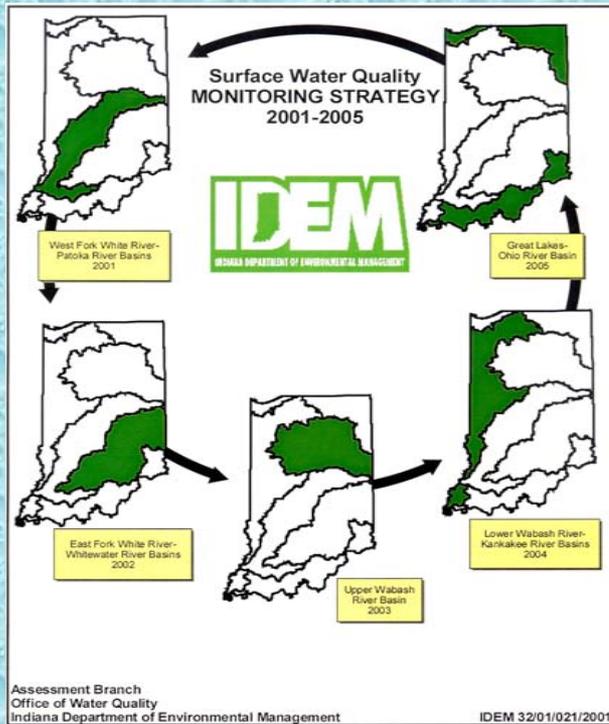


Implementation of Indiana's Probabilistic Watershed Monitoring Program and Second Year Source Identification Sampling



Presented by:
Art Garceau, Chief
Surveys Section

IDEM/Office of Water Quality/Assessment Branch

Probabilistic Monitoring Design

• Rivers and streams are sampled by targeting watershed basins and sampling them every 5 years

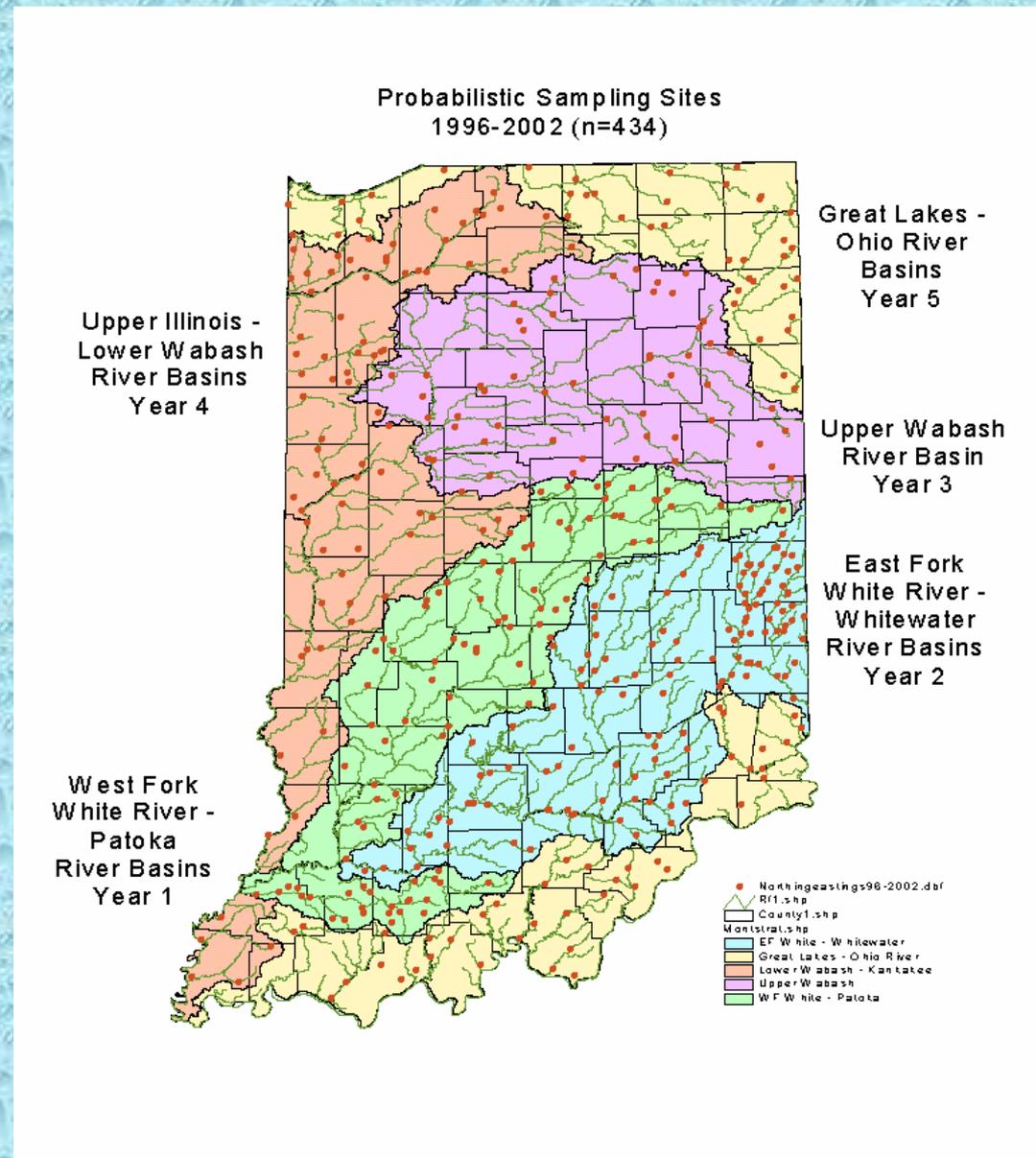
–Year 1: WFWR & Patoka

–Year 2: EFWR & Whitewater

–Year 3: Upper Wabash

–Year 4: Lower Wabash & Kankakee

–Year 5: Great Lake & Ohio R. tribs



Probabilistic Monitoring Design

•USEPA Western Ecology Division generated probabilistic site locations

•25% 1st Order

•25% 2nd Order

•25% 3rd Order

•25% 4th or Greater Order

Stream Length (km) by Stream Order for each 8 Digit Hydrologic Unit Code Area in Indiana

8 digit HUC	1	2	3	4	5	≥ 6	Total
4040001	597.583	131.411	91.874	46.295	0.385	0.000	867.549
4050001	1,249.877	418.534	155.291	197.844	92.232	45.631	2,159.408
4100003	686.639	198.234	88.151	67.817	52.876	0.000	1,093.718
4100004	371.773	69.904	28.537	15.177	61.690	0.000	547.081
4100005	297.556	118.501	29.643	35.255	0.000	0.000	480.954
4100007	130.114	38.906	25.515	1.896	0.000	0.000	196.431
7120001	3,600.497	286.061	243.976	37.334	106.901	0.000	4,274.769
7120002	958.625	214.127	97.559	22.742	38.507	0.000	1,331.560
7120003	58.919	12.387	14.886	0.000	0.000	0.000	86.193
5120101	945.966	264.846	139.356	34.491	109.546	62.563	1,556.768
5120102	386.484	73.194	19.841	97.368	0.000	0.000	576.887
5120103	497.078	126.602	129.628	0.000	0.000	0.000	753.308
5120104	799.003	221.750	63.985	119.979	0.000	0.000	1,204.717
5120105	623.232	208.222	68.558	62.962	0.000	56.255	1,019.230
5120106	2,500.016	353.355	224.511	192.353	71.017	0.000	3,341.252
5120107	618.570	211.266	101.782	153.140	11.134	0.000	1,095.892
5120108	2,362.317	650.829	332.749	179.528	23.413	148.589	3,697.425
5120109	138.176	36.588	19.871	0.000	0.478	17.285	212.397
5120110	809.336	242.825	140.359	94.016	65.599	0.000	1,352.135
5120111	801.608	270.100	132.627	51.732	24.228	167.299	1,447.595

Stream Length (km) by Stream Order for each 8 Digit Hydrologic Unit Code Area in Indiana

8 digit HUC	1	2	3	4	5	≥ 6	Total
5120113	521.047	130.886	71.241	20.066	0.000	148.627	891.866
5120201	1,693.540	656.771	224.790	195.031	59.703	0.000	2,829.835
5120202	1,063.442	396.353	192.131	39.039	0.000	117.550	1,808.515
5120203	876.304	212.785	140.577	106.802	0.000	0.000	1,336.468
5120204	708.135	292.796	124.439	116.850	25.052	0.000	1,267.273
5120205	420.835	172.444	111.029	27.328	0.000	1.451	733.087
5120206	587.837	166.362	99.396	66.462	0.000	94.949	1,015.006
5120207	842.399	354.139	149.531	135.800	49.421	0.000	1,531.290
5120208	1,274.130	422.867	296.491	49.751	0.000	212.491	2,255.730
5120209	635.923	196.169	60.440	57.391	130.376	0.000	1,080.300
5080001	42.164	14.301	0.000	0.000	0.000	0.000	56.465
5080002	67.738	21.766	16.341	0.000	0.000	1.900	107.746
5080003	1,391.808	359.719	208.912	122.862	22.506	0.000	2,105.807
5090203	748.628	211.315	152.499	58.227	0.000	0.000	1,170.668
5140101	600.554	135.739	105.291	42.157	0.000	0.000	883.741
5140104	709.699	279.764	166.747	225.455	0.000	0.000	1,381.665
5140201	762.727	277.414	107.630	63.575	0.000	0.000	1,211.345
5140202	456.605	87.117	27.254	54.787	0.000	0.000	625.764

Total Stream Length (km)

49,587.84

Stream Length (km) by Stream Order for each 8 Digit Hydrologic Unit Code Area in Indiana

- Stream Length (km) **49,587.84**
- This table shows all streams/rivers in the "frame" as defined by the samples drawn for the Indiana Department of Environmental Management (IDEM) by US EPA National Health and Environmental Effects Research Laboratory (NHEERL), Western Ecology Division (WED), Corvallis, Oregon. Data sent by Barbara J. Rosenbaum, contractor to the US EPA NHEERL-WED, to Stacey L. Sobat, Environmental Scientist IDEM, Office of Water Quality, Assessment Branch, Biological Studies Section.
- All Orders (Strahler 1957) of Streams were selected based on 1:100,000 scale of U.S EPA's River Reach File 3 with reaches coded "R" (regular reach), "S" (start/headwater reach), "T" (terminal reach), "N" (un-networked reach), and "W" (wide river - one bank only). For double-line "wide" rivers, only one side of the channel/linework was used for measuring rather than taking the whole length and dividing by two. The length values (in kilometers) in the table reflect the specific reaches as they are coded in RF3-Alpha. The Strahler stream order was added via an automated process that may have some errors in it, but is generally reliable for lower order streams. For information on RF3-Alpha, check out the documentation at <http://www.epa.gov/OWOW/monitoring/rf/rfindex.html> (go to "Reach File References" Document #3 - the Technical Reference Publication).
- Strahler, A.N. 1957. Quantitative Analysis of Watershed Geomorphology. Trans. Am. Geophys. Un. 38,913-920.

Probabilistic Monitoring Design

- **Site Reconnaissance (Feb.-April)**
 - **Topographic Maps**
 - **Brochures**
 - **Contact Landowner**
 - **Site Accessibility & Equipment**
 - **Enter Recon data**
- **Data Collected (June-October)**
 - **Water, Nutrient, and Bacteriological Samples For Laboratory Analysis**
 - **Macroinvertebrate Community Assessments**
 - **Fish Community Assessments**
 - **Habitat Assessments**

Fish Community Assessments

- **15 x the wetted stream width** (backpack, totebarge, boat electrofishing)
- **All stream sizes included**
- **Species Level Identification**
- **IBI: 12 metrics (range 6-60)**
 - 1. # species
 - 2. # darter species/ #dms species
 - 3. % headwater ind./ # sunfish sp.
 - 4. # minnow sp./ # sucker sp.
 - 5. # sensitive sp.
 - 6. % tolerant ind.
 - 7. % omnivore ind.
 - 8. % insectivore ind.
 - 9. % pioneer ind./% carnivore ind.
 - 10. Total # ind.
 - 11. % simple lithophils
 - 12. % DELT anomalies



Macroinvertebrate Community Assessments

- **KICK sample**
- **Hester-Dendy**
- **Laboratory Processing**
- **mIBI: 10 metrics (range = 0-8)**
 - 1. **Family level HBI**
 - 2. **Number of taxa**
 - 3. **Number of individuals**
 - 4. **Percent dominant taxa**
 - 5. **EPT Index**
 - 6. **EPT Count**
 - 7. **EPT count to total number of individuals**
 - 8. **EPT Count to Chironomid Count**
 - 9. **Chironomid Count**
 - 10. **Total number of individuals to number of squares sorted**



Water Chemistry, Nutrients, & *E.coli*

- Grab water samples and nutrients collected **3x** in spring, summer, and fall (USGS contract)

Chemistry Parameters

Priority Metals	Physical/Anions	Nutrients/Organic
Arsenic	Alkalinity	TKN
Calcium	Total Solids	Ammonia-N
Cadmium	Suspended Solids	Nitrate+Nitrite-N
Chromium	Dissolved Solids	Total Phosphorus
Copper	Sulfate	TOC
Lead	Chloride	Cyanide-Total
Magnesium	Hardness	Cyanide-Free
Mercury		COD
Nickel		
Selenium		
Zinc		

Water Chemistry, Nutrients, & *E.coli*

- Hydrolab data collected during each sampling event:

- D.O., pH, Conductivity, Water temperature, Turbidity

- Nutrients:

- Chlorophyll A in phytoplankton and periphyton samples, ash-free dry mass in periphyton samples

- E.coli*:

- each site sampled once each week for **5** consecutive weeks



Qualitative Habitat Evaluations (QHEI)

REGIONAL **SWAMP** Qualitative Habitat Evaluation Index Field Sheet QHEI Score: **73**

Event I.D. **00016** Stream **West Branch Mosquito Creek** County **Harrison**
 Date **7-25-00** Location **Brittany Lane**
 Scorers Name: **SLM** Crew **ARB, SBT** River Mile **AA00932**

1) SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % present);

TYPE	POOL RIFFLE	POOL RIFFLE	SUBSTRATE ORIGIN	SUBSTRATE QUALITY
<input type="checkbox"/> BLDR /SLBS [10]	<input checked="" type="checkbox"/> GRAVEL [7]	<input checked="" type="checkbox"/> SAND [6]	<input checked="" type="checkbox"/> LIMESTONE [1]	<input type="checkbox"/> SILT: MODERATE [-1]
<input type="checkbox"/> BOULDER [9]	<input type="checkbox"/> BEDROCK [5]	<input type="checkbox"/> TILLS [1]	<input type="checkbox"/> WETLANDS [0]	<input type="checkbox"/> SILT MODERATE [-1]
<input checked="" type="checkbox"/> COBBLE [8]	<input type="checkbox"/> DETRITUS [3]	<input type="checkbox"/> HARDPAN [0]	<input type="checkbox"/> SANDSTONE [0]	<input checked="" type="checkbox"/> SILT NORMAL [0]
<input type="checkbox"/> HARDPAN [4]	<input type="checkbox"/> ARTIFICIAL [0]	<input type="checkbox"/> RIP/RAP [0]	<input type="checkbox"/> LACUSTRINE [0]	<input type="checkbox"/> SILT FREE [1]
<input type="checkbox"/> MUCK [2]		<input type="checkbox"/> SHALE [-1]	<input type="checkbox"/> COAL FINES [-2]	<input type="checkbox"/> EXTENSIVE [-2]
<input type="checkbox"/> SILT [2]				<input type="checkbox"/> NEARLY ABSENT < 5% [1]

NOTE: (Ignore sludge originating from point-sources; score on natural substrates) 5 or More [2] 4 or Less [0]

NUMBER OF SUBSTRATE TYPES: 4 or Less [0]

2) INSTREAM COVER

TYPE (Check All That Apply)	AMOUNT (Check ONLY One or check 2 and AVERAGE)
<input checked="" type="checkbox"/> UNDERCUT BANKS [1]	<input type="checkbox"/> EXTENSIVE > 75% [1]
<input type="checkbox"/> OVERHANGING VEGETATION [1]	<input checked="" type="checkbox"/> MODERATE 25-75% [7]
<input checked="" type="checkbox"/> SHALLOWS (IN SLOW WATER) [1]	<input type="checkbox"/> SPARSE 5-25% [3]
<input type="checkbox"/> ROOTMATS [1]	<input type="checkbox"/> NEARLY ABSENT < 5% [1]
<input type="checkbox"/> DEEP POOLS > 70cm [2]	
<input type="checkbox"/> ROOTWADS [1]	
<input type="checkbox"/> BOULDERS [1]	
<input type="checkbox"/> OXBOWS [1]	
<input type="checkbox"/> AQUATIC MACROPHYTES [1]	
<input type="checkbox"/> LOGS OR WOODY DEBRIS [1]	

3) CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER
<input checked="" type="checkbox"/> HIGH [4]	<input type="checkbox"/> EXCELLENT [7]	<input checked="" type="checkbox"/> NONE [6]	<input checked="" type="checkbox"/> HIGH [3]	<input type="checkbox"/> SNAGGING
<input type="checkbox"/> MODERATE [3]	<input checked="" type="checkbox"/> GOOD [5]	<input type="checkbox"/> RECOVERED [4]	<input type="checkbox"/> MODERATE [2]	<input type="checkbox"/> RELOCATION
<input type="checkbox"/> LOW [2]	<input type="checkbox"/> FAIR [3]	<input type="checkbox"/> RECOVERING [3]	<input type="checkbox"/> LOW [1]	<input type="checkbox"/> CANOPY REMOVAL
<input type="checkbox"/> NONE [1]	<input type="checkbox"/> POOR [1]	<input type="checkbox"/> RECENT OR NO RECOVERY [1]		<input type="checkbox"/> DREDGING
				<input type="checkbox"/> BANK SHAPING
				<input type="checkbox"/> ONE-SIDE CHANNEL MODIFICATIONS

4) RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) ★ River Right Looking Downstream ★

RIPARIAN WIDTH	FLOOD PLAIN QUALITY (PAST 100 FOOT RIPARIAN)	BANK EROSION
<input checked="" type="checkbox"/> WIDE > 50m [4]	<input checked="" type="checkbox"/> FOREST, SWAMP [3]	<input checked="" type="checkbox"/> NONE/LITTLE [3]
<input type="checkbox"/> MODERATE 10-50m [3]	<input type="checkbox"/> SHRUB OR OLD FIELD [2]	<input type="checkbox"/> MODERATE [2]
<input type="checkbox"/> NARROWS 10m [2]	<input type="checkbox"/> RESIDENTIAL, PARK, NEW FIELD [1]	<input type="checkbox"/> HEAVY/SEVERE [1]
<input type="checkbox"/> VERY NARROW < 5m [1]	<input type="checkbox"/> FENCED PASTURE [1]	
<input type="checkbox"/> NONE [0]	<input type="checkbox"/> CONSERVATION/TILLAGE [1]	
	<input type="checkbox"/> URBAN OR INDUSTRIAL [0]	
	<input type="checkbox"/> OPEN PASTURE, ROW CROP [0]	
	<input type="checkbox"/> MINING/CONSTRUCTION [0]	

5) POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY (POOL & RIFFLES!) (Check All That Apply)
<input type="checkbox"/> > 1m [6]	<input checked="" type="checkbox"/> POOL WIDTH > RIFFLE WIDTH [2]	<input type="checkbox"/> EDDIES [1]
<input type="checkbox"/> 0.7-1m [4]	<input type="checkbox"/> POOL WIDTH = RIFFLE WIDTH [1]	<input type="checkbox"/> TORRENTIAL [-1]
<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 type="checkbox"/> MODERATE [1]
<input type="checkbox"/> < 0.2m [POOL=0]		<input checked="" type="checkbox"/> SLOW [1]

6) GRADIENT (ft/mi): **26.4** DRAINAGE AREA (sq. mi.): **12**

RIFFLE /RUN DEPTH	CHECK ONE OR CHECK 2 AND AVERAGE	RIFFLE/RUN EMBEDDEDNESS
<input type="checkbox"/> GENERALLY > 10 cm; MAX > 50 [4]	<input type="checkbox"/> STABLE (e.g., Cobble, Boulder) [2]	<input checked="" type="checkbox"/> NONE [2]
<input type="checkbox"/> GENERALLY > 10 cm; MAX < 50 [3]	<input checked="" type="checkbox"/> MOD. STABLE (e.g., Large Gravel) [1]	<input type="checkbox"/> LOW [1]
<input checked="" type="checkbox"/> GENERALLY 5-10 cm [1]	<input type="checkbox"/> UNSTABLE (Fine Gravel, Sand) [0]	<input type="checkbox"/> MODERATE [0]
<input type="checkbox"/> GENERALLY < 5 cm [RIFFLE=0]	<input type="checkbox"/> NO RIFFLE [Metric=0]	<input type="checkbox"/> EXTENSIVE [-1]

7) POOL: **60** %GLIDE: **0**
 %RIFFLE: **40** %RUN: **0**

ARB/GAPR 2001

1. Substrate
 2. Instream Cover
 3. Channel Morphology
 4. Riparian Zone & Bank Erosion
 5. Pool/Glide Quality Riffle/Run Quality
- Gradient
- Range 0-100

Using Probabilistic Results to Predict the Percentage of Stream Miles Not Attaining Aquatic Life Use

Assessment for River Basin

Project Name	Target Population	*% Attainment*	*% Non-Attainment*	Confidence Level	*Confidence Interval*
West Fork	05120201	69%	31%	95%	15%
White River	05120202		1st order=4		
n=36	05120203		2nd order=5		
1st=13			3rd order=2		
2nd=14			4th+ order=0		
3rd=4			n= 11/36 Impaired		
4th+=5					
Patoka River	05120209	29%	71%	95%	15%
n=26			1st order=4		
1st=5			2nd order=7		
2nd=11			3rd order=0		
3rd=3			4th+ order=7		
4th+=7			n=18/26 Impaired		

Target population = 8 digit HUC

% Attainment = Combined Assessment of Biology (IBI>35, mIBI>2.2,HD>1.4) and No Chemical Parameter Violations

% Non-Attainment = Combined Assessment of Biology (IBI<35, mIBI<2.2,HD<1.4) and Chemical Parameter Violations

The Confidence Interval is the % Non-Attainment +/- the value for 95% Confidence Level.

* These are values produced by IDEM staff using "R" (<http://cran.us.r-project.org/>) and commands provided by

USEPA National Health and Environmental Effects Research Laboratory, Corvallis, Oregon.

Advantages & Disadvantages of Probabilistic Sampling

•Advantages:

- 100% waters of the state assessed
- monitoring long term watershed trends
- discovering non-point source pollution
- finding impairments at distant remote sites
- can focus resources to watershed specific impairments
- Bonus: biological expansion of species distribution, Threatened & Endangered Species, educate public and landowners in watershed



Photo Credit: Rob Criswell

Bluebreast Darter, *Etheostoma camurum*

•Disadvantages:

- Time, Access, Safety
- Cause and source of impairment
- Basins sampled only once every 5 years
- Where are the other impairments?



Conclusions

• **Probability Monitoring**

– Completed one cycle, after 2005 2nd cycle will be completed!

– Assess 100% of the waters of the state for the Integrated Water Monitoring and Assessment Report

• **Follow up impairments with second year studies**

– intensive surveys both biological and chemical in impaired watersheds

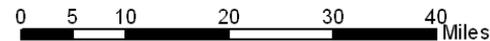
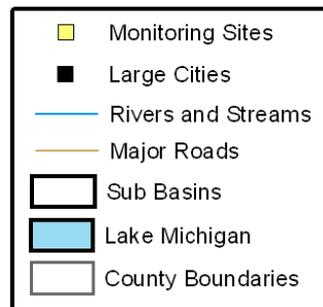
– evaluate tiered aquatic life uses for modified streams

2005 Fixed Stations in LM Basin

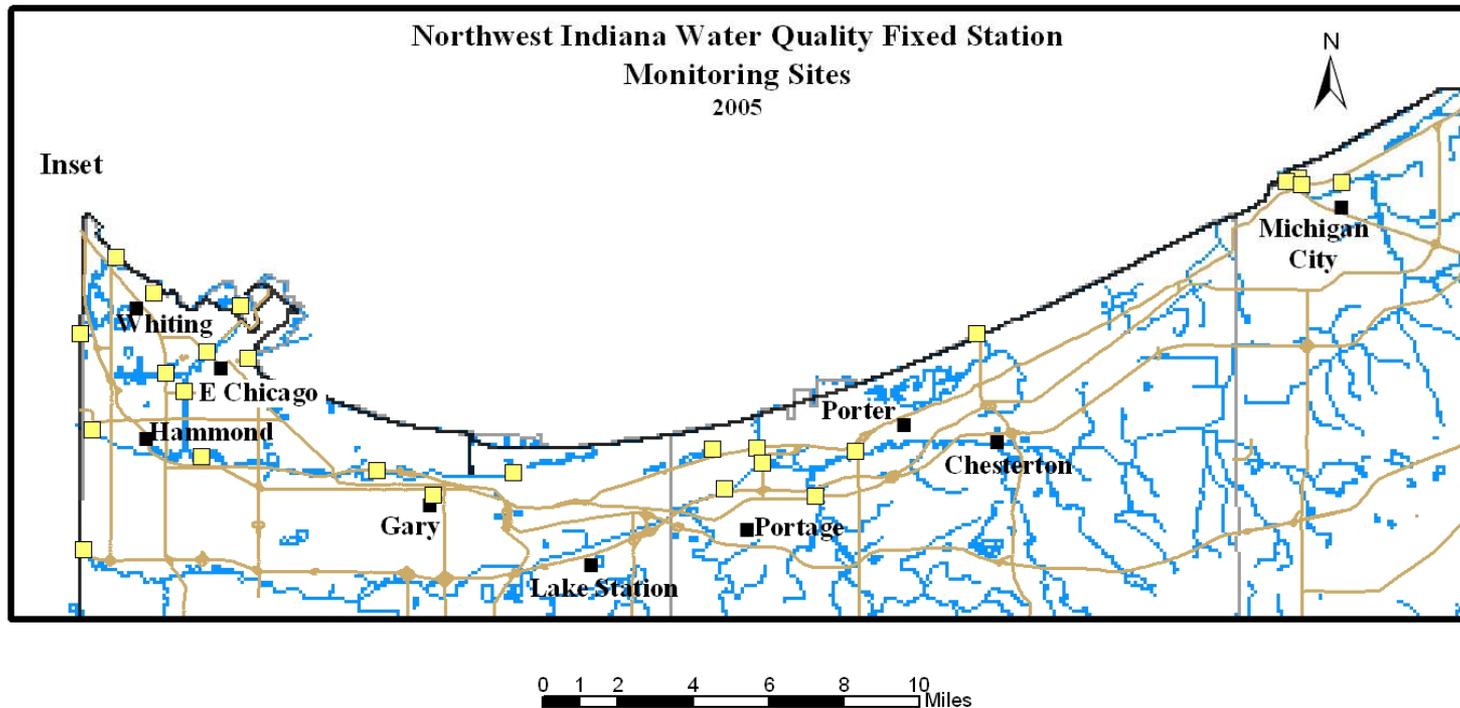
Lake Michigan Basin Fixed Station Monitoring Sites 2005



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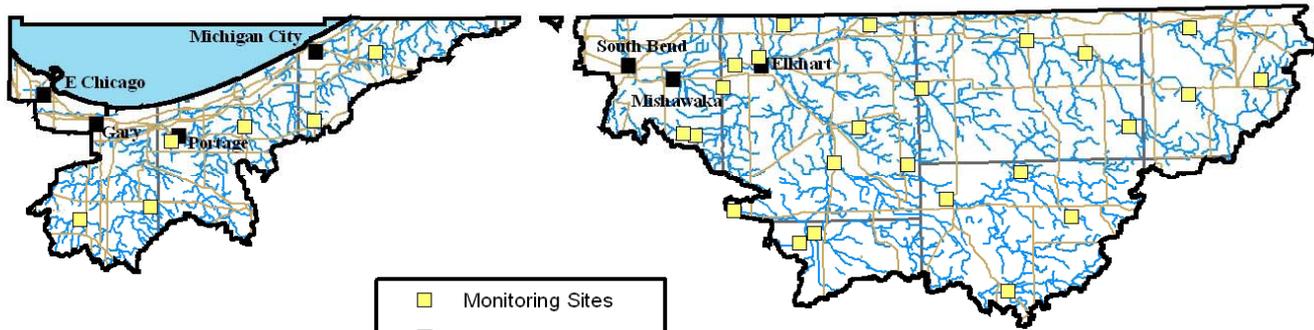


2005 Fixed Stations in LM Basin

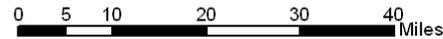


2005 Proposed Probabilistic Sites in LM Basin (1st 50 in GL Basin)

Lake Michigan Basin
Probabilistic Monitoring Sites
2005



- Monitoring Sites
- Large Cities
- Rivers and Streams
- Major Roads
- Sub Basins
- Lake Michigan
- County Boundaries



Acknowledgements

- **Stacey Sobat, Biological Studies Section**
- **Cindy Martin, Surveys Section**
- **Tony Olsen, USEPA NHEERL Corvallis, Oregon**
- **Assessment Branch Staff**

