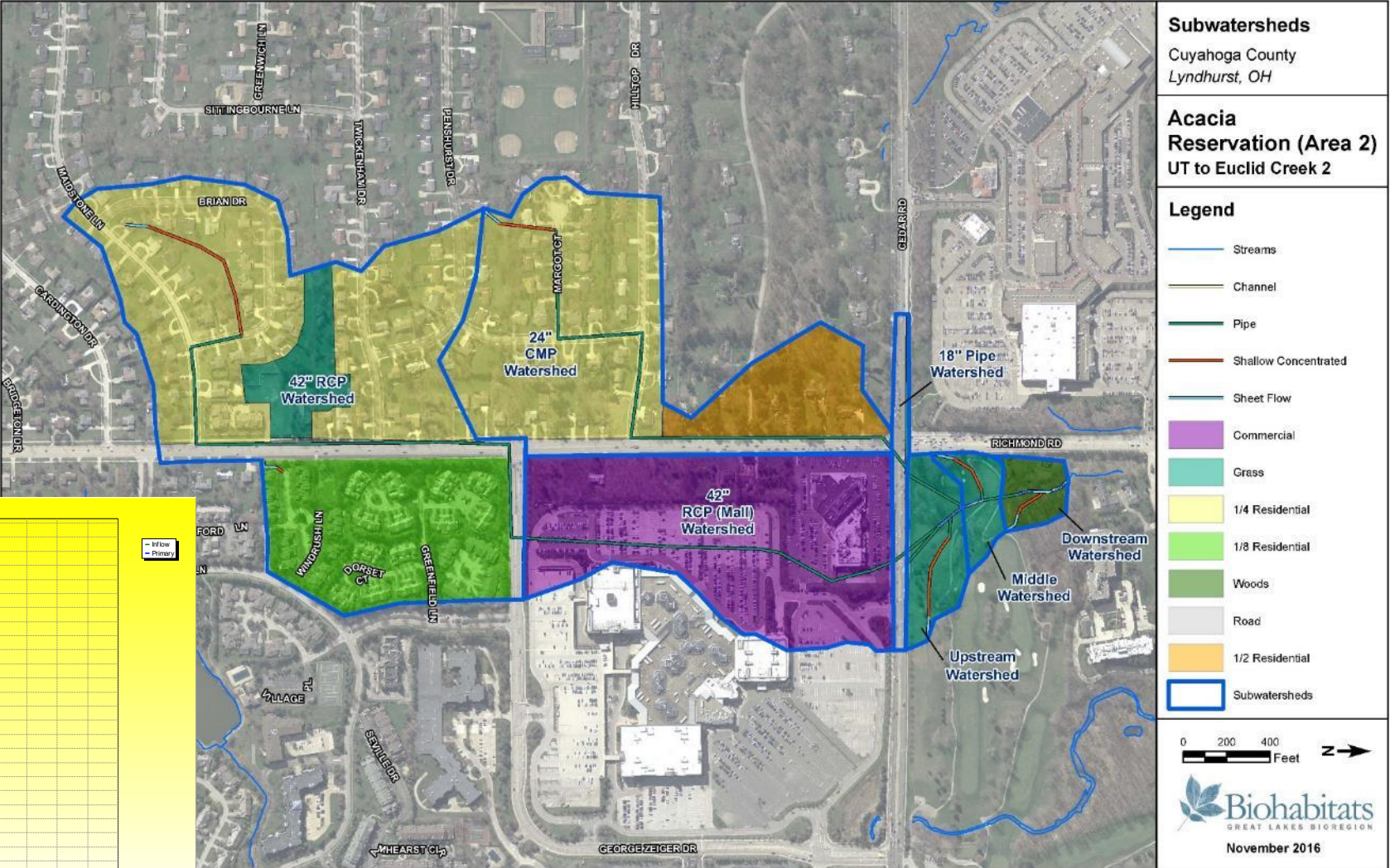
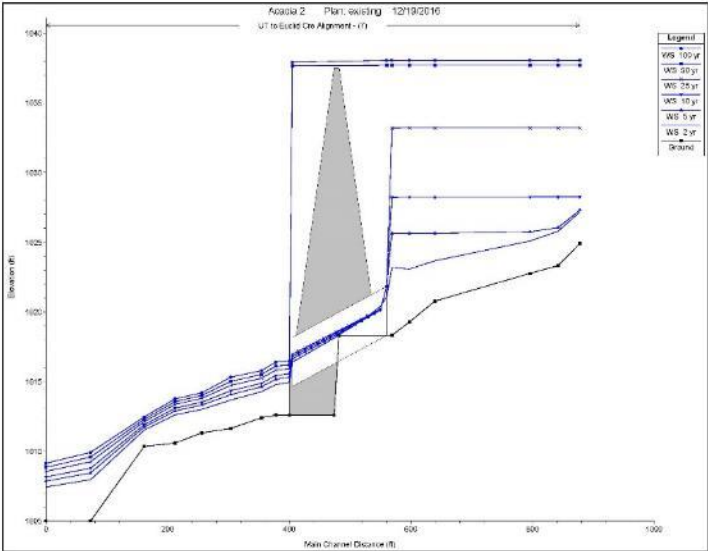
- Daylight 150' of culverted stream
- Connect channel to proposed floodplain downstream of culvert
- Restore “rough” to forest and wetlands
- Supplement existing forest



Southwest Tributary Existing Conditions



Southwest Tributary Design

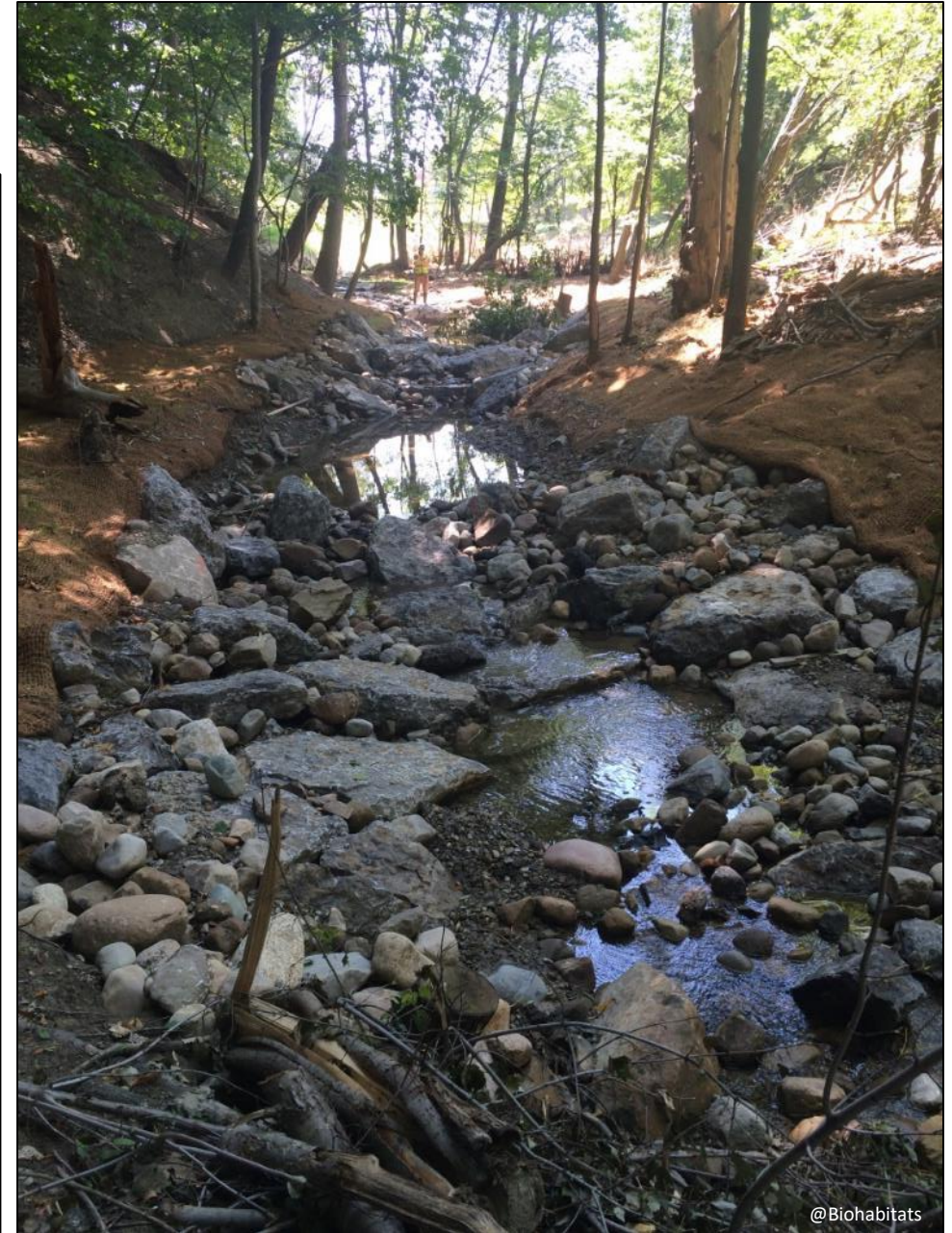


thwest Tributary Design

This topographic map illustrates a tributary design project. The map features contour lines indicating elevation, with a proposed channel or road layout running through the center. Key features include:

- Channel Layout:** A central channel or road alignment with stationing markers such as 0+00, 1+00, 2+00, 3+00, 4+00, and 5+00.
- Structures:** A bridge structure is shown near station 2+00. Two large rectangular structures, labeled "TANK", are located near station 5+00.
- Annotations:** Text annotations include "REMOVE 6' OF 30' CAP PLACE BOULDER APRON AT OUTLET", "REMOVE PEDESTRIAN BRIDGE AND GRADE BANKS BACK 31' AND WAT", and "UT TO EUGENE CREEK".
- Topography:** Contour lines are labeled with elevations such as 1000, 1020, 1040, 1060, 1080, 1100, 1120, 1140, 1160, 1180, 1200, 1220, 1240, 1260, 1280, 1300, 1320, 1340, 1360, 1380, 1400, 1420, 1440, 1460, 1480, 1500, 1520, 1540, 1560, 1580, 1600, 1620, 1640, 1660, 1680, 1700, 1720, 1740, 1760, 1780, 1800, 1820, 1840, 1860, 1880, 1900, 1920, 1940, 1960, 1980, 2000, 2020, 2040, 2060, 2080, 2100, 2120, 2140, 2160, 2180, 2200, 2220, 2240, 2260, 2280, 2300, 2320, 2340, 2360, 2380, 2400, 2420, 2440, 2460, 2480, 2500, 2520, 2540, 2560, 2580, 2600, 2620, 2640, 2660, 2680, 2700, 2720, 2740, 2760, 2780, 2800, 2820, 2840, 2860, 2880, 2900, 2920, 2940, 2960, 2980, 3000, 3020, 3040, 3060, 3080, 3100, 3120, 3140, 3160, 3180, 3200, 3220, 3240, 3260, 3280, 3300, 3320, 3340, 3360, 3380, 3400, 3420, 3440, 3460, 3480, 3500, 3520, 3540, 3560, 3580, 3600, 3620, 3640, 3660, 3680, 3700, 3720, 3740, 3760, 3780, 3800, 3820, 3840, 3860, 3880, 3900, 3920, 3940, 3960, 3980, 4000, 4020, 4040, 4060, 4080, 4100, 4120, 4140, 4160, 4180, 4200, 4220, 4240, 4260, 4280, 4300, 4320, 4340, 4360, 4380, 4400, 4420, 4440, 4460, 4480, 4500, 4520, 4540, 4560, 4580, 4600, 4620, 4640, 4660, 4680, 4700, 4720, 4740, 4760, 4780, 4800, 4820, 4840, 4860, 4880, 4900, 4920, 4940, 4960, 4980, 5000, 5020, 5040, 5060, 5080, 5100, 5120, 5140, 5160, 5180, 5200, 5220, 5240, 5260, 5280, 5300, 5320, 5340, 5360, 5380, 5400, 5420, 5440, 5460, 5480, 5500, 5520, 5540, 5560, 5580, 5600, 5620, 5640, 5660, 5680, 5700, 5720, 5740, 5760, 5780, 5800, 5820, 5840, 5860, 5880, 5900, 5920, 5940, 5960, 5980, 6000, 6020, 6040, 6060, 6080, 6100, 6120, 6140, 6160, 6180, 6200, 6220, 6240, 6260, 6280, 6300, 6320, 6340, 6360, 6380, 6400, 6420, 6440, 6460, 6480, 6500, 6520, 6540, 6560, 6580, 6600, 6620, 6640, 6660, 6680, 6700, 6720, 6740, 6760, 6780, 6800, 6820, 6840, 6860, 6880, 6900, 6920, 6940, 6960, 6980, 7000, 7020, 7040, 7060, 7080, 7100, 7120, 7140, 7160, 7180, 7200, 7220, 7240, 7260, 7280, 7300, 7320, 7340, 7360, 7380, 7400, 7420, 7440, 7460, 7480, 7500, 7520, 7540, 7560, 7580, 7600, 7620, 7640, 7660, 7680, 7700, 7720, 7740, 7760, 7780, 7800, 7820, 7840, 7860, 7880, 7900, 7920, 7940, 7960, 7980, 8000, 8020, 8040, 8060, 8080, 8100, 8120, 8140, 8160, 8180, 8200, 8220, 8240, 8260, 8280, 8300, 8320, 8340, 8360, 8380, 8400, 8420, 8440, 8460, 8480, 8500, 8520, 8540, 8560, 8580, 8600, 8620, 8640, 8660, 8680, 8700, 8720, 8740, 8760, 8780, 8800, 8820, 8840, 8860, 8880, 8900, 8920, 8940, 8960, 8980, 9000, 9020, 9040, 9060, 9080, 9100, 9120, 9140, 9160, 9180, 9200, 9220, 9240, 9260, 9280, 9300, 9320, 9340, 9360, 9380, 9400, 9420, 9440, 9460, 9480, 9500, 9520, 9540, 9560, 9580, 9600, 9620, 9640, 9660, 9680, 9700, 9720, 9740, 9760, 9780, 9800, 9820, 9840, 9860, 9880, 9900, 9920, 9940, 9960, 9980, 10000.

Southwest Tributary Design



Southwest Tributary Design



Southwest Tributary Construction

- approximately \$200,000 in base contract for construction
- 2 months for construction - July to August 2017
- planting mid October 2017
- 138 trees
- 34 shrubs
- 1,078 live stakes
- 1.85 acres of seeding



Southwest Tributary Construction

- 500 LF of channel construction/restoration
- 10.0 feet of elevation change – 2.0% slope
- 3,700 CY of excavation
- 154 LF of 42 Inch RCP pipe removed
- 200 tons of cobble – 9 loads
- 177 tons of imbricated rock – 8 loads



Southwest Tributary Construction



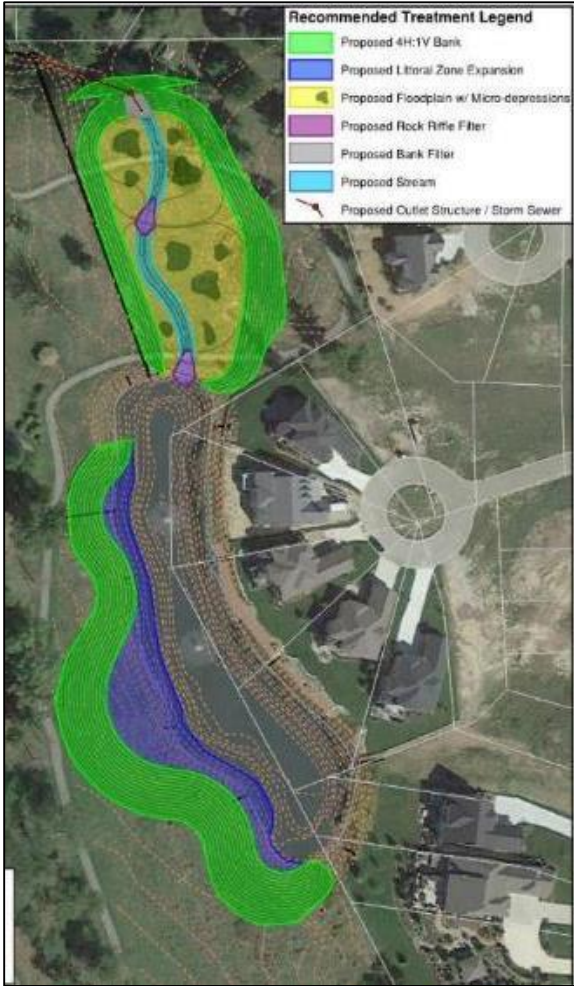
Southwest Tributary Post Construction



Wildlife Infill



NE Pond Enhancement & Daylighting



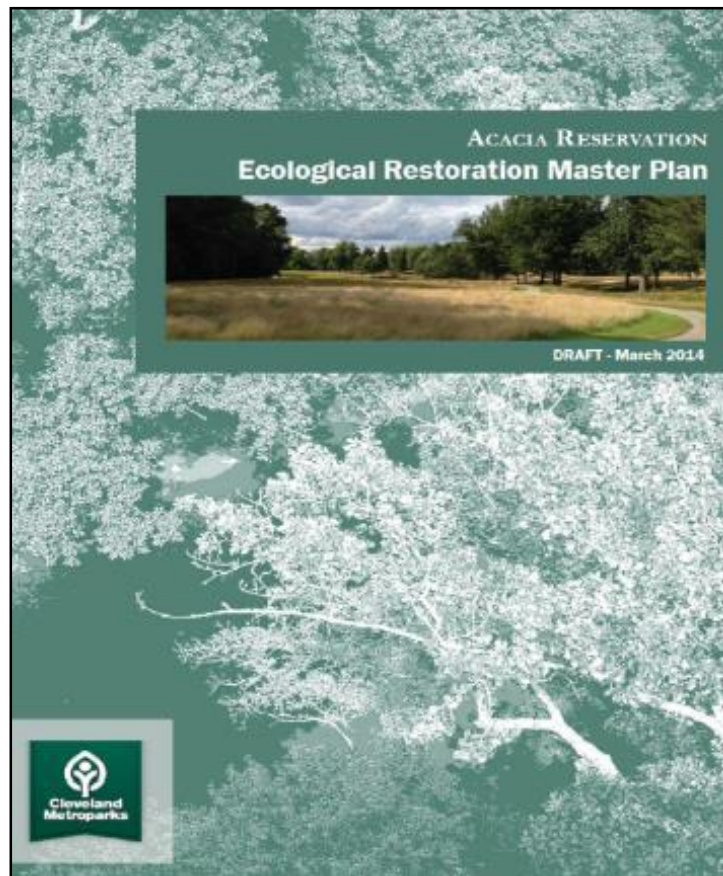


Table 3. Implementation of Restoration Strategies

STRATEGY	PHASE	YEAR	ASSOCIATED MAINTENANCE TASKS	PRIORITY	MONITORING AND RESEARCH NEEDS	ORDER OF MAGNITUDE COSTS
Euclid Creek Conservation Corridor - Riparian Forest	1 to 3	3 to 10+	Invasives control, herbivory suppression, habitat structures	High	Seasonal condition assessment to support understanding and ability to predict performance.	\$20,000 to \$40,000 per acre, depending on contractor vs Metroparks staff and stewardship planting, and deer fencing.
Euclid Creek Stream Restoration	1	1 to 2	trash removal	High	Metrics of channel stability, habitat, aquatic biology, water quality, etc.	\$1.75 to \$3.25 million for all four elements (main stem, tributary, daylight, and SW trib)
Forest enhancement, buffer enhancement, seedling regeneration	1 to 3	1 to 10+	Invasives control, herbivory suppression, habitat structures	High to Low	Seasonal condition assessment to support understanding and ability to predict performance.	\$20,000 to \$40,000 per acre, depending on contractor vs Metroparks staff and stewardship planting, and deer fencing.
Stream Daylighting and hydrologic restoration - headwater tributaries, southwestern stream	1 to 2	1 to 5	trash removal	High to Moderate	Metrics of channel stability, wetland condition, aquatic biology, water quality	\$300 to \$600 per linear ft of stream length
Pond Fringe Enhancement - Northeast Pond	2	4 to 5	Installed and volunteer plant management	Moderate - Low	Metrics for aquatic biology, soil stabilization, and wetland condition.	\$35,000 to \$75,000 depending on volume of grading and Metroparks stewardship planting vs contractor work
Pond Fringe Enhancement - Northwest Pond	2	4 to 5	Installed and volunteer plant management, access and path maintenance	Moderate	Metrics for aquatic biology, soil stabilization, and wetland condition. Perhaps creel census and user satisfaction survey	\$150,000 to \$300,000 depending on grading, material disposition, and planting by contractor vs Metroparks stewardship project.
Pond Fringe Enhancement - Central Pond	1	1 to 2	Installed and volunteer plant management, access and path maintenance	High	Metrics for wetland condition, aquatic biology, and user satisfaction survey.	\$130,000 to \$260,000 based on 5,000 CY of excavation, disposition of material, and contractor vs Metroparks stewardship implementation.
Wetland Hydrology Restoration (restore forested wetlands, wet swales & meadows)	1 to 2	1 to 5	Installed and volunteer plant management, management of any surface erosion, access and path maintenance	Moderate	Peak discharge and hydrograph duration, pre- and post-restoration, metrics for wetland condition and aquatic biology.	\$150 to \$300 per linear ft based on extent of drain removal and earthwork
Fairway to native meadow establishment moist to wet meadows as transition habitat	1	1 to 3	plant community management	Moderate to low	Seasonal condition assessment to support understanding and ability to predict performance.	\$4000 to 10,000 per acre depending on Metroparks or contractor led services; drill seeding, with higher costs for areas of nursery stock planting
Existing Maintenance facility upgrade/retrofits - potential plant nursery	1	1 to 2	'stump dump' removal and grinding, mulch access, upgrade building and material/debris removal.	High	Monitoring associated with seedling collection, growout and replanting in the rehabilitated greenhouse?	Placeholder estimate of \$200,000 to \$300,000 pending refinement with metroparks
Off-site stormwater management/ partnering opportunities	1 to 3	1 to 10+	litter pickup, street sweeping, other best practices	High to Low	Floatable debris and water quality	TBD based on opportunity, could reflect a cost or an income

ongoing



ongoing

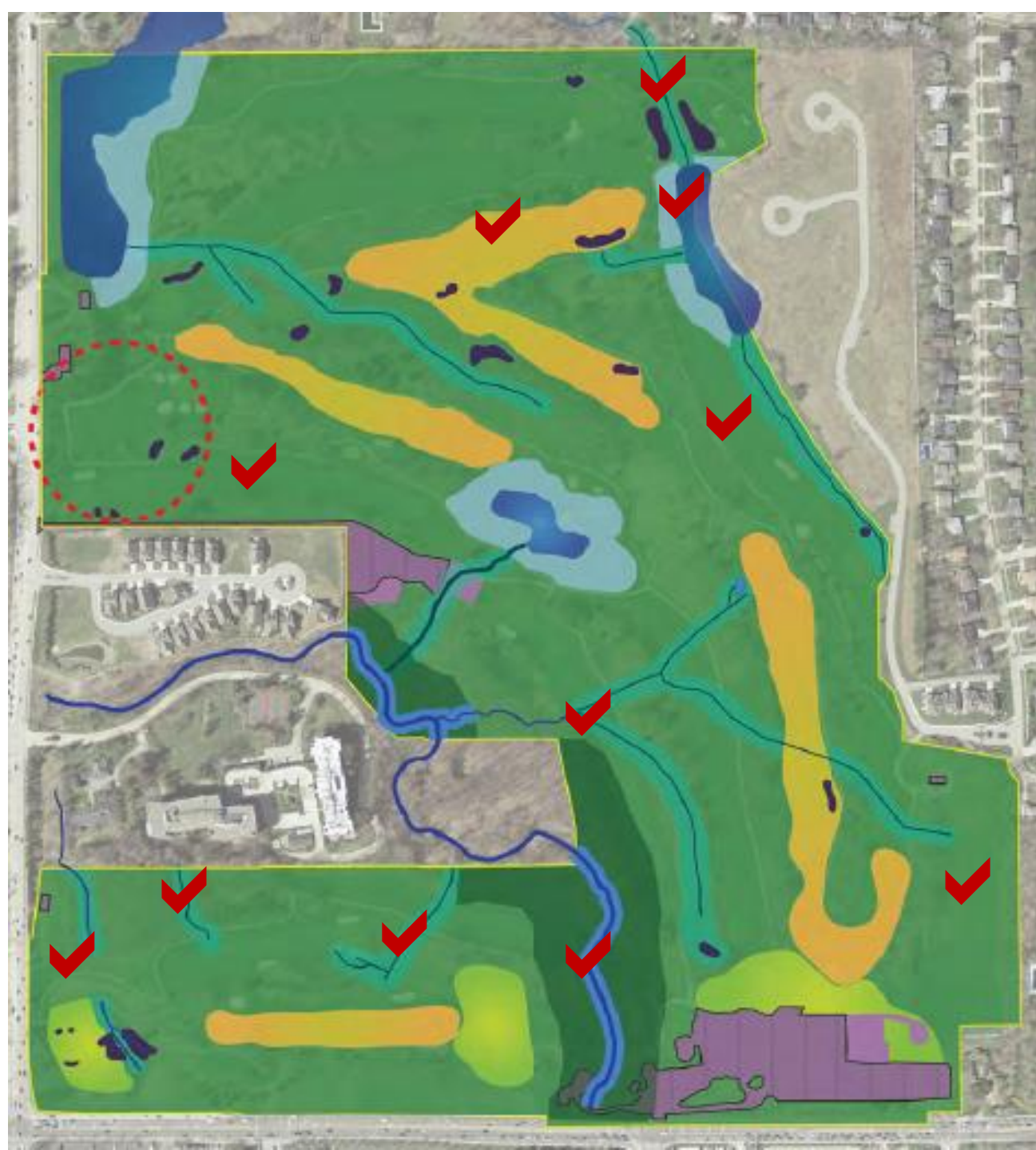


ongoing

ongoing

partial

partial



QUESTIONS?



@Stuart Pearl

Jennifer Grieser
Sr. Natural Resources Mgr.



Suzanne Hoehne
Ecological Engineer



May 2018