Jun 27th, 3:50 PM - 4:10 PM

Concurrent Sessions A: Passage Effectiveness Monitoring in Small Streams III - Fish Passage Analysis Through Circular Culverts in Northeast Ohio: Identifying the Design Parameters Linked With Passage Success

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Darshan Baral & Hans Tritico

Does Ohio Need to Care about Fish Passage?

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Anecdotal Evidence Against

- No Endangered Fish Species
- No Strongly Migratory (Native) Species
- Mild Slopes and Water Velocities
- Generally Hardy Fish

Anecdotal Evidence For

+ 176 Species of Fish
+ 60,000 Miles of Streams
+ 90,000 Culverts
+ 6 Federally Endangered Mussel Species
+ No Significant Prior Consideration

Do Ohio fish pass through Ohio Culverts?

1 Previous Study

- Embedded Bankfull Culvert Effectiveness (Tumeo & Pavlick, 2011)
- 61 Attempts at Bankfull Culverts in the State of Ohio
- 2 Culverts are in dynamic equilibrium

Study

- Look specifically at passage efficiencies
- Start with the 90,000 existing culverts
  - What percentage pass fish already?
  - Can we identify characteristics that make a culvert successful from our existing inventory?
- Northeast Ohio
  - Ashtabula, Mahoning, Portage, Stark, Summit, and Trumbull County
  - 5,000+ culvert database

Study Area

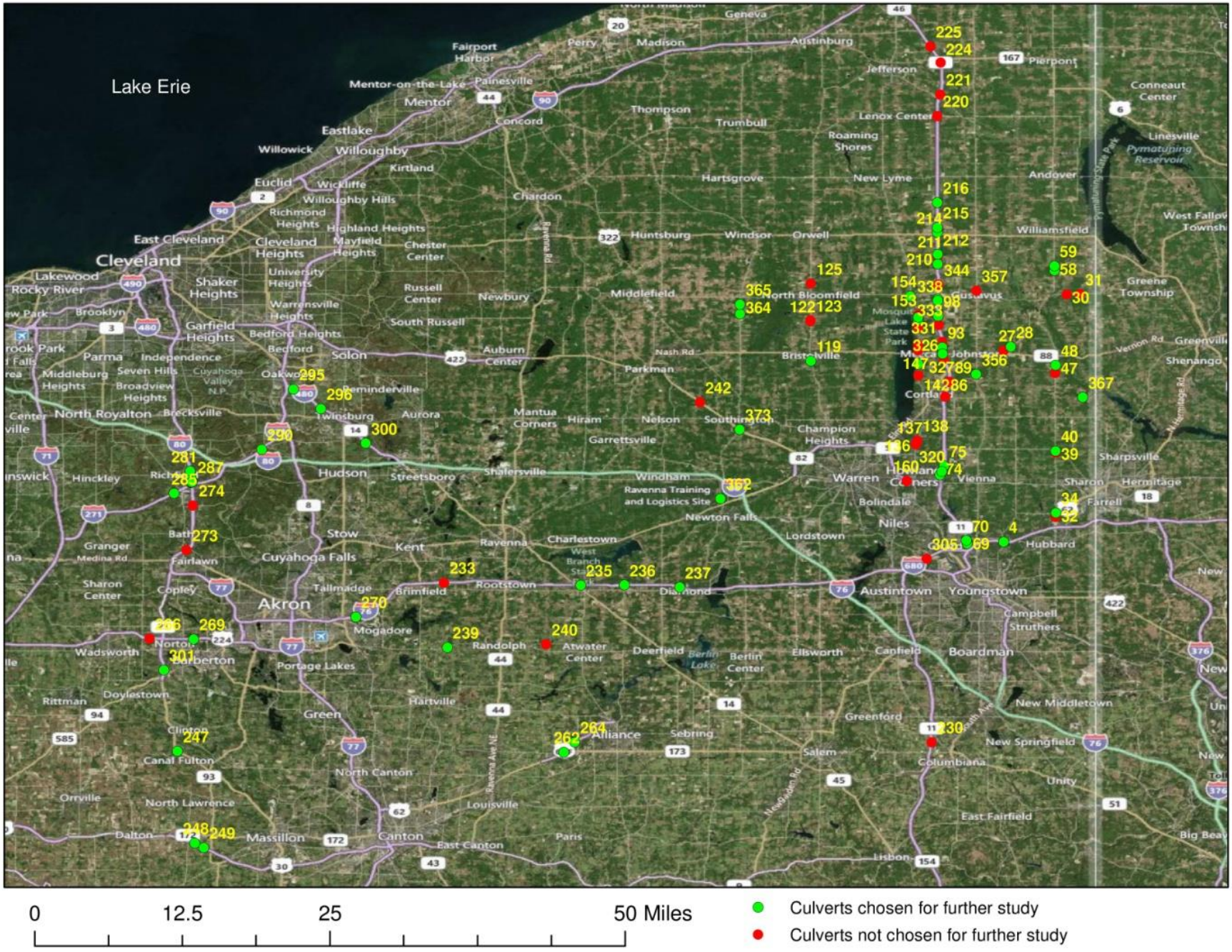
County Map of the State of Ohio and the Study Area in Red

Data Sources

- Ohio Department of Transportation (ODOT) District 4
  - 5,837 culverts
- Ohio GAP Analysis
  - Fish distribution information
- USGS Seamless Data Warehouse
  - 1/9 NED as Digital Elevation Model (Approx. 3m × 3m)
- Ohio Streamstats
  - 14 Discharge data: 12 monthly averages, 25% low flow, and 2yr flood
- FishXing Helpfile
  - Fish dimensions and swimming speed

Selection of culverts for analysis

- One celled circular culverts with diameter > 24 inches
- Having slope, length, and tributary data
- 241 (192 circular) culverts selected
- 94 chosen for field study after GIS inspection
- 55 out of 5,837 culverts selected
- 54 analyzed in FishXing, 40 analyzed in HEC-RAS



Map showing the 94 culverts for which field visits were conducted

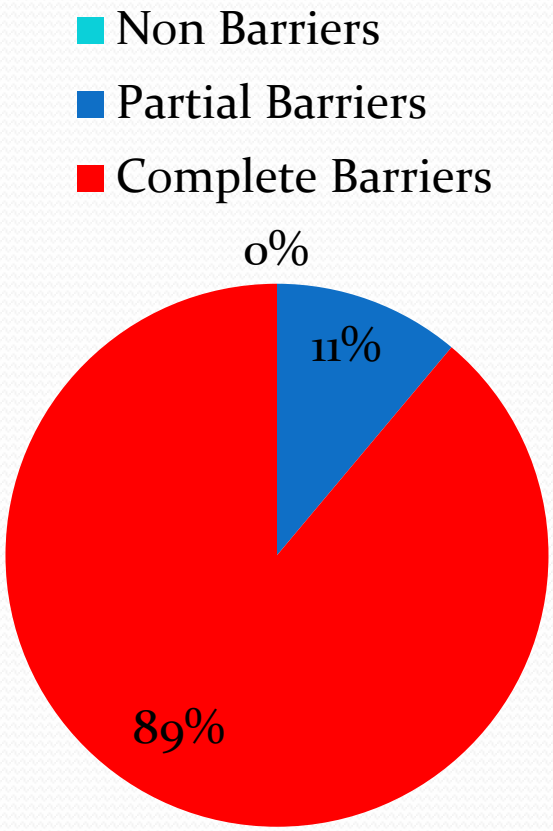
Fish Species

Table 1: Properties of the fish used in the study

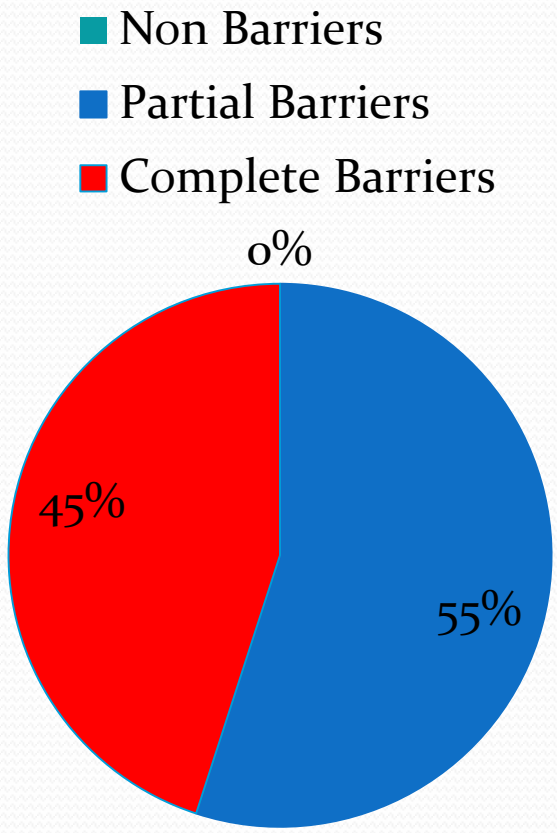
Fish	Swimming Speed (m/s)		Fish Length (m)	Fish Body Depth (m)
	Prolonged	Burst		
Blacknose dace	0.384	-	0.043	0.009
Central stoneroller	0.399	-	0.062	0.015
Golden shiner	0.742	-	0.140	0.043
Greenside darter	0.312	-	0.051	0.009
Largemouth bass	1.047	-	0.419	0.122
Longear sunfish	0.390	-	0.089	0.034
Northern pike	0.481	-	0.635	0.094
Pumpkinseed	0.372	-	0.127	0.058
Smallmouth bass	0.818	-	0.343	0.094
Walleye	0.521	2.195	0.365	0.058
White sucker	0.768	-	0.381	0.070

Results:

FishXing



HEC-RAS



Results: FishXing Analysis

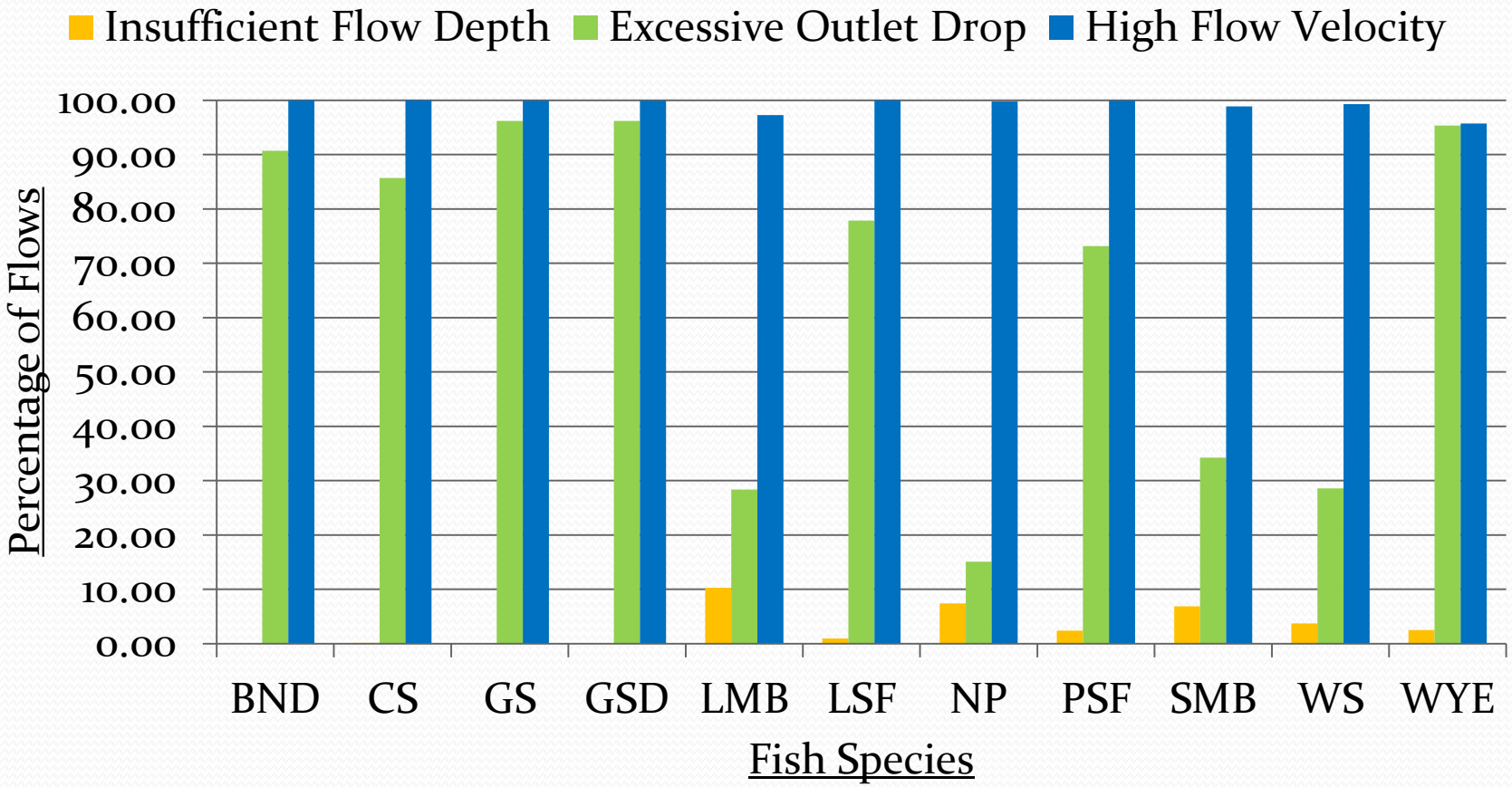


Fig 10: Barrier types for each fish species

Difference between FishXing and HEC-RAS

- FishXing
  - Only 1 cross-section downstream from culvert
  - Time to exhaustion
  - Passage analysis over range of flows
- HEC-RAS
  - At least 3 cross-section both upstream and downstream from culvert
  - No time to exhaustion
  - Passage analysis for 14 individual flows

Do Ohio fish pass through Ohio culverts?

Preliminary Answer:

Infrequently

In Ohio what design modifications will help the most?

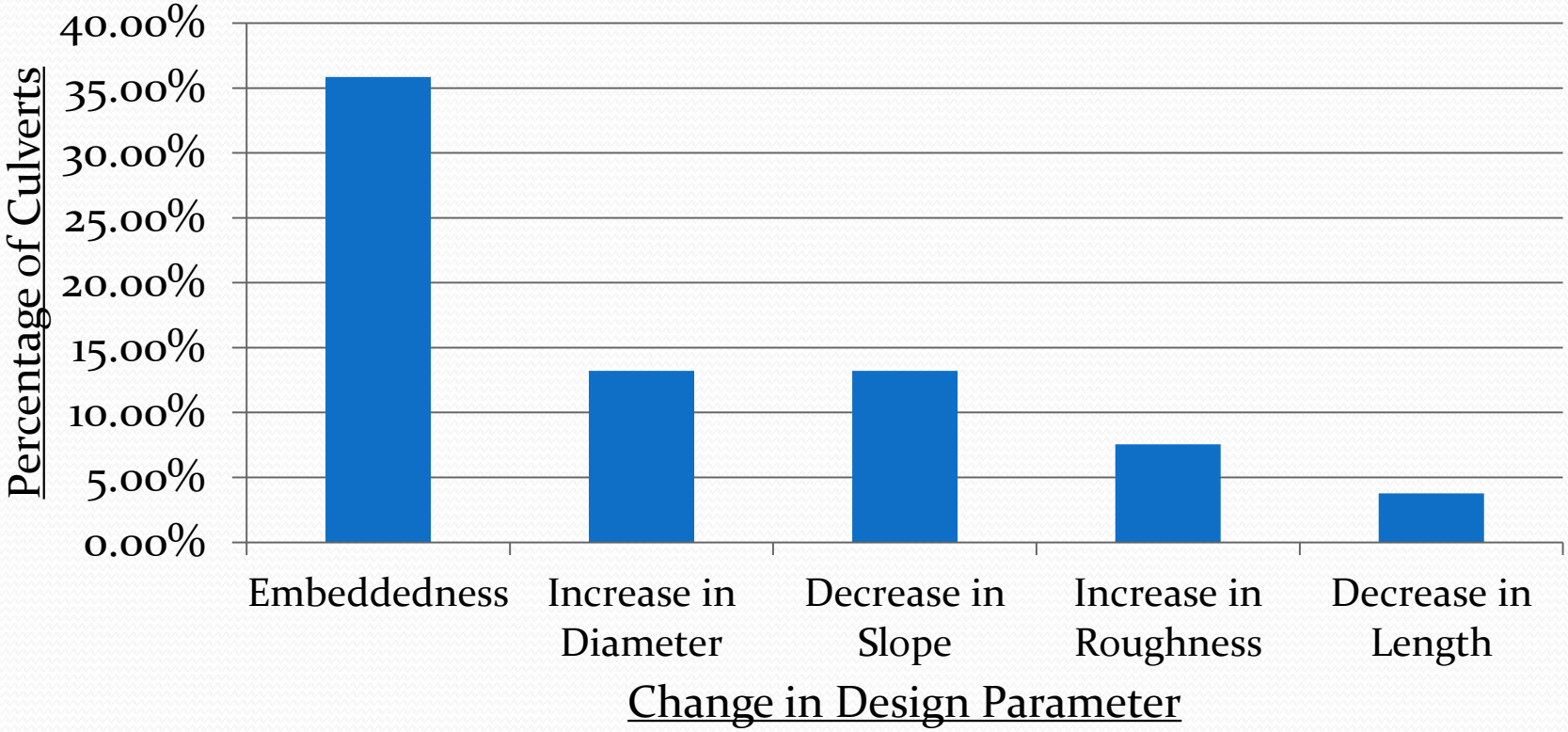
Classic Options:

- Increased diameter
- Decreased length
- Reduced slope
- Rougher culvert material
- Embedding the culvert

Identification of design parameters

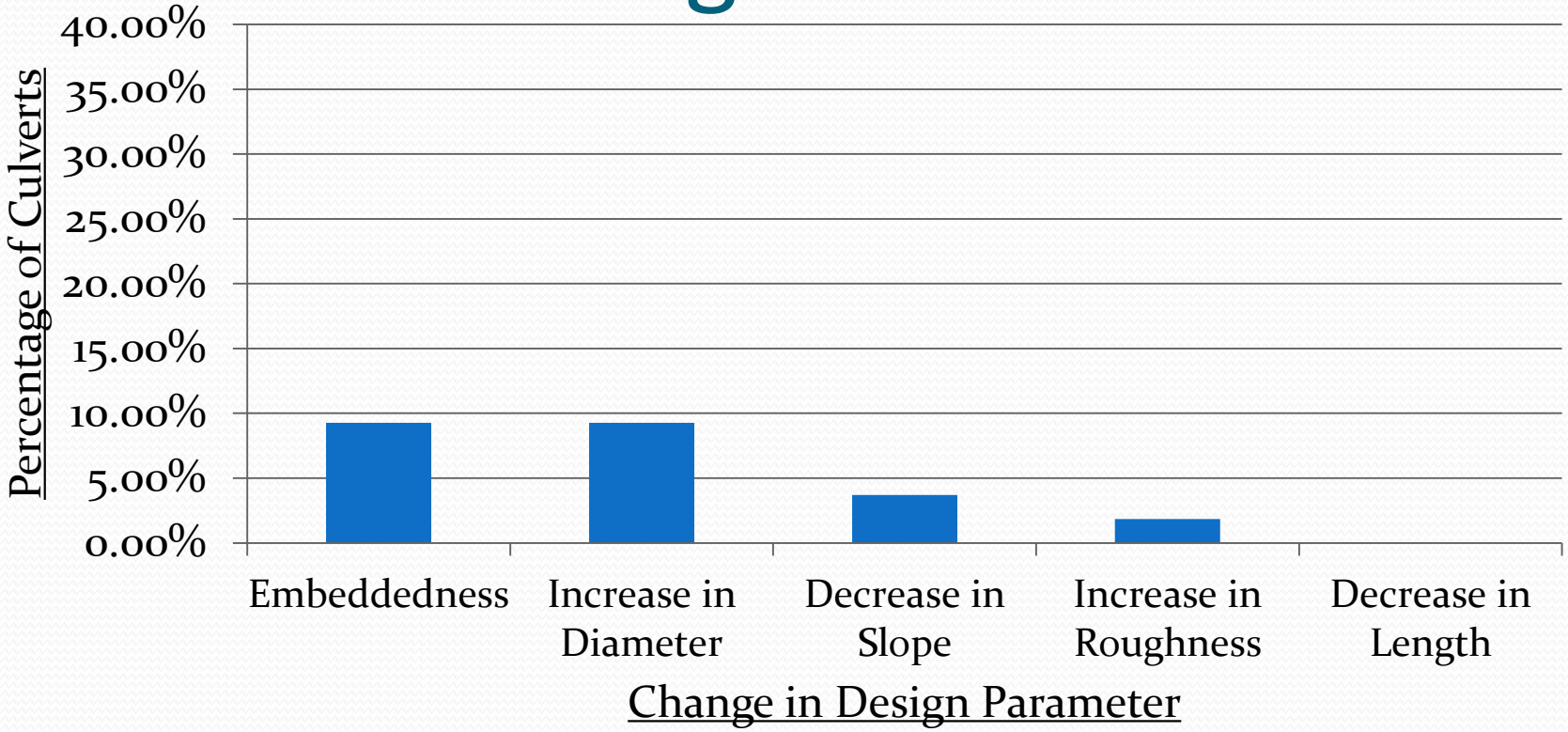
- In FishXing for
  - Greenside darter (shallowest body)
  - Largemouth bass (fastest prolonged swimming speed)
- Change of design parameters independently
  - Diameter (existing dia to up to ten times the existing dia)
  - Length (existing length down to 25')
  - Slope (existing slope down to 0% slope)
  - Manning's n (current material to corrugated metal)
  - Embeddedness with gravel of n= (6" for pipes with dia < 48" and 12" for pipes with dia > 48 ")

Identification of design parameters: Greenside darter



Percentage of culverts (out of 53) that turn into partial barrier because of change in design parameters independently

Identification of design parameters: Largemouth bass



Percentage of culverts (out of 54) that turn into partial barrier because of change in design parameters independently

In Ohio what design modifications will help the most?

Ohio Options:

1) **Embedding the culvert**
2) Increased diameter
3) Reduced slope
4) Rougher culvert material
5) Decreased length

Conclusions for Ohio

- Most of the time fish are not passing through culverts
- Embedding culverts will help the most
  - Bigger impact for smaller bodied fish
  - Must ensure dynamic equilibrium

Future Questions/Directions

- What do the prevalent barriers mean in the context of Ohio ecosystems?
- More culverts – Potentially 900 culverts
- Field sampling
- Obtain swimming speed for more species

Thank You

contact:

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Results: Selected Culverts

Table 2: Properties of the culverts selected for study

	Diameter (in)	Length (ft)	Pipe Slope (%)	Embedded depth (in)	Perched height (in)
Average	61	177	1.00	1.8	8
Minimum	28	41	0.06	0	0
Maximum	120	548	3.70	48	66

- 6 culverts were embedded, 49 were not
- 26 culverts were perched, 29 were not

Results: Fish Distribution

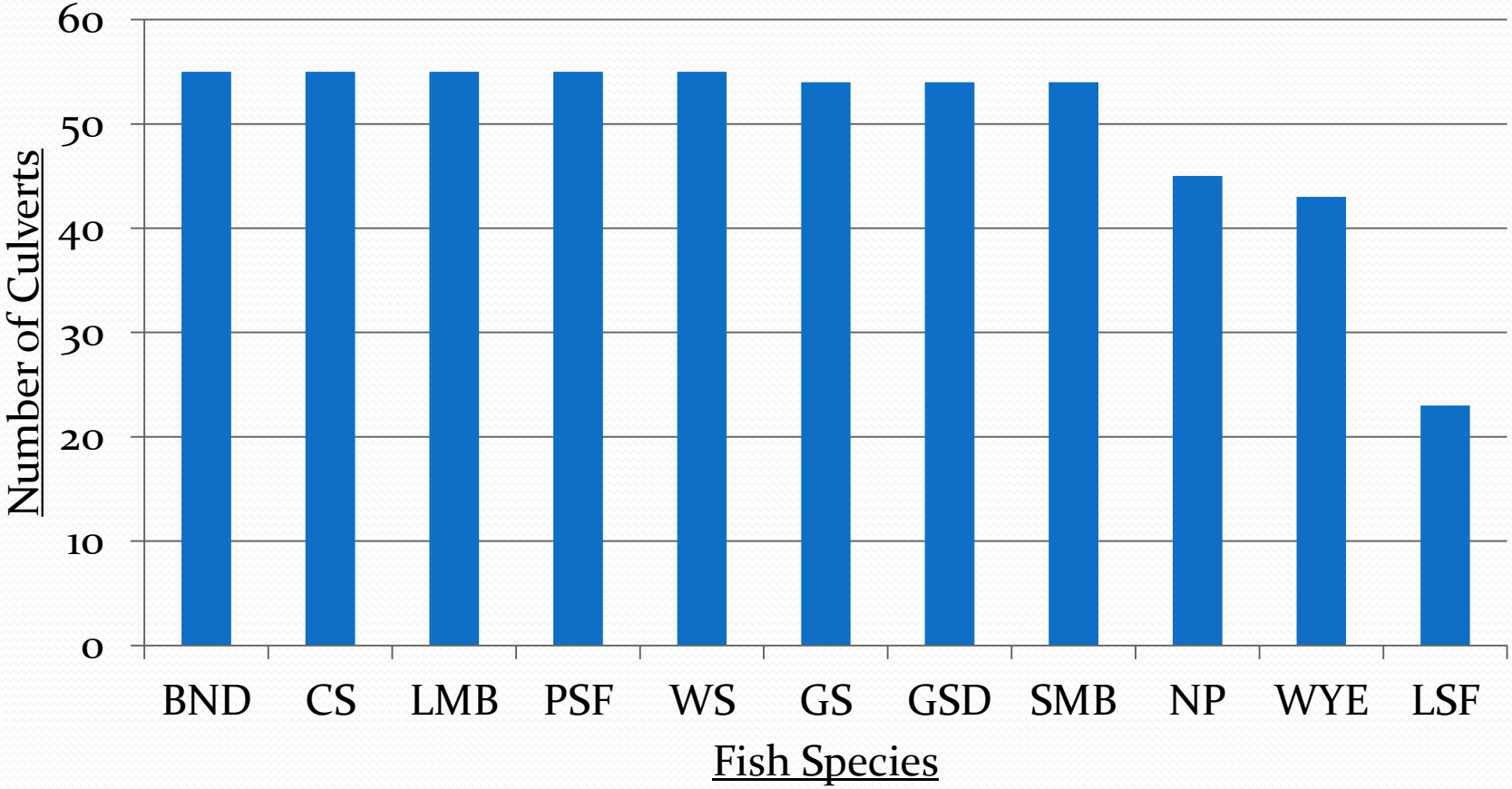

Fig 8: The number of culverts in which each fish species are present in

Results: FishXing Analysis

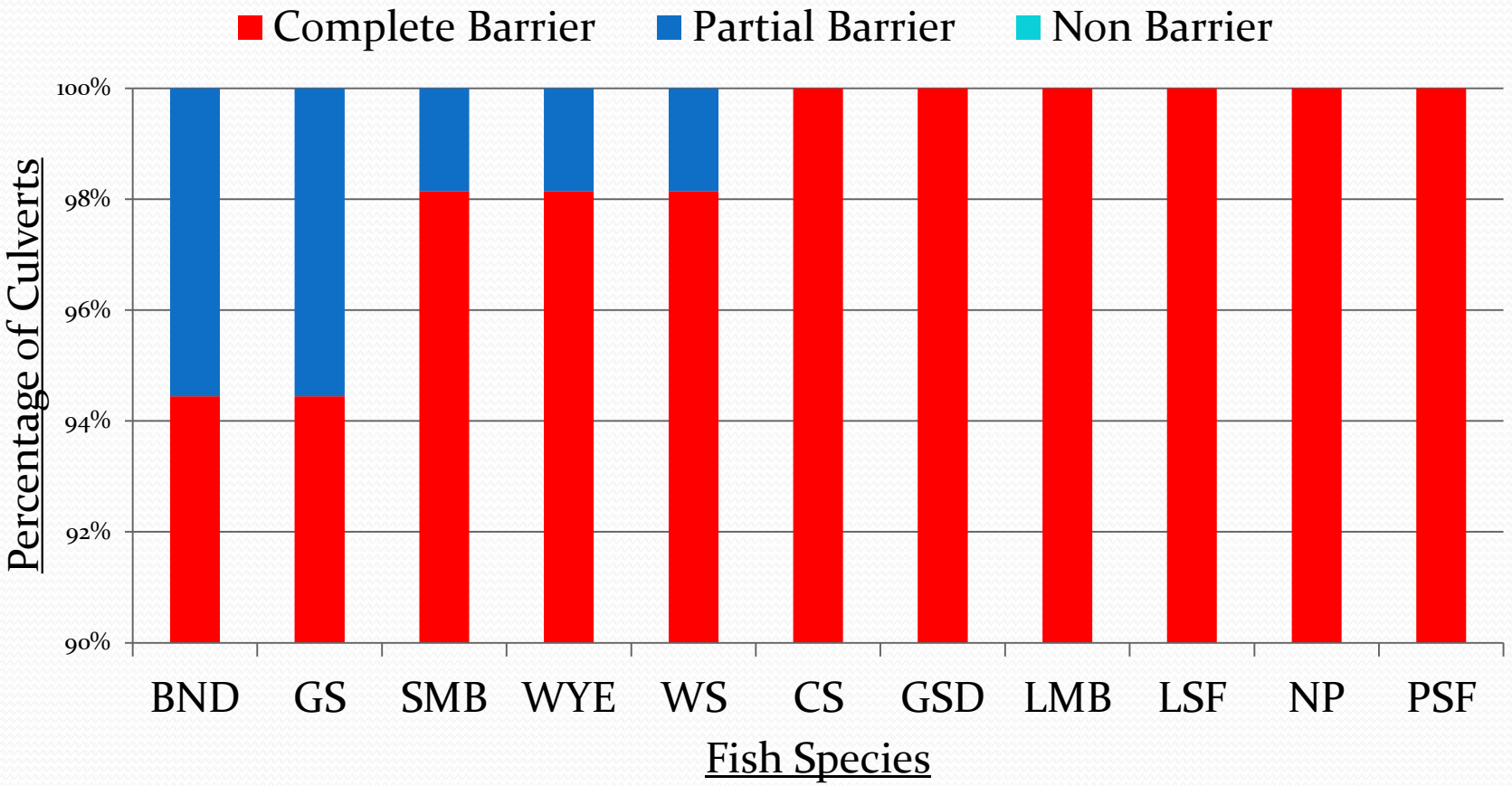

Fig 9: % of culverts out of 54 that are non barriers, partial barriers, and complete barriers broken up by fish species

Results: FishXing Analysis

Table 3: Important Culvert Parameters according to FishXing analysis

Parameter	Barrier	Numbers	Mean	Std. Deviation	Std. Error Mean
Length (feet)	Partial	6	196	98	40
	Complete	48	174	103	15
Diameter (in)	Partial	6	69	26	11
	Complete	48	61	19	3
Slope	Partial	6	0.87%	0.76%	0.31%
	Complete	48	0.97%	0.65%	0.09%
Perched height (in)	Partial	6	0	0	0
	Complete	48	9	14	2
Embedded height (in)	Partial	6	5	5	2
	Complete	48	2	7	1

Results: FishXing Analysis

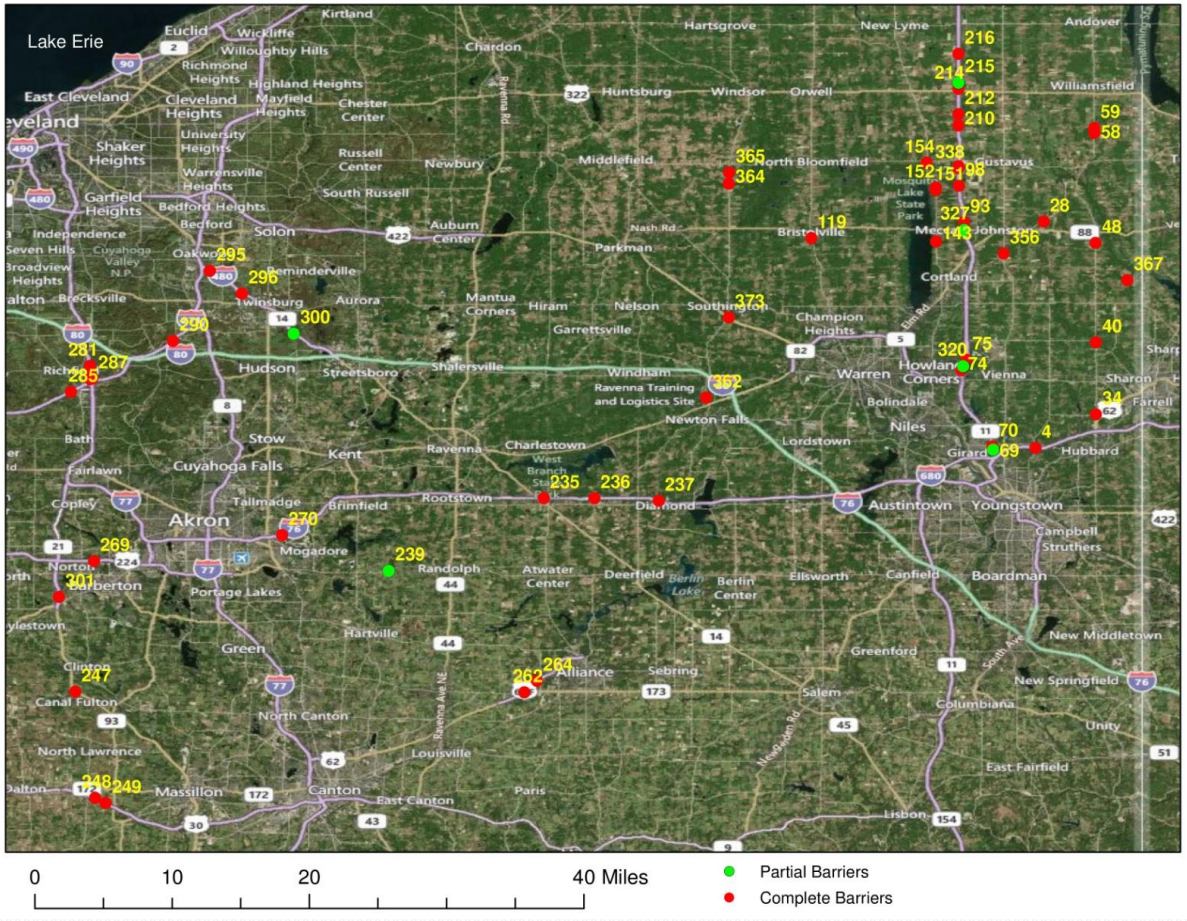

Fig 11: Culvert map showing FishXing Results

Results: HEC-RAS Analysis

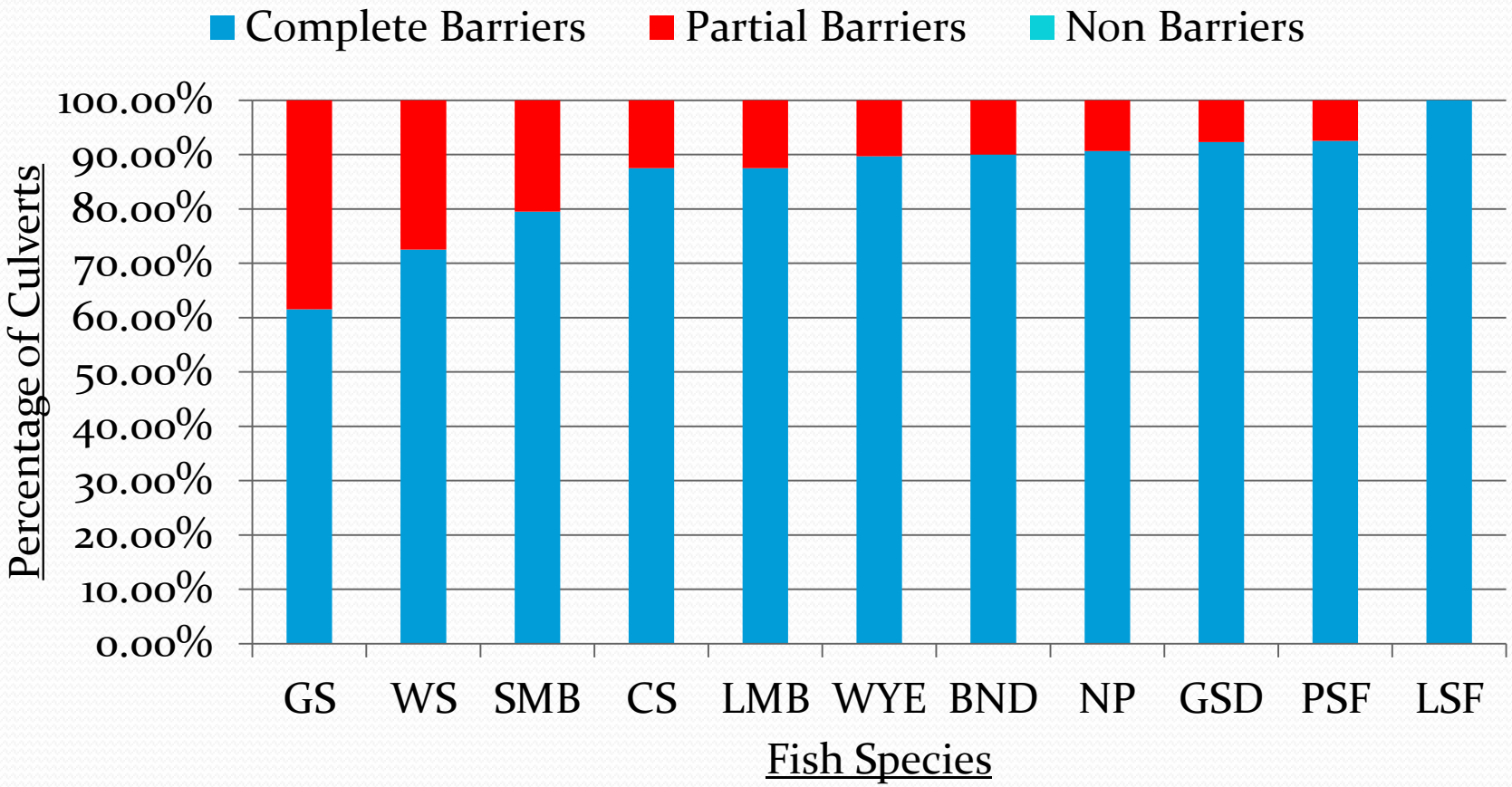

Fig 13: % of culverts out of 40 that are non barriers, partial barriers, and complete barriers broken up by fish species

Results: HEC-RAS Analysis

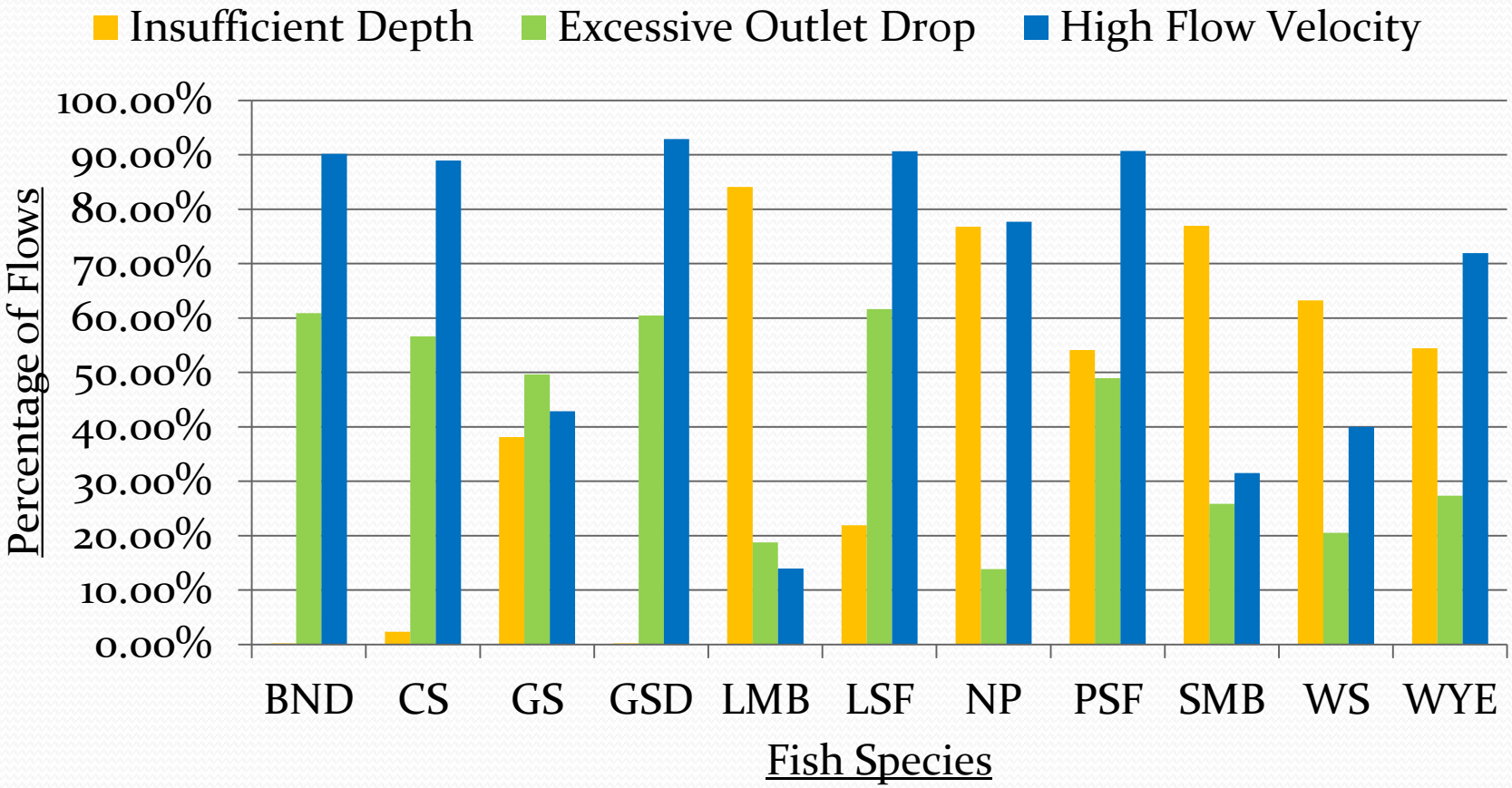

Fig 14: Barrier types for each fish species

Results: HEC-RAS Analysis

Table 4: Important Culvert Parameters according to HEC-RAS analysis

Parameter	Barrier	N	Mean	Std. Deviation	Std. Error Mean
Length (feet)	Partial	22	155	80	17
	Complete	18	184	80	19
Diameter (in)	Partial	22	63	21	4
	Complete	18	58	13	3
Slope	Partial	22	0.89%	0.74%	0.16%
	Complete	18	1.10%	0.72%	0.17%
Perched height (in)	Partial	22	2	4	1
	Complete	18	17	18	4
Embedded height (in)	Partial	22	1	3	1
	Complete	18	0	0	0

Results: HEC-RAS Analysis

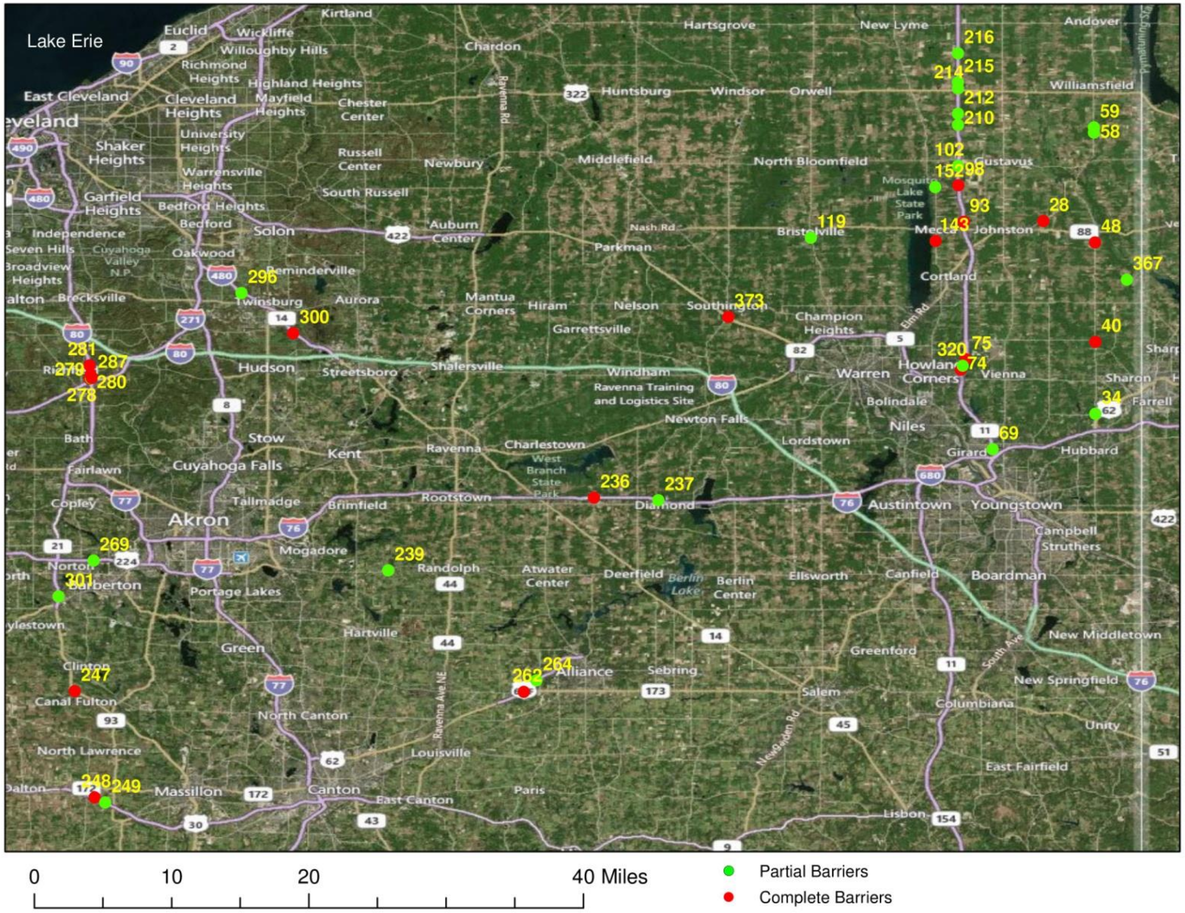

Fig 15: Culvert map showing FishXing Results