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**Probabilistic versus Fixed Site  
Monitoring:  
How Do The Results Compare?**

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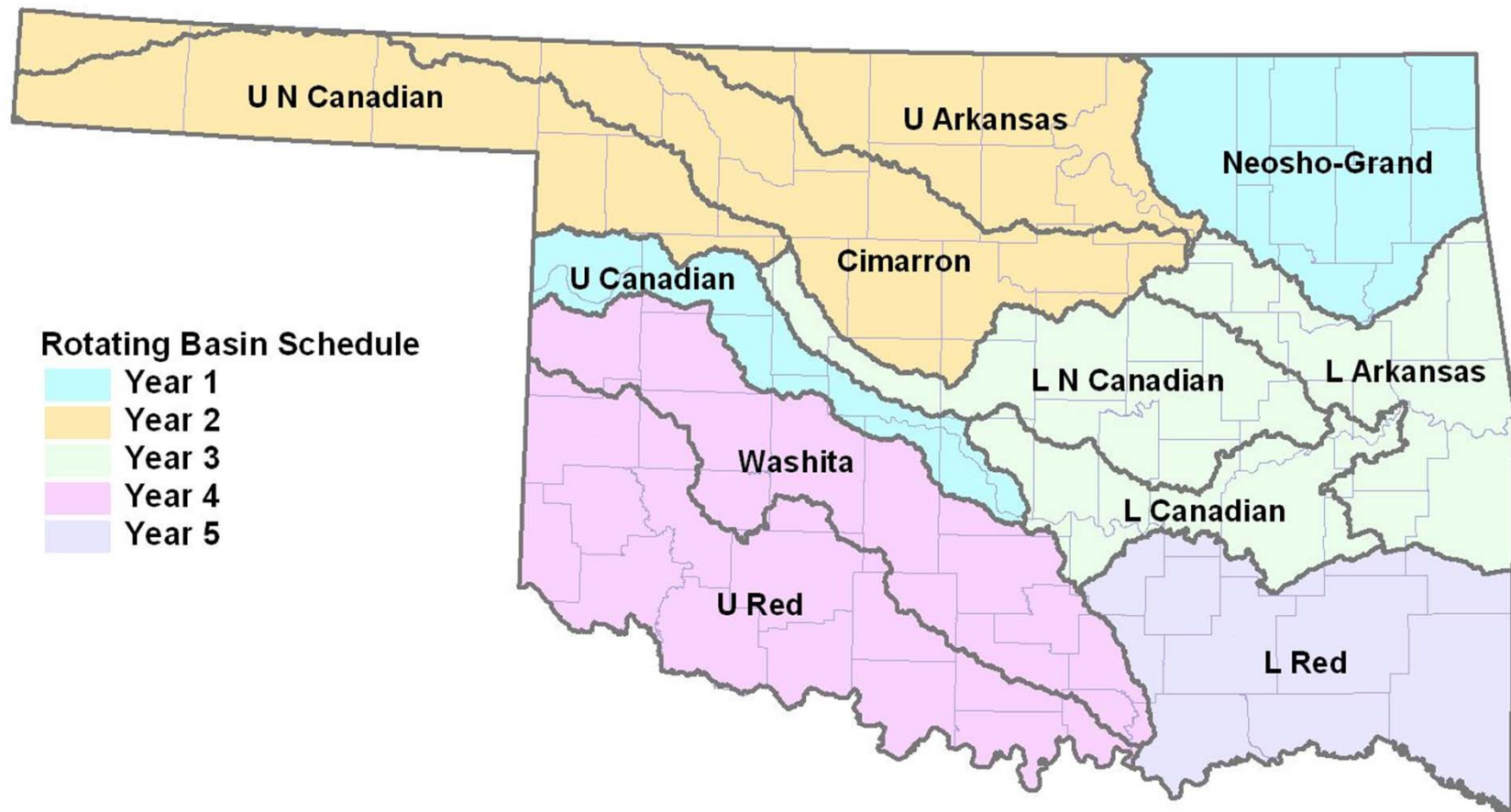


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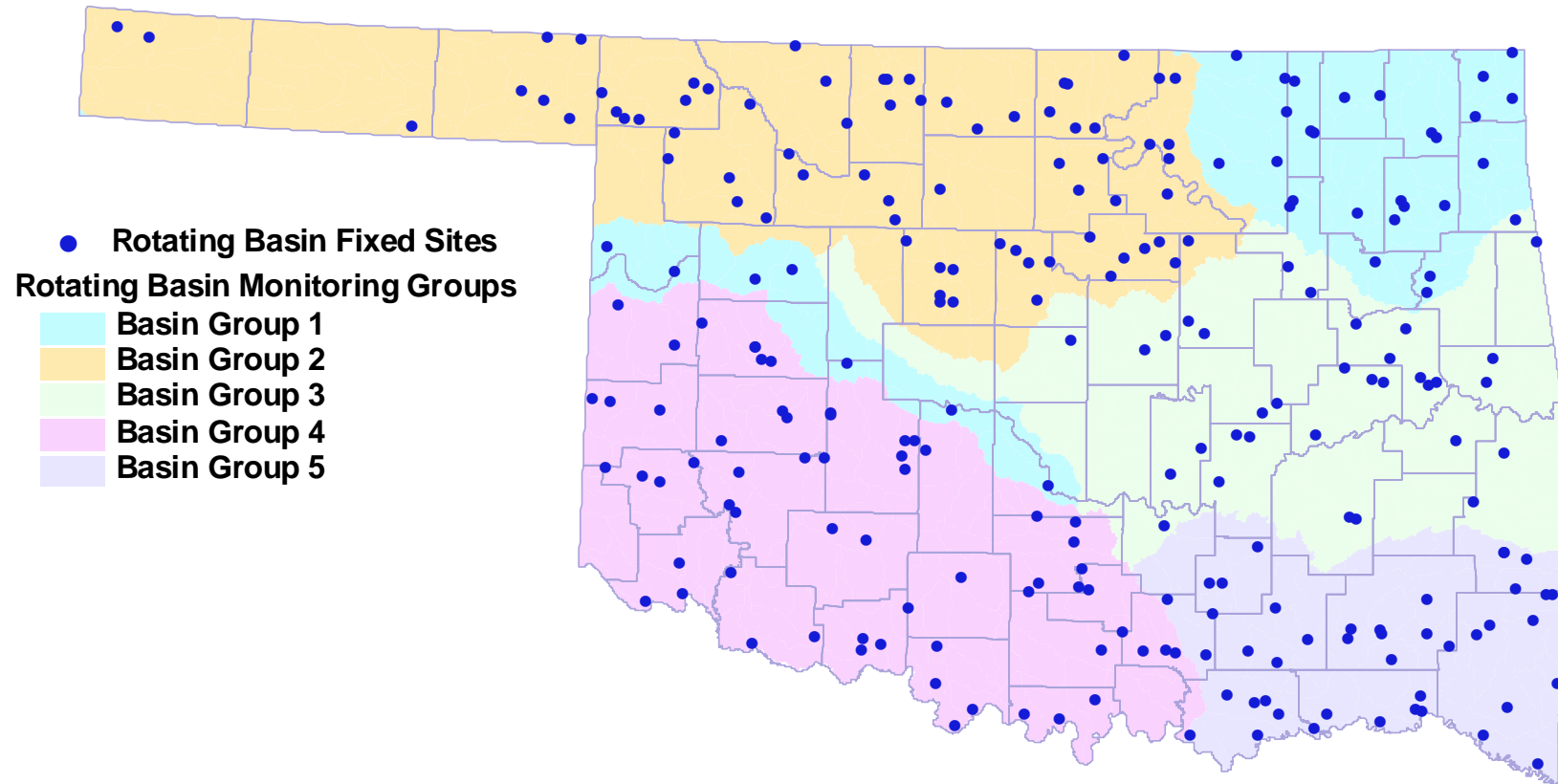
# Oklahoma Conservation Commission, Water Quality Division

- Technical lead for NPS pollution assessment and identification in OK
- Small to mid-sized, wadeable streams and rivers
- Started monitoring under Rotating Basin design in 2001

# Rotating Basin Monitoring Program



# Rotating Basin Monitoring Program



- Collect data every 5 weeks for 2 years
- Approx. 245 fixed sites every 5 years on staggered rotational schedule

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# Rotating Basin Monitoring Program

## ■ Fixed site selection

- ❑ Monitoring at the outlet of most HUC 11's
- ❑ Sites moved short distances to “best” sampling site
- ❑ Monitoring staff experienced and trained to select “best” sites
- ❑ If adequate site for collection of representative data is not available and site is not “significant”, then site may be dropped

# Monitoring Protocol: Physico-chemical Parameters

Every five weeks (ten times a year)

## *In-situ* parameters:

- water temperature
- dissolved oxygen
- pH
- specific conductance
- alkalinity
- hardness
- turbidity
- flow







# Monitoring Protocol: Physico-chemical Parameters

Every five weeks (ten times a year)

## Lab parameters:

- nitrate, nitrite, ammonia, total Kjeldahl nitrogen (TKN)
- orthophosphate, total phosphorus
- chloride, sulfate, TDS, TSS
- *E. coli* and Enterococcus bacteria  
(only during May through Sept. recreation season)



# Monitoring Protocol: Biological Parameters

## Fish / Instream Habitat

- Once every cycle (~5 years)
- Electroshock and seine
- 400 meters, total
- 20 meter transects for habitat assessment





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## Oklahoma has a lot of water!

**79,000 miles** of perennial and intermittent streams/rivers

**32,885 miles** (3,762 stream/river segments) delineated  
for assessment



As of 2010, **62%** of delineated miles have no data or  
**insufficient data** to determine designated use status

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# Monitoring: Improving the Coverage

- **2008:** OCC began probabilistic program to supplement ambient program



- ❑ 50 sites each summer
- ❑ On same basin schedule as ambient program
- ❑ One-time grab sample and *in-situ* measures
- ❑ Fish, bugs, instream habitat

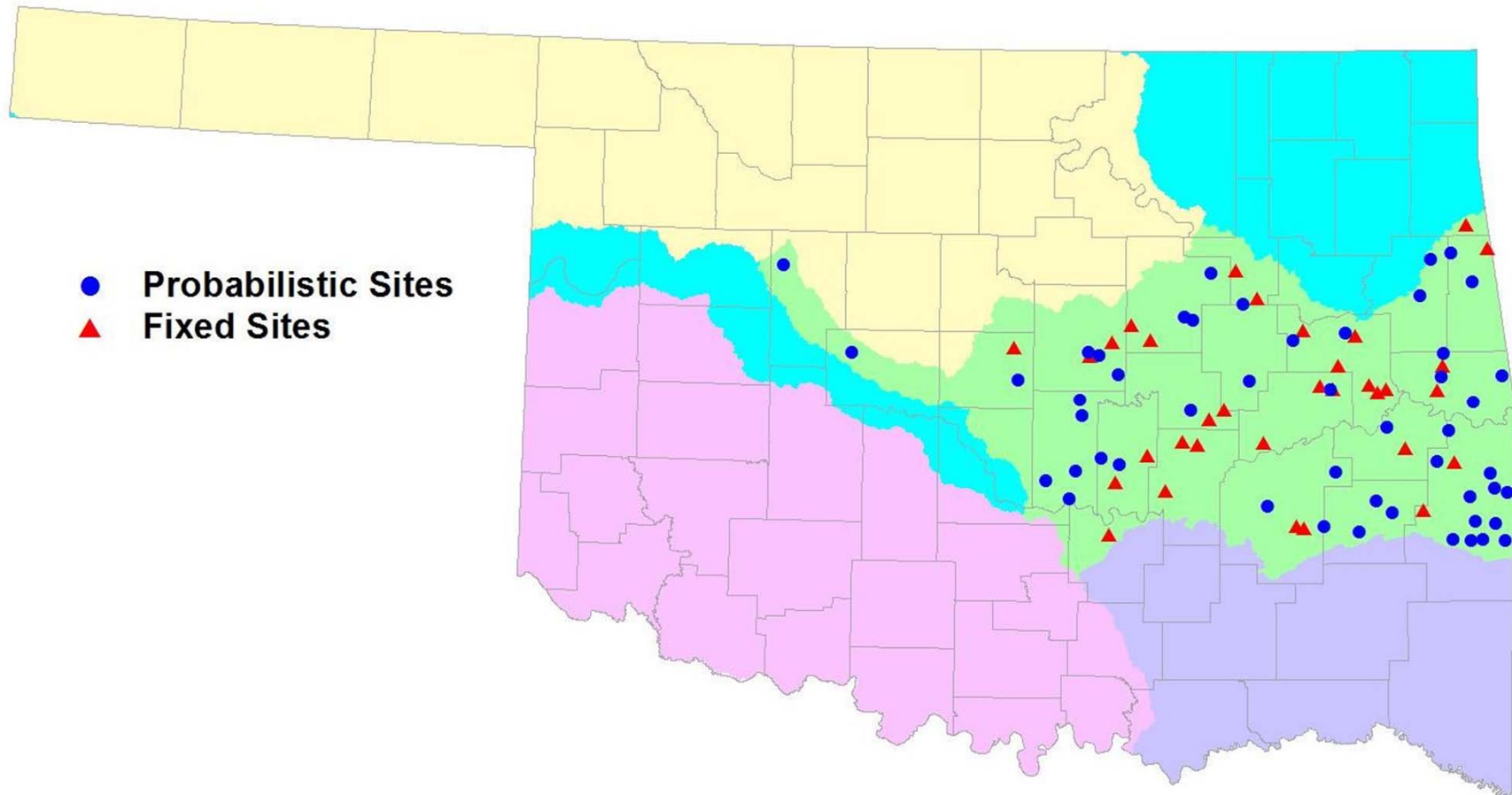
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# Probabilistic Survey Design

- Site draw by Tony Olsen of USEPA NHEERL
- Sample Frame: National Rivers and Streams Assessment w/ Oklahoma Watersheds as attributes
- Target Population: 2<sup>nd</sup>-6<sup>th</sup> strahler order with unequal probability by stream order
- Generalized Random Tessellation Stratified (GRTS) survey
- 50 base samples with 100% over sample

# Probabilistic Component of Rotating Basin Monitoring Program

Lower Arkansas, Lower Canadian and Lower N. Canadian





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# Probabilistic vs. Fixed Results

## Basin-Wide WQ Standards Impairment:

- **Dissolved oxygen is a problem in this basin group:**
  - **47% fixed sites** impaired vs. **35% prob. sites** low DO  
(need 10% of samples < 5 or 6 mg/L, date-specific, for impairment)
- **Base flow turbidity may be a problem:**
  - **18% fixed sites** impaired vs. **8% prob. sites** high turb  
(need 10% of samples > 50 NTU for impairment)
- **pH may be a problem in this basin group:**
  - **3% fixed sites** impaired vs. **16% of prob. sites** low pH  
(need 10% of samples < 6.5 for impairment)



# Probabilistic vs. Fixed Results

## Basin-Wide WQ Standards Impairment:

- **Enterococcus is a problem in this basin group:**

(geomean standard of 33 colonies/100 ml)

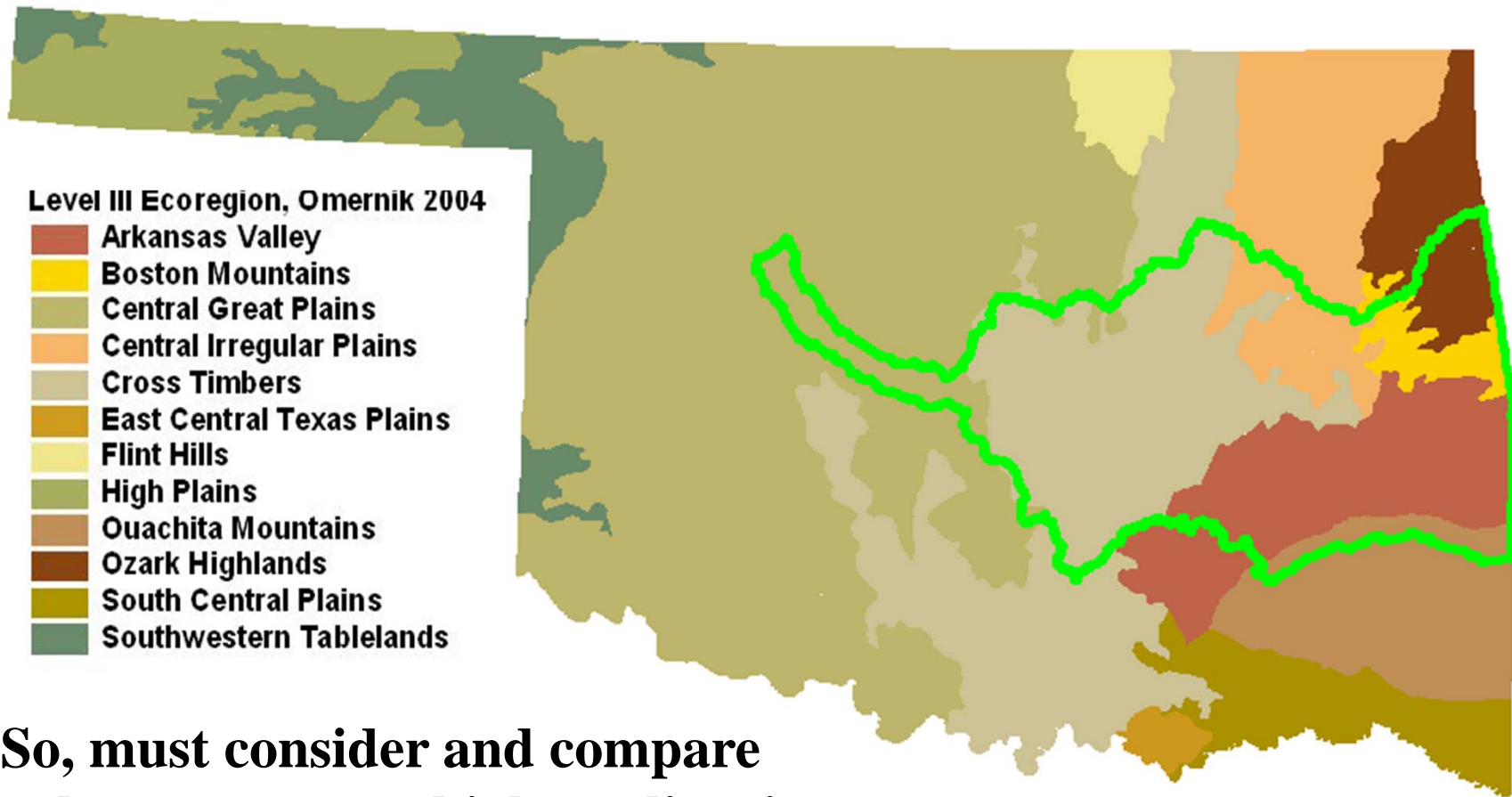
- ❑ **91% fixed sites** impaired vs **59%** exceedance for **prob sites**
- ❑ **Geomean of probabilistic sites = 48 col/100 ml = impaired**
- ❑ **Average geomean of fixed sites = 137 col/100 ml = impaired**

- ***E. coli* is a not as much of a problem in this basin group:**

(geomean standard of 126 colonies/100 ml)

- ❑ **26% fixed sites** impaired vs **25%** exceedance for **prob sites**
- ❑ **Geomean of probabilistic sites = 34 col/100 ml = not impaired**
- ❑ **Average geomean of fixed sites = 106 col/100ml = not impaired**

# Seven Ecoregions Just in Basin 3!



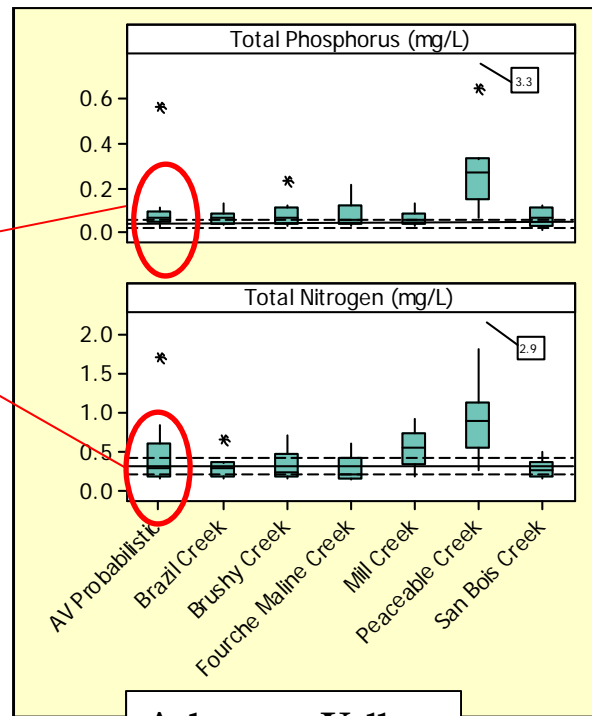
**So, must consider and compare values to average high quality sites in the appropriate ecoregion**

# Probabilistic vs. Fixed Results

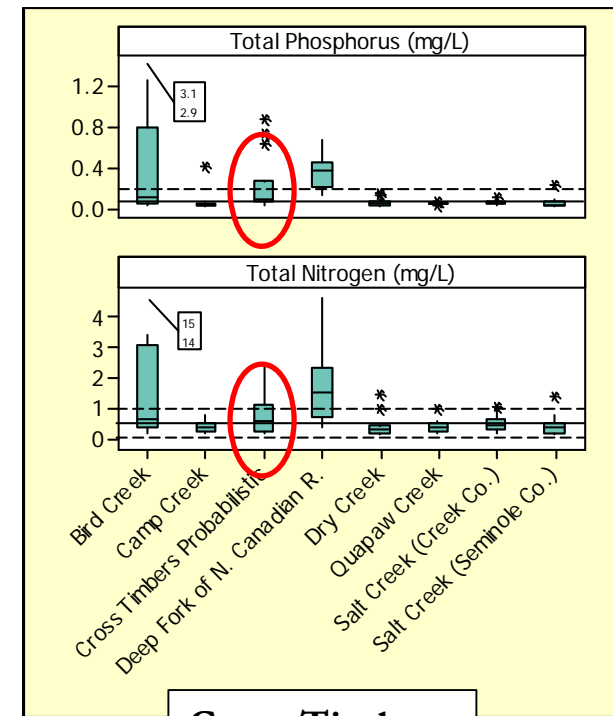
## Ecoregion trends:

- High nutrient concentrations relative to high quality sites in the Arkansas Valley and Cross Timbers ecoregions

Total Phos and Total Nitrogen from probabilistic sites exceed high quality site averages, as do multiple fixed sites



Arkansas Valley



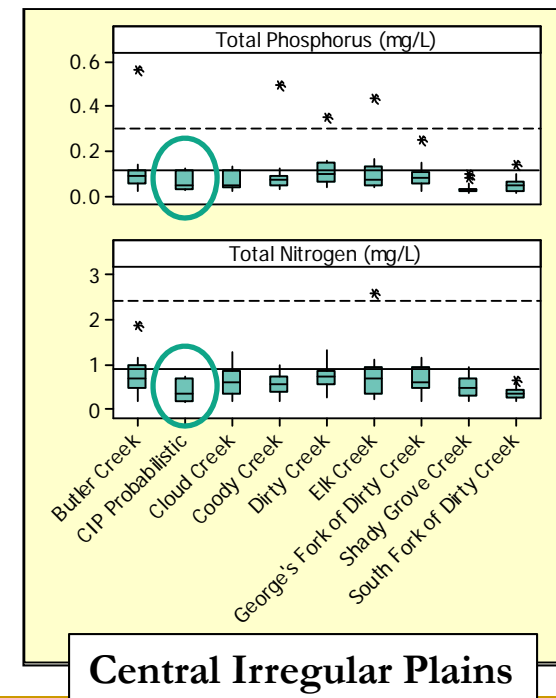
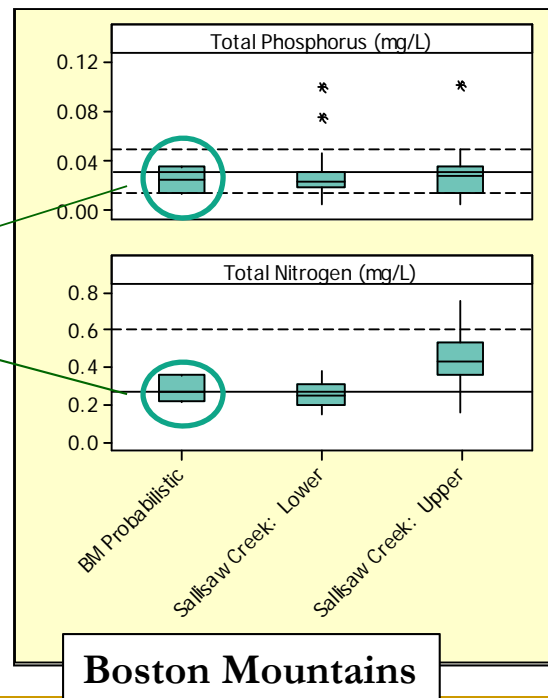
Cross Timbers

# Probabilistic vs. Fixed Results

## Ecoregion trends:

- Other ecoregions, no discernable problem with nutrients relative to high quality sites

Total Phos and Total Nitrogen from probabilistic sites not different from high quality site averages; neither are fixed sites



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# Probabilistic vs. Fixed Results

## Biological Data:

### Fish IBI Scores

(based on high quality sites in ecoregion)

#### Fixed Sites:

- ❑ 12% “excellent”
- ❑ 33% “good”
- ❑ 24% “fair”
- ❑ 30% “poor”

#### Probabilistic Sites:

- ❑ 29% “excellent”
- ❑ 13% “good”
- ❑ 27% “fair”
- ❑ 27% “poor”
- ❑ 4% “very poor”



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# Probabilistic vs. Fixed Results

## Biological Data:

### Macroinvertebrate IBI Scores

(based on high quality sites in ecoregion)

#### Fixed Sites:

- ❑ 43% “non-impaired”
- ❑ 46% “slightly impaired”
- ❑ 11% “moderately impaired”

#### Probabilistic Sites:

- ❑ 34% “non-impaired”
- ❑ 47% “slightly impaired”
- ❑ 19% “moderately impaired”

Winter and summer collections included for fixed sites

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# Probabilistic vs. Fixed Results

## Biological Data:

### Macroinvertebrate IBI Scores

(based on high quality sites in ecoregion)

#### Fixed Sites:

- ❑ 39% “non-impaired”
- ❑ 50% “slightly impaired”
- ❑ 11% “moderately impaired”

#### Probabilistic Sites:

- ❑ 34% “non-impaired”
- ❑ 47% “slightly impaired”
- ❑ 19% “moderately impaired”

Summer collections only for fixed sites

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# Probabilistic vs. Fixed Results

## Habitat Data:

### Average Habitat Scores by Ecoregion

#### Fixed Sites:

- Ark Valley 79% of ref
- Boston Mtns 94% of ref
- Cent Irreg Plns 95% of ref
- Cross Timbers 81% of ref
- Ozark Highlds 110% of ref

#### Probabilistic Sites:

- Ark Valley 76% of ref
- Boston Mtns 87% of ref
- Cent Irreg Plns 79% of ref
- Cross Timbers 74% of ref
- Ozark Highlds 95% of ref

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# Stream Order...

**Small Headwaters      vs.      Medium**  
**(2<sup>nd</sup>-3<sup>rd</sup> order)                      (4<sup>th</sup>-6<sup>th</sup> order)**

**Only flow and TSS are significantly different  
between these two categories**

# Stream Order...

	<b>Small</b>	<b>vs.</b>	<b>Medium</b>
	(2 <sup>nd</sup> -4 <sup>th</sup> order)		(5 <sup>th</sup> -6 <sup>th</sup> order)
Flow	11 cfs		96 cfs
DO	5.68 mg/L		7.86 mg/L
Cond	439 uS/cm		840 uS/cm
Chloride	52 mg/L		152 mg/L
TKN	0.29 mg/L		0.54 mg/L
Tot Phos	0.08 mg/L		0.26 mg/L
orthoPhos	0.04 mg/L		0.18 mg/L
TSS	14.94 mg/L		49.45 mg/L



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# PROS of Ambient, Fixed Site Rotating Basin Program:

- ❑ Comprehensive, consistent monitoring
- ❑ Assessment of stream health/attainment or impairment of WQ standards
- ❑ Diagnosis of potential sources of pollution
- ❑ Analysis of trends—are the streams changing for the better, worse, or not at all

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# PROS of Ambient, Fixed Site Rotating Basin Program:

- ❑ Can track improvements which can lead to delisting from the 303(d) list
- ❑ Moderates episodic/environmental effects
- ❑ Buffers sampling/analytical errors

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# CONS of Fixed Site Monitoring:

- ❑ Transferability of data to unmonitored streams is limited
- ❑ Time and \$ resource demand is high, so can only accommodate a limited number of sites

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# PROS of Probabilistic Monitoring:

- ❑ Statistically valid assessments of water quality conditions in unmonitored waterbodies
- ❑ May indicate regional issues of concern
- ❑ May identify critical pollution issues and help determine appropriate standards (basin-specific?)

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# CONS of Probabilistic Monitoring:

- ❑ Data represent a snapshot in time that may not represent typical conditions = limited temporal analysis
  - ❑ Difficult to identify causes of WQ degradation
  - ❑ Does not account for loading from high-flow events
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# Suggestions Based on OCC Experience (so far!)

- Both monitoring designs have strengths
- Best of both worlds is to have some fixed sites combined with probabilistic sites
- Maybe not necessary to do everything all at once...one cycle of probabilistic monitoring could indicate problems and help target sites/watersheds that need further monitoring...then repeat several years later

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## For Future...

- Identify the relationship between various stressors and the extent and degree of impairment = relative risk analysis
- Determine need and extent of probabilistic monitoring

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# OKLAHOMA CONSERVATION COMMISSION

