**FY-2005 104(b)3 Regional Environmental Monitoring and Assessment Program Study**

# *Implementation of a Stream/River Probabilistic Monitoring Network for the State of Oklahoma*

OWRB
the water agency

OKLAHOMA CONSERVATION COMMISSION

Final Report

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FY-2005 Section 104(b)3 Regional Environmental Assessment Program Study: Implementation of a Stream/River Monitoring Sampling Network for the State of Oklahoma

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## EXECUTIVE SUMMARY

It is the intent of this Oklahoma Water Resources Board (OWRB) report to advance concepts and principles of the Oklahoma Comprehensive Water Plan (OCWP). Consistent with a primary OCWP initiative, this and other OWRB technical studies provide invaluable data crucial to the ongoing management of Oklahoma's water supplies as well as the future use and protection of the state's water resources. Oklahoma's decision-makers rely upon this information to address specific water supply, quality, infrastructure, and related concerns. Maintained by the OWRB and updated every 10 years, the OCWP serves as Oklahoma's official long-term water planning strategy. Recognizing the essential connection between sound science and effective public policy, incorporated in the Water Plan are a broad range of water resource development and protection strategies substantiated by hard data – such as that contained in this report – and supported by Oklahoma citizens.

Several agencies conduct water quality monitoring in Oklahoma including: (a) the Beneficial Use Monitoring Program (a long-term, fixed-station water quality monitoring network), and (b) the Small-Watershed Rotating Basin Monitoring Program (targeting water quality and ecological conditions in waters flowing from 11-digit hydrologic units). The state recently completed a water quality monitoring strategy that describes their existing programs in detail and the monitoring objectives that cannot be met with existing resources. These objectives include the ability to make statistically valid inferences about environmental conditions throughout the state, based on a probabilistic selection of sites. Meeting this objective will improve the ability to make condition estimates required in section 305(b) of the Clean Water Act. This requirement includes a description of the quality of all lotic waters, and the extent that all waters provide for the protection and propagation of aquatic life.

The Environmental Protection Agency (EPA) recently released guidance establishing the "10 Required Elements of a State Water Monitoring and Assessment Program" (USEPA, 2006a). Among other things, the document states, "a State monitoring program will likely integrate several monitoring designs (e.g., fixed station, intensive and screening-level monitoring, rotating basin, judgmental and probability design) to meet the full range of decision needs. The State monitoring design should include probability-based networks (at the watershed or state-level) that support statistically valid inferences about the condition of all State water types, over time. EPA expects the State to use the most efficient combination of monitoring designs to meet its objectives." Until 2005, Oklahoma had several monitoring programs that met these requirements including the Beneficial Use Monitoring Program (BUMP) and the Rotating Basin Monitoring Program (RBMP) (OWRB, 2009b). Furthermore, the state has developed several programs to intensively monitor areas that have been listed on Oklahoma's 303(d) list of impaired waters (ODEQ, 2008).

In 2001, the State requested assistance with the design of a probabilistic approach to stream and river site selection from the U.S. Environmental Protection Agency, Office of Research and Development (ORD), Western Ecology Division (Olsen, 2001). The probability-based survey was designed to assist Oklahoma's water quality managers in several ways. An unequal probability random tessellation stratified (RTS) survey design (Stevens 1997, Stevens and Olsen 2004) was used to select stream sample sites across the state (Olsen, 2001), and was weighted by Strahler stream order categories. For the study, a total of 284 randomly chosen sites were evaluated for candidacy. The survey was a three-year study (2005-2007) with one hundred twenty-six (126) sites sampled. The study was spatially, temporally and hydrologically limited.

To assess ecological and human health, one-time collections were made for a variety of biological, chemical, and physical parameters. All target sites were visited once during a late spring to late summer index period in which fish assemblage was determined and a comprehensive suite of physical habitat measurements was made. In addition, an *in-situ* water quality collection was made for most sites including measurements for water temperature, dissolved oxygen, pH, specific conductance, and turbidity. All selected sites were visited again during an index period from June 1st through August 30th in which a comprehensive collection of water quality chemistry and microbiology, a collection for benthic macroinvertebrates, short form physical habitat measurements, and a collection of benthic periphyton was made under base flow conditions.

In keeping with the environmental goals of the state as outlined in the comprehensive water plan, an effective long-term management strategy based on sound science and defensible data can be developed using this data. The four over-arching goals of the study were:

1. Estimate the condition of various measures of biological integrity for Oklahoma's waters through a statistically-valid approach.
2. Estimate the extent of stressors that may be associated with biological condition.
3. Evaluate the relationship between stressors and condition for use in various long and short term environmental management strategies.
4. Assess waters for inclusion in Oklahoma's Integrated Water Quality Report.

For data analysis, sites were grouped by Omernik Level III ecoregions based upon proximity and statewide to produce estimates. Regions include the Western Plains/Tablelands, the Temperate Forests, and the Forested Plains/Flint Hills region. Fish data were analyzed using two indices of biological integrity (IBI) commonly used in Oklahoma bioassessment studies—the OKFIBI and the OCCFIBI. The OKFIBI estimated that nearly half of the state has a supporting fish condition over 47% (+/-8%) of the target population, 7% of the population is not supporting, while 28% are undetermined. An additional 16% of the population is lacking adequate biocriteria to determine condition. Conversely, the OCCFIBI estimates an excellent/good condition for 54% (+/- 8%) of the population, while 16% is in poor/very poor and 27% in fair condition. Macroinvertebrate taxonomic results for each site were analyzed to produce a percent of reference score for the OKBIBI. The OKBIBI estimates that 50% (+/-8%) of the population has a supporting macroinvertebrate condition and that 27% and 17% of the population is either slightly or moderately impaired, respectively.

To estimate condition of algal biomass, benthic and sestonic chlorophyll-a concentrations were compared to multiple screening levels. For both benthic and sestonic populations, the greater majority of waterbodies are not exceeding any screening limit, approximately 65-66% (+/-8%) statewide. To create condition estimates, bacteria data were compared to the applicable screening limits, and for enterococci to the OWQS standard. The estimate for not exceeding any indicator screening level or standard is nearly 70% (+/-8%) statewide.

A variety of stressors were used to determine extent and calculate relative risk. Nutrient stressors include measures total phosphorus, total nitrogen (nitrate + nitrite + total Kjeldahl nitrogen), and available nitrogen (nitrate + nitrite + ammonia). General water quality stressors represent a diverse group of parameters—*in situ* and salinity-related parameters *In situ* parameters include pH, dissolved oxygen, turbidity, and water temperature. Salinity-related parameters include conductivity, chloride, sulfate, and total dissolved solids (TDS). Metals were used in stressor studies to provide insight into stressors related to biological condition as well as those related human health beneficial uses—public/private water supply and fish consumption. Habitat stressors include total habitat score, several individual habitat metrics, and an index for sedimentation

The concept of using relative risk to develop a relationship between biological condition and stressor extent was developed initially for the USEPA's National Wadeable Streams Assessment (USEPA, 2006) by Van Sickle et al. (2006). The method calculates a ratio between the number of streams with poor biological condition/high stressor concentration and those with poor biological condition/low stressor concentration. Relative risk was determined for fish, macroinvertebrate, and algal condition

This report marks Oklahoma's first attempt at making a statistically based assessment of the condition of Oklahoma's waters. The OWRB recommends that this report be adopted into the 305(b) section of the integrated report. Second, individual waterbodies not yet included in the integrated report now have some level of assessment including category 5 (impaired), as well as category 3 (not impaired for some uses).

The relative risk analysis produced widely variable results depending upon both condition and stressor and has implications for criteria development, not only at the stressor level, but for biological condition as well. Conclusions based on analysis are: 1) regional reference condition needs to be refined across all Omernik Level III ecoregions to include many Omernik Level IV ecoregions, 2) effective nutrient criteria will lie somewhere between regional screening levels and those in Oklahoma rule, 3) macroinvertebrates tend to respond in a more predictable fashion to water quality stressors than do fish, 4) sestonic algal condition is more easily predicted by nutrient concentrations than benthic algal condition, 5) application of naturally occurring condition protocols can benefit from relative risk analysis, 6) Oklahoma should explore the use of relative bed stability (RBS) as a measure of sedimentation, and 7) regional nuisance benthic algal screening levels are needed.

Additionally, other recommendations can be made from the varied analysis, including: 1) all metals listed in the OWQS (OWRB, 2007a) but not occurring above criteria in ambient monitoring programs should not be monitored further, 2) since most metals occur regionally, a table specifying regional metals of concern should be created, 3) the contact recreation use should be a tiered use much like the aquatic life uses, and 4) refine agriculture criteria to include conductivity as a surrogate for TDS or create a regional criteria for conductivity to use in place of TDS.

In Oklahoma, probabilistic monitoring is an ongoing process. In terms of monitoring, probabilistic design has been completely integrated into both the OWRB and OCC monitoring programs (OWRB, 2009b). The OWRB is currently participating in the National Rivers and Streams Assessment and will use data from it to provide an update to the current report. Also, the third two-year statewide study will begin in winter or summer 2009 and include 50 sites. Substantive changes to the program will include: 1) use of the NRSA protocols for large wadeable and non-wadeable waterbodies, 2) use of NRSA habitat protocols for wadeable streams in concert with the current RBP habitat protocol, 3) inclusion of a second winter macroinvertebrate index period, 4) inclusion of dissolved metals for some analytes, and 5) exclusion of bacteria from program. The OCC initiated a probabilistic program during 2008 that will provide estimates for planning basins throughout the state. Fifty random sites are being monitored per basin over the five-year rotating basin cycle. Lastly, the OWRB will conclude the Illinois River Probabilistic Monitoring Survey in 2009-2010. It is the first regionally based probabilistic study in Oklahoma, and is centered on setting a baseline biological condition to assist in implementation of nutrient criteria in Oklahoma's scenic rivers. Additional plans are in the works for future regionally based studies.

## INTRODUCTION

Several agencies conduct water quality monitoring in the State of Oklahoma. These agencies meet complementary monitoring objectives that support the management of Oklahoma's surface waters. The two primary components of the statewide monitoring program include (a) the Beneficial Use Monitoring Program, a long-term, fixed-station water quality monitoring network of the Oklahoma Water Resources Board (OWRB), and (b) Oklahoma Conservation Commission's (OCC) Small-Watershed Rotating Basin Monitoring Program, targeting water quality and ecological conditions in waters flowing from 11-digit hydrologic units. The state recently completed a water quality monitoring strategy that describes their existing programs in detail and the monitoring objectives that cannot be met with existing resources (OWRB, 2009b). These objectives include the ability to make statistically valid inferences about environmental conditions throughout the state, based on a probabilistic selection of sites. Meeting this objective will improve the ability to make condition estimates required in section 305(b) of the Clean Water Act. This requirement includes a description of the quality of all lotic waters, and the extent that all waters provide for the protection and propagation of aquatic life.

The Environmental Protection Agency (EPA) recently released guidance establishing the "10 Required Elements of a State Water Monitoring and Assessment Program" (USEPA, 2006a). Among other things, the document states, "a State monitoring program will likely integrate several monitoring designs (e.g., fixed station, intensive and screening-level monitoring, rotating basin, judgmental and probability design) to meet the full range of decision needs. The State monitoring design should include probability-based networks (at the watershed or state-level) that support statistically valid inferences about the condition of all State water types, over time. EPA expects the State to use the most efficient combination of monitoring designs to meet its objectives." Until 2005, Oklahoma had several monitoring programs that met these requirements including the Beneficial Use Monitoring Program (BUMP) and the Rotating Basin Monitoring Program (RBMP) (OWRB, 2009b). Furthermore, the state has developed several programs to intensively monitor areas that have been listed on Oklahoma's 303(d) list of impaired waters (ODEQ, 2008).

In 2001, the State requested assistance with the design of a probabilistic approach to stream and river site selection from the U.S. Environmental Protection Agency, Office of Research and Development (ORD), Western Ecology Division (Olsen, 2001). The study design was completed, but Oklahoma agencies remained unable to initiate further planning and implementation because of a lack of resources and commitment. In 2004, the OWRB and OCC took part in the National Wadeable Streams Assessment (WSA) (USEPA, 2006), which was fortuitous to future planning efforts for several reasons. First, the timing of the study coincided with discussions in the state about implementing a probabilistic design. Although money was a question, staff and management were worried staff time could not be spent performing all of the necessary reconnaissance work or sampling that is required in a random based monitoring program. Participating in the WSA instilled confidence that this type of monitoring could be accomplished without impeding the success of other programs. In fact, this facet of Oklahoma's monitoring program has only enhanced other programs. Second, because the state showed interest in implementing a random design, USEPA Region 6 began working with staff to find appropriate funding. The initial funding came through a Clean Water Act (CWA) Section 104(b)3 grant. This money funded not only the initial year of study (2005), but an outcome was to investigate the feasibility of full implementation (OWRB, 2006a). The study investigated feasibility on two fronts—logistic and funding—finding that the logistic portion could be overcome through proper planning and coordination of staff. The funding, however, was not easily dealt with because of program priorities.

In 2005, another funding opportunity came open when the USEPA announced further funding of the Regional Environmental Monitoring and Assessment Program (REMAP) (OWRB, 2005a). Funding from the REMAP grant allowed the state to continue implementation of probabilistic monitoring for an additional two years through 2007. Funding for the survey is outlined in Table 1.

**Table 1. Breakdown of yearly funding and activity funded (OWRB, 2005a).**

| STUDY YEAR | FEDERAL 104(B)3 | REMAP | STATE |
|---|---|---|---|
| SY-2005 (1) | $130,118— recon and sampling of 30 sites; supplies and equipment | No Funding | $55,882—the state 5% match to the 104(b)3 ($6,849); recon and sampling of 12 sites; final reports |
| SY-2006 (2) | No Funding | $180,000—recon and sampling of all 42 sites; project and data management activities; supplies and equipment | $100,000—project and data management |
| SY-2007 (3) | No Funding | $140,000—recon and sampling of 32 sites; project and data management; portion of final report | $54,000—recon and sampling of 10 sites (Upper Arkansas Planning Basin); project and data management; portion of final report |
| 3 year Total ($660,000) | $130,118 | $320,000 | $209,882 |

The probability-based survey was designed to assist Oklahoma's water quality managers in several ways. Furthermore, in keeping with the environmental goals of the state as outlined in the comprehensive water plan, an effective long-term management strategy based on sound science and defensible data can be developed using this data. The four over-arching goals were:

1. Estimate the condition of various measures of biological integrity for Oklahoma's waters through a statistically-valid approach.
2. Estimate the extent of stressors that may be associated with biological condition.
3. Evaluate the relationship between stressors and condition for use in various long and short term environmental management strategies.
4. Assess waters for inclusion in Oklahoma's Integrated Water Quality Report.

The current assessment allows the state to make a statistically valid assessment of the condition of all of Oklahoma's streams/rivers, as required under Section 305(b) of the Clean Water Act (CWA) (ODEQ, 2008). At the end of the 3-year project period, there were one hundred twenty-six (126) sites available for inclusion in data analyses. This sample size allows for a statewide as well as a regional estimate of fish, macroinvertebrate, and algal condition. Also, human health estimates are provided. Additionally, extent is evaluated for a number of potential environmental stressors at both the statewide and regional level. Lastly, under the guidelines of the Integrated Listing Methodology (ODEQ, 2006), data allow for the assessment of the Fish & Wildlife Propagation beneficial use on more waters of the state. Although currently limited to certain beneficial uses and associated criteria, the support status of more waters can be determined. Future work may allow for more comprehensive 303(d) assessments so that the support status of probabilistic sites may be fully vetted.

Furthermore, the survey provides information that will allow for better long- and short-range planning and resource allocation. A benefit of probabilistic design is that data results can be applied in a much broader context. For example, the relationship of condition can be associated with stressor extent through methodologies like relative risk analysis. The current study yields a wealth of biological, chemical, and physical data across a broad gradient of environmental conditions, supporting evaluation of these indicator relationships. Data can be used to calibrate existing biocriteria ranges, establish reference condition, and assist in nutrient criteria development. When integrated with fixed-station networks, it will assist in identifying local areas of concern. Also, although not accomplished by this report, landscape metrics can be associated with stressors and condition to develop predictive models. Third, probabilistic data will assist in efforts to regionalize environmental concerns. A bottom up approach to management identifies not only statewide issues but allows managers to identify local and regional concerns first, which often lead to issues farther down the watershed, and put resources where they are needed. The probabilistic methodology adds a valuable layer to that management approach.

## METHODS

**Study Design**

An unequal probability random tessellation stratified (RTS) survey design (Stevens 1997, Stevens and Olsen 2004) was used to select stream sample sites across the state (Olsen, 2001). The sample design was weighted by Strahler stream order categories to achieve an approximately equal expected sample size across stream order categories 1st, 2nd, 3rd, and 4th+ to ensure that larger order streams are represented, and all perennial waterbodies were included in the design. The design also included an "oversample" to provide alternate sites for those that do not fit the target population, or where access is prohibited by landowners. The original 2001 balanced sampling design was modified to a spatially stratified design to support estimates of conditions at the statewide scale within the three-year project period, and to support estimates at the scale of selected planning basins, or combinations of basins (Figures 1 and 2).

Oklahoma's probabilistic survey was originally scheduled for a five-year period but was shortened to a three-year study (study years 2005-2007) with approximately 42 sites sampled annually. During study years one through three, at least fifteen (15) sites were visited annually at the statewide scale, yielding a sample size of forty-five (45) sites. Additionally, a total of twenty-seven (27) sites were visited annually within seven specific planning basins as outlined in Table 2, yielding an additional eighty-one (81) sites. Because of the differing size or geographic area covered by each basin, the number of sites targeted within each planning basin ranged from three to thirty-three sites (Table 3). At the end of the project period, one hundred twenty-six (126) sites were available for inclusion in data analyses.

**Table 2. Numbers of sites originally targeted both statewide and within selected basins.**

| STUDY YEAR (SY) | GEOGRAPHIC SCALE | # SITES SAMPLED |
|---|---|---|
| SY-2005 (1) | Lower Red River | 27 |
| | Statewide Stations | 15 |
| SY-2006 (2) | Grand-Neosho River | 15 |
| | Upper North Canadian River | 5 |
| | Upper Canadian River | 7 |
| | Statewide Stations | 15 |
| SY-2007 (3) | Upper Arkansas River | 10 |
| | Lower Canadian River | 6 |
| | Cimarron River | 11 |
| | Statewide Stations | 15 |
| SY-2005-7 | Total Stations | 126 |

The study was spatially, temporally and hydrologically limited. Spatially, the study excluded all flowing waterbodies receiving major hydrological influence from oxbow lakes because of a lack of developed biological collection protocols. In southeastern Oklahoma, the lower Red River below its confluence with the Kiamichi River and the Little River below its confluence with the Mountain Fork River were excluded. In northeastern and east-central Oklahoma, the McClellan-Kerr Navigational System was excluded below its confluence with the Caney River, encompassing large portions of the lower Verdigris River and Arkansas River as they flow through the state. Temporal limitations were defined by biological index periods. The index period for the fish assemblage in Oklahoma was May 15th through September 15th with an optional extension to October 1st if the stream had not risen above summer seasonal base flow (OWRB, 2004). The index habitat period for the macroinvertebrate assemblage in Oklahoma was June 1st through August 30th with collections completed in as short a time period as possible (OWRB, 2006c). Hydrologically, the study was limited by both an extended drought in SY-2005 as well as excessive rains and flooding in SY-2006-2007. This impeded study progress in several ways. Sites originally verified as target sites were removed and an oversample site visited because of site changes between the period of reconnaissance and sampling. Additionally, several sites had partial collections because conditions changed between the period of macroinvertebrate/water sampling and fish sampling, or vice-versa.

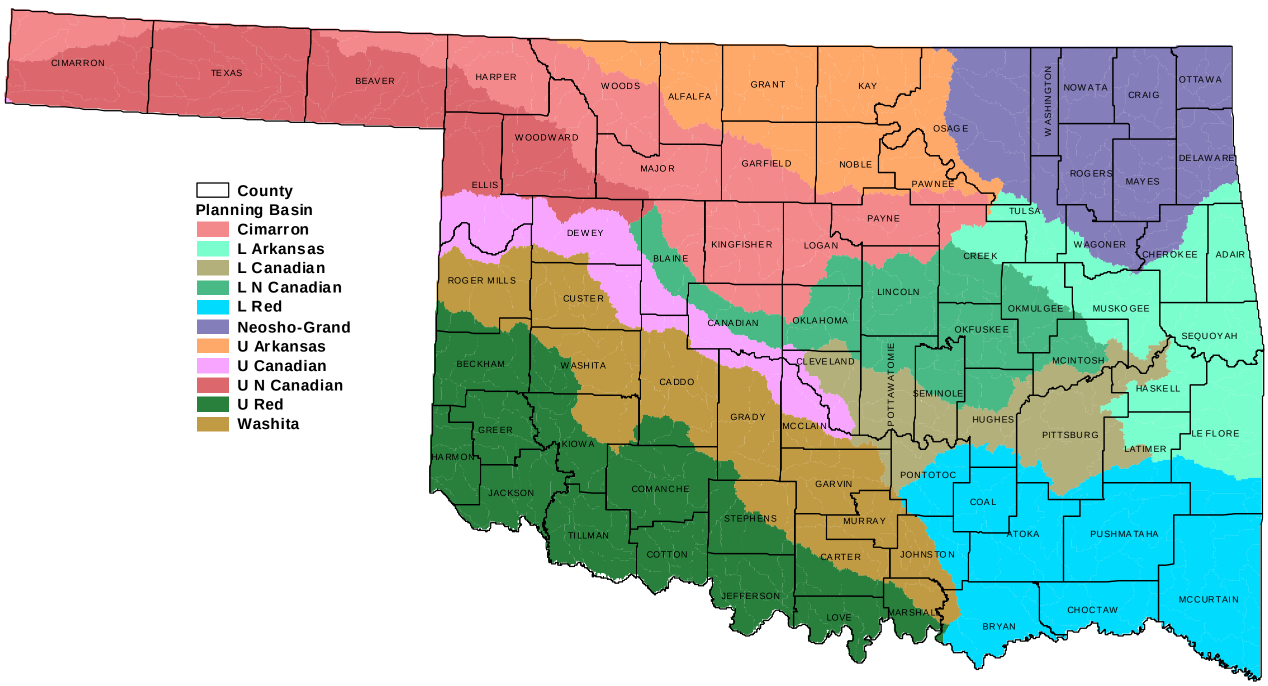



**Figure 1. State of Oklahoma Planning Basins**

## Revised Study Regions

After extent and condition estimates were completed, it was decided that planning basins were not a viable option for examining more refined geographical scales. Because of the limited number of sites visited in many of them (Table 3), confidence intervals were considered to be too broad to draw any valid conclusions about estimates or stressor extent. Several alternatives were explored including the grouping of planning basins by geographic area or only reporting on basins with an adequate number of sites. The most feasible alternative under this scenario involved logically grouping planning basins by geographic area. The Upper Arkansas was joined with the Cimarron planning basin, which is one of its major sub-basins. A Lower Arkansas basin group was formed, including the Upper and Lower North Canadian, Upper and Lower Canadian, and Neosho-Grand planning basins. And, the entire Red River basin was grouped to encompass the Upper and Lower Red and the Washita planning basins. The final sample sizes are given in Table 3. It was concluded that these groups still produced sample sizes too low to make meaningful estimates.

Eventually, the decision was made to move away from the planning basin approach for this report. Although considered unique to Oklahoma's study design, implementation was not possible over the three year study period. Consideration was given to future needs for planning basin work. The OCC is currently in the process of implementing a probabilistic approach in each of the eleven planning basins as part of their five year Rotating Basin Monitoring Program (OWRB, 2009b). Eventually, this will yield estimates that can be used in the state's 305(b) reporting. The current study will still benefit that work by providing a template methodology for approaching analysis. On the other hand, drawing potentially poor conclusions because of inadequate sample size does not benefit those future endeavors.

**Table 3. Numbers of sites sampled within selected basins geographical groupings.**

| Geographical Groupings | Planning Basin | # of Sites |
|---|---|---|
| Ecoregion Option (Final Choice) | Temperate Forests | 40 |
| | Forested Plains/Flint Hills | 41 |
| | Western Plains/Tablelands | 45 |
| Alternate Planning Basin Design | Alternate Lower Arkansas | 60 |
| | Alternate Red River | 40 |
| | Alternate Upper Arkansas | 27 |
| Original Planning Basin Design | Cimarron | 12 |
| | Grand Neosho | 23 |
| | Lower Arkansas | 8 |
| | Lower Canadian | 11 |
| | Lower North Canadian | 3 |
| | Lower Red | 33 |
| | Upper Arkansas | 15 |
| | Upper Canadian | 7 |
| | Upper North Canadian | 8 |
| | Upper Red | 7 |

After exploring options that kept planning basins intact, other potential regional groupings were investigated. The most reasonable alternative was to group sites by Omernik Level III ecoregions based upon proximity. Several considerations were given when making these groupings. Foremost, water quality should be similar and habitat should not be greatly divergent. Secondly, groupings should be supported by some previously published sources such as Omernik Level II ecoregions. The final regional groupings are presented in Table 3 and Figure 2.

The Western Plains/Tablelands region is comprised of the Central Great Plains, Southwestern Tablelands, and Western High Plains Level III ecoregions (Woods, 2005), which are encompassed by the South Central Semi-arid Prairies Level II ecoregion (NACEC, 2001, Omernick, 1987). Generally, in stream habitat is comprised mostly of loose bed substrates with extensive shoreline vegetation. Habitat structure is dominated by extensive glides and moderate to shallow pools, with extensive sand bar formation and braiding in larger systems. Coarse substrates are present in some areas but are not common. Water quality varies within the area, but is unique in one respect when compared to the rest of Oklahoma. Conductivity throughout the region typically is abnormally high, with normal ranges from 1,000-3,000 microsiemens (OCC, 2005a, 2005b, 2006a, 2007; OWRB, 2008). In the Red Prairie and Red River Tablelands of southwestern Oklahoma, conductivity ranges from 2,500 up to greater than 75,000 below the gypsum outcroppings of the Elm

Fork River. In northwestern Oklahoma along both the Cimarron and Beaver Rivers, similar conductivity ranges are present. Human influence is mostly row crop agriculture and pasture/grazinglands with influence from several major urban centers in the eastern portion of the region including the Oklahoma City Metro, Enid, and Lawton. Moderate sized communities (e.g., Woodward or Altus) are spread throughout the area east of the panhandle to the eastern border with the Cross Timbers. Oil and gas exploration is common throughout the region.

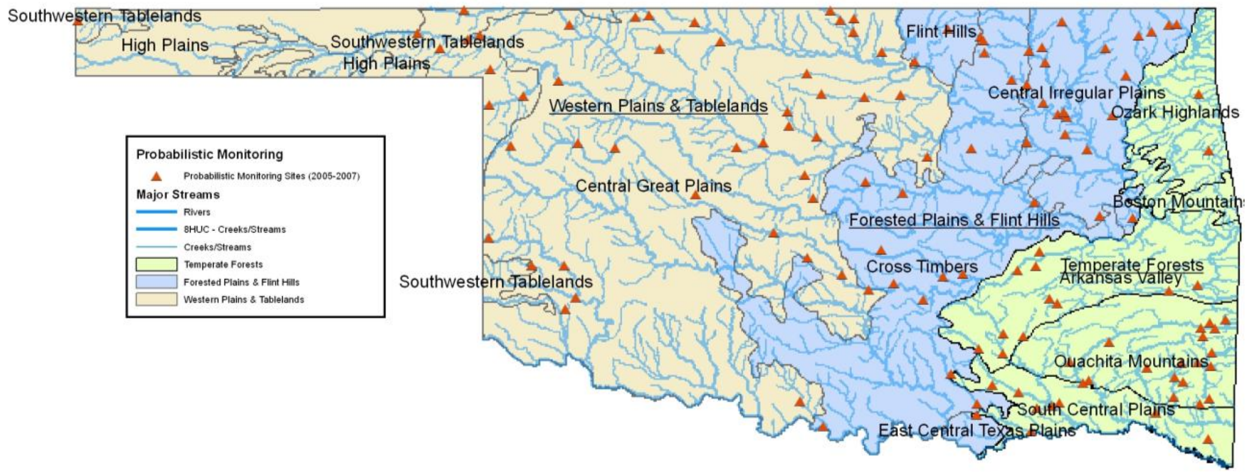



**Figure 2 . Ecoregion groupings used for regional assessment of sites.**

The Temperate Forests region is located along the eastern border of Oklahoma and encompasses the South Central Plains, Ouachita Mountains, Arkansas Valley, Boston Mountains, and Ozark Highlands (Woods, 2005). These areas are all contained with the Eastern Temperate Forests Level I ecoregion, with most being in the extensive Ozark, Ouachita-Appalachian Forests Level II ecoregions. The South Central Plains are in the Southeastern USA Plains Level II ecoregion. With the exception of parts of the valleys and plains regions, the majority of streams are dominated by coarse substrates and bedrock, with extensive gravel bar formation. Gradients vary throughout, but riffle-run complexes are common with relatively deep pools in all sized waterbodies. In-stream habitat is widely diverse with a variety of ledges and interstitial spaces as well as in-stream vegetation and large woody debris. From a water quality perspective, the area has widely varying nutrient concentrations, but is dominated by relatively low conductivity water, 10-350 microsiemens on a gradient from south to north (OCC, 2005a, 2005b, 2008; OWRB, 2008). Because most streams are cool water communities, dissolved oxygen is typically higher, except in far eastern portions of the South Central Plains which have natural dissolved oxygen levels well below 3 ppm. Another naturally-occurring variation is low pH (below 6.5) in the central and eastern Ouachita Mountains, which is dominated by waters with extremely low buffering capacities (hardness < 10 ppm). Human influence is mostly forestry with light to moderate agriculture, mostly pasture and grazinglands. Row crop agriculture is rare except in the Arkansas Valley and South Central Plains. However, there are a number of confined animal feeding operations throughout the region and in western Arkansas. Several moderately sized population centers are in the area, including Grove and Tahlequah to the north with McAlester and Idabel/Broken Bow in the south.

The Forested Plains/Flint Hills region is a hodgepodge of central and eastern Oklahoma, including the Cross Timbers, Central Irregular Plains, and Flint Hills Level III ecoregions (Woods, 2005). The East Central Texas Plains ecoregion did not have any sites located within its boundaries, but likely would have been considered for inclusion here. The area is wholly contained within the Great Plains

Level I ecoregion, but encompasses both the South Central Semi-arid Prairies and Temperate Prairies Level II ecoregions (NACEC, 2001, Omernick, 1987). With the exception of the Arbuckle Uplift is the south central portion of the area, the region is mostly different from the Temperate Forests region for several reason. Although coarse substrates are common in many areas of the region, fine substrates are generally in greater concentrations and commonly more dominant in areas throughout the Cross Timbers (OCC, 2005a, 2006a, 2006b, 2007, 2008; OWRB, 2008). Additionally, conductivity throughout the region is relatively high when compared to the Temperate Forests region, ranging from 200-1000 microsiemens in most parts. Parts of the Cimarron and Canadian basins do range from 1000-4000 microsiemens. The major differences in comparison to the Western Plains/Tablelands are domination by riparian forests in all but the Flint Hills and generally more riffle-run complexes with deeper pools. Human influence in the area is mixed agriculture including row crops, pasture, and grazinglands. A number of major urban centers are present including the Oklahoma City and Tulsa Metro areas as well as Muskogee in the east, Ardmore and Ada in the south and central, and Stillwater and Ponca City/Bartlesville to the north. Moderate sized communities are spread throughout the area. Oil and gas exploration as well as refining is common throughout the region.

**Site Reconnaissance**

Limited accessibility is the most serious problem with any probabilistic study. Unlike a fixed station design, study sites are typically not accessible by public roads and may only be accessed by foot. Compounding the problem is private ownership of land and the need to respect a landowner's choice of who may or may not access the property. Finally, probabilistic sites are selected from data frames that are not 100% accurate and may include non-candidate sites. Fortunately, proper planning and having an excess of available oversample sites can alleviate these issues. During the EPA's Wadeable Streams Assessment (USEPA, 2006) and the first year of this study (OWRB, 2006a), the OWRB developed (with assistance from EPA documentation) and implemented a three-stage reconnaissance plan.

The first stage of planning was a "desk top" reconnaissance to determine if the proposed site was a candidate site. Candidate sites must meet certain criteria, including: 1) perennial flow, 2) not within normal pool elevation of a lake (oxbows or reservoirs), 3) not a wetland/swamp dominated river, 4) accessible by foot, and 5) landowner permission granted. Initially, each site was located using a variety of resources including topographic maps (OWRB, 2005d), and other GIS mapping tools. For each site, a site reconnaissance and tracking form (Figure 3) was created with the ultimate determination made to "accept" or "reject". At the outset, required hydrological characteristics were verified, and if not met, the site was rejected without further consideration. Then, a series of site maps containing at least two geographic scales were included with the site tracking form, and the necessary information to determine landowner was collected, including legal description of site and county. County assessor offices were the main source of landowner information. However, for some problem sites, staff used a variety of other resources including development of relationships with local realtors/developers or personal visits to nearby residences. Finally, a landowner permission packet was sent to each landowner, including a standardized permission letter (Figure 4), maps, a study brochure, and self addressed/stamped envelope for them to review and mail back to the OWRB either approving or disallowing access to their property. Based on landowner response, the site was accepted, accepted with restrictions/further instructions, or rejected. However, even when good landowner information was available, response to permission requests was occasionally slow for a variety of reasons, and therefore, a two stage process was developed to deal with slow responses. After two to three weeks, staff attempted contact by phone, and if unsuccessful, would send a reminder postcard. If still unsuccessful, in-person contact was attempted. If each of these attempts failed, the site was rejected.

Once site accessibility was verified (i.e., accepted) and a site was labeled as a study target site, a second planning stage was initiated.  The planning objective was simply to collect thorough, well-documented information to assist field crews in locating and accessing the sampling reach. Because of color aerial satellite imagery, much of this information was gathered from the desktop. Notes were made and included in the tracking form of special considerations including hazards, best route of entry, time of travel, etc.  Unfortunately, some sites required an o-nsite initial visit to complete the planning phase.  Concerns did arise about the cost versus benefit of an extra site visit.  However, over the course of three years, crews discovered that much of the information collected during the initial on-site planning visit was of great benefit on the actual day of sampling. Furthermore, because sites could be visited in batches and only one staff member was required, not much expense was incurred.

The final planning stage involved all activities up to the first sampling visit, and involved compiling a complete site packet.  The packet incorporated all information gathered in stages one and two, including a completed tracking form, landowner permission letter, and pertinent pictures and maps. In addition, all necessary field forms and labels were compiled and a checklist of equipment needed was completed.

## Probabilistic Monitoring – Site Reconnaissance & Tracking Form

Stream Name: **Little Creek**

Site ID: **OKPB01-*027***

Lat/Long: **$34^0$ 46' 50.8" / $99^0$ 23' 33.5"**

Site Type: **target** or oversample

Sample Status: **Accepted** or Rejected

If rejected, what is the reason:

[ ] Landowner Denied Permission
[ ] Site is Dry
[ ] Site is impounded (part of a lake)
[ ] Site is not riverine habitat (i.e., wetland, swamp, etc.)
[ ] Site is not physically accessible
[ ] Other, please explain:

If rejected, what site replaces this one:

Landowner Contact Information:

**John Doe (Doe Land & Cattle Co.)**
**P.O. Box A**
**Your Town, OK 11111**
**(580)555-2222**

Landowner Requests:

**None. You can drive down to the site if you need. (see attached permission letter)**

Directions/Access to Site:

**From Your Town, go west on SH 1 for 3.25 miles. The property is South of this point. Walk or drive across pasture to get to the X-site. (see attached maps)**

**Figure 3. Template site reconnaissance and tracking form used during study.**

Date

John Doe Trust
C/O Jane Doe
Rt. 1 Box 1
Anywhere, OK 74534

Dear Sir/Madam:

The Oklahoma Water Resources Board (OWRB) is conducting a five-year project to perform environmental assessments on 210 to 220 randomly selected streams across Oklahoma. This effort involves on-site visits by OWRB personnel to a stream adjacent to your property to take samples of the water, fish and other aquatic life, and to gather other information concerning stream habitat such as measurements of stream width and depth and observations of stream bed and vegetation characteristics. The findings of the study are not intended for enforcement or regulatory purposes.

One of the sites that we would like to assess is a point on Your Creek located on your property in Section 1, Township 1 N, Range 1 E, in Your County, Oklahoma. We have enclosed a copy of a topographic map with the site identified by an "X" at the specific point on the stream to be sampled.

We are writing to ask for your permission to come onto your property to visit the site and conduct sampling activities. We realize that working on your property is a privilege and we will respect your landowner rights at all times. If you grant us permission, we will make no more than three visits to your land. The first visit will be for site reconnaissance and will occur sometime between March and April of 2006. A crew of one to two people will use your land to access the site and only gather information about site accessibility. In addition, one or two more visits will be made between May and October of 2006 for sampling and collection. We expect to have a crew of no more than four OWRB employees or its contractors coming on site during the sample collection visits. Fish will only be collected during one of these visits.

Once a sampling date is set, OWRB employees will contact you, either by telephone or in person, before entering onto your land. After OWRB staff contact you, they will access the site either on foot or by vehicle and collect the necessary samples and data. Other than driving or walking across your land and walking in and around the stream site, we expect that staff will not leave any trace of their activity. Staff will honor any special instructions you have, such as accessing land only by foot, driving on pasture roads only, and opening and closing gates responsibly.

If you are agreeable to the activities described above, please complete and sign one copy of the "Landowner Permission" page and mail it back to us in the enclosed, stamped return envelope by Date. We have enclosed a duplicate of this page, which you may keep for your records. Please include contact information so that we may contact you by phone. Thank you for your consideration. If you have any questions about this request, please contact Jason Childress (Project Coordinator) or myself at 405-530-8800.
Sincerely,

Monty Porter
Water Quality Programs Streams/Rivers Monitoring Coordinator

Enclosures: Topo map
Duplicate original of letter
Return envelope

LANDOWNER PERMISSION

I grant permission to the employees of the Oklahoma Water Resources Board to come onto my property and conduct stream sampling activities as described in this letter.

_________ Permission granted
_________ Permission granted, subject to the following restrictions or instructions:
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
_________ Permission not granted

Landowner's Name (please print): ________________________________________

Landowner's Signature: ________________________________________

Landowner's Daytime Phone No.

**Figure 4. Template landowner permission letter used during study.**

**Data Collection**

To assess ecological and human health, one-time collections were made for a variety of biological, chemical, and physical parameters (Table 4). When sites were verified as target, a sampling schedule was implemented. All target sites were visited once during a late spring to late summer index period in which fish assemblage was determined and a comprehensive suite of physical habitat measurements was made. In addition, an *in-situ* water quality collection was made for most sites including measurements for water temperature, dissolved oxygen, pH, specific conductance, and turbidity. All selected sites were visited again during an index period from June 1st through August 30th in which a comprehensive collection of water quality chemistry and microbiology, a collection for benthic macroinvertebrates, short form physical habitat measurements, and a collection of benthic periphyton was made under base flow conditions. Depending on circumstances, information was collected during the same site visit.

**Table 4. Water quality variables included in study.**

| SAMPLE VARIABLES | | |
|---|---|---|
| ***In situ* Variables** | | |
| Dissolved Oxygen (D. O.) | % D. O. Saturation | PH |
| Water Temperature | Specific Conductance | |
| **Field Variables** | | |
| Nephelometric Turbidity | Total Alkalinity | Total Hardness |
| Instantaneous Flow | Stage | |
| **Laboratory Variables--General Chemistry** | | |
| Total Kjeldahl Nitrogen | Ortho-Phosphorus | Total Phosphorus |
| *Nitrate Nitrogen | *Nitrite Nitrogen | Ammonia Nitrogen |
| Total Dissolved Solids—gravimetric | Chlorides | Sulfates |
| Total Settleable Solids | Total Suspended Solids | |
| **Laboratory Variables—Metals** | | |
| Arsenic | Cadmium | Chromium |
| Copper | Lead | Mercury |
| Nickel | Selenium | Silver |
| Zinc | Thallium | Calcium |
| Barium | Iron | Magnesium |
| Potassium | Sodium | |
| **Laboratory Variables—Microbiological** | | |
| Fecal Coliform | *Escherichia coli* | Enterococci |
| **Biological Variables** | | |
| Fish | Macroinvertebrates | Sestonic Chlorophyll-a |
| Habitat--Long Form | Habitat--Short Form | Benthic Chlorophyll-a |

Data for water quality variables was collected in one of two ways (OWRB, 2006d). Several variables (pH, dissolved oxygen, water temperature, and specific conductance) were monitored *in-situ* utilizing a Hydrolab® Minisonde or YSI® multi-probe instrument or with single parameter probes. Regardless of instrumentation and in accordance with manufacturer's specifications and/or published SOP's, all instruments (except water temperature) were calibrated at least weekly and verified daily with appropriate standards. The measurement was taken at the deepest point of the channel at a depth of at least 0.1 meters and no greater than one-half of the total depth. The data were uploaded from the instrument and saved to a data recorder, transferred manually to a field log sheet, and manually entered into the OWRB Water Quality database. Data for all other variables were amassed from water quality samples collected at the station. Grab samples were collected by one of two methods—a grab or a composite grab. The most common method employed was a grab sample, which was used in streams with a single, well-mixed channel. The sample was collected at the deepest, fastest flowing portion of the horizontal transect by completely submerging the bottle, allowing it to fill to the top, and capping the bottle underwater. Composite grabs were collected in rivers with multiple channels and were aliquotted into sample bottles using a clean splitter-churn. Each sample included three bottles for general chemistry analyses (two ice preserved and one sulfuric acid preserved), one bottle for metals analysis (nitric acid preserved), and one bottle each for field chemistry analysis and sestonic chlorophyll-a (ice preserved and kept dark). Two bottles for microbiological analysis (ice preserved) were collected using only a grab sample technique. For benthic chlorophyll-a, a sample was composited, placed on ice to be preserved, and kept dark. The Oklahoma Department of Environmental Quality-State Environmental Laboratory (ODEQ-SEL) in accordance with the ODEQ's Quality Management Plan (QTRACK No. 00-182) (ODEQ, 2007) analyzed samples for most parameters listed in Table 4. OWRB or OCC personnel measured hardness and alkalinity using Hach® titration protocols, and nephelometric turbidity using a Hach® Portable turbidometer.

Samples for algal biomass were collected in both the sestonic and benthic zones of each waterbody and processed in accordance with standard procedures outlined (OWRB, 2006b). Sestonic, or water column, samples were processed from water collected during the general water quality collection. A benthic sample was processed from a reach-wide composite. Benthic filters were extracted using a alternate method, whereby filters are placed in a standard aliquot of ethanol (25 mL) and extracted at room temperature for at least 72 hours. All chlorophyll-a samples were analyzed by the ODEQ-SEL under the previously mentioned QMP (ODEQ, 2007).

Biological assemblages included aquatic macroinvertebrates and fish that were collected in accordance with Oklahoma's Rapid Bioassessment Protocols (RBP) (OWRB, 1999) and the OWRB's biological collection protocols (OWRB, 2004). Collections were completed over a 400-1000 meter reach depending on wetted width, with 400 meters serving as the default reach length. Fish were primarily collected using a pram or boat electrofishing unit depending on wadeability. Each fishing unit consisted of a Smith-Root 2.5 generator powered pulsator (GPP) attached to a 3000W Honda generator, and were operated with AC output current at 2-4 amps. Using two netters with ¼ inch mesh dipnets, collections were made in an upstream direction with a target effort of 2000-4000 units depending on reach length. When habitats existed that could not be effectively electrofished, supplemental collections were made using 6' X 10' seines of ¼ inch mesh equipped with 8' brailes. Fish were processed at several intervals during each collection. Fish that were too large for preservation and/or readily identifiable were processed in the field, including identified to species and enumerated along with appropriate photodocumentation and representative vouchers. All other fish were preserved in a 10% formalin solution and sent to the University of Oklahoma Sam Noble Museum Of Natural History (OUSNMNH) for identification to species and enumeration. Several collections made by OCC were processed by Brooks Tramell. Additionally, a detailed habitat assessment was made targeting in-stream substrate, habitat, width and depth as well as bank and riparian measurements (OWRB, 2005b).

Aquatic macroinvertebrate collections were made during the summer index period of each study year (OWRB, 2006c). Each sampling event targeted three habitats (when available)—streamside vegetation, wood, and rocky riffles—that theoretically should be species rich. The streamside vegetation and wood collections were semi-qualitative samples collected over flowing portions of the reach for total collection times of three and five minutes, respectively. The streamside sample was collected using a 500-micron D-frame net to agitate various types of fine structure sample including fine roots, algae, and emergent and overhanging vegetation. Likewise, the wood sample was collected using a 500-micron D-frame net to agitate, scrape, and brush wood of any size in various states of decay. Additionally, wood that could be removed from the stream was scanned for additional organisms outside the 5-minute sampling time. The riffle collection was a quantitative sample compositing three kicks representing slow, medium and fast velocity rocky riffles within the reach. Each sub-sample was collected by fully kicking one square meter into a 500-micron Zo seine. All samples were field post-processed in a 500-micron sieve bucket to remove large material and silt in an effort to reduce sample size to fill no more than ¾ of a quart sample jar. Additionally, all nets and buckets were thoroughly scanned to ensure that no organisms were lost. After processing, each sample type was preserved independently in quart wide mouth polypropylene jars with ethanol and interior and exterior labels were added. Prior to taxonomic analysis, all samples were laboratory processed by study personnel to obtain a representative 100-count subsample (OWRB, 2006c). After sorting, the "100-count subsample" was sent to EcoAnalysts, Inc. for identification and enumeration, and the large and rare sample was identified and enumerated by OWRB staff. Taxonomic data for each sample were grouped by EcoAnalysts and metrics were calculated. In general, most organisms were identified to genera with midges identified to tribe.

Discharge and/or stage data were also collected at each station (OWRB, 2005c). Flow was determined through several methods including direct measurement of instantaneous discharge using a flow meter, interpolation of flow from a stage/discharge rating curve developed by the United States Geological Survey (USGS) or the OWRB, or through estimation of discharge using a float test (OWRB, 2004b).

For a more detailed discussion of sampling procedures, please contact the OWRB/Water Quality Programs Division at (405) 530-8800 for copy of the BUMP Standard Operating Procedures (SOP) or visit the OWRB website at http://www.owrb.state.ok.us/quality/monitoring/monitoring.php#SOPs.

## Extent Estimates

For the study, a total of 284 randomly chosen sites were evaluated for candidacy representing a total of 34,379 stream miles. Using pie charts, results are illustrated for statewide and regional extent in Figure 5. Stream miles determined to be target, or sampleable, totaled 14,284 miles statewide (42%, +/- 6%). Regionally, the total stream miles assessed break out as follows: 4,846 of 10,544 total miles in the Forested Plains (46%, +/-12%), 4,411 of 10,569 total miles in the Temperate Forests (42%, +/-9%), and 5,027 of 13,276 total miles in the Western Plains (38%, +/-9%). Stream miles that did not meet the target criteria were divided into two categories—non-sampleable and no access. The non-sampleable stream length totaled 6,556 miles (19% +/-11%) and were divided into four sub-categories—dry channel (4,308 miles), impounded (1,026 miles), temporary/persistent flooding conditions (1,103 miles), and wetland (and 119 miles). Stream length with no access equaled 13,540 (39%, +/-7%), which was nearly equivalent to the totaled sampled length. Reasons for lack of access varied but can be divided into three general sub-categories—access permission denied (13,169 miles), physical barrier to access (231 miles), and no existing protocols (140 miles). The last category was for extremely large rivers (e.g., the Arkansas River portion of the McClellan-Kerr Navigational System) where attempting to apply rapid bioassessment protocols was neither feasible nor practical.

## Analysis of Fish Biological Condition

Fish data were analyzed using two indices of biological integrity (IBI) commonly used in Oklahoma bioassessment studies. Primarily, state biocriteria methods are outlined in Oklahoma's Use Support Assessment Protocols (OWRB, 2008b). In addition, an IBI commonly used by the OCC's Water Quality Division was used to provide an alternative bioassessment (OCC, 2005a and 2008). All metrics and IBI calculations were made using the OWRB's "Fish Assessment Workbook", an automated calculator OWRB staff built in Microsoft Excel (OWRB, 2008a).

Oklahoma's biocriteria methodology (OKFIBI) uses a common set of metrics throughout the state (Table 5). Each metric is scored a 5, 3, or 1 depending on the calculated value, and scores are summed to reach two subcategory totals for sample composition and fish condition (OWRB, 2008b). The two subcategories are then summed for a final IBI score. The score is compared to ecoregion biocriteria to determine support status. For example, if the final IBI score is between 25-34, the status for sites in the Ouachita Mountain Ecoregion is deemed undetermined. Likewise, for scores greater than 34 and less than 25, the status is supported or not supported, respectively.

The OCCFIBI uses "a modified version of Karr's Index of Biotic Integrity (IBI) as adapted from Plafkin et al., 1989" (OCC, 2008). The metrics as well as the scoring system are in Table 6. Metric scores are calculated in two ways for both the test site and composite reference metric values of high-quality streams in the ecoregion (OCC 2005). Species richness values (total, sensitive benthic, sunfish, and intolerant) are compared to composite reference value to obtain a "percent of reference". A score of 5, 3, or 1 is then given the site depending on the percentages outlined in Table 6, while the reference composite is given a default score of 5. Proportional metrics (% individuals as tolerant, insectivorous cyprinids, and lithophilic spawners) are scored by comparing the base metric score for both the test site and the reference composite to the percentile ranges given in Table 6. After all metrics are scored, total scores are calculated for the test and composite reference sites. Finally, the site final score is compared to the composite reference final score and a percent of reference is obtained. The percent of reference is compared to the percentages in Table 7 and an integrity classification is assigned with scores falling between assessment ranges classified in the closest scoring group.

**Figure 5. Statewide extent estimates representing considered and sampled stream miles.**

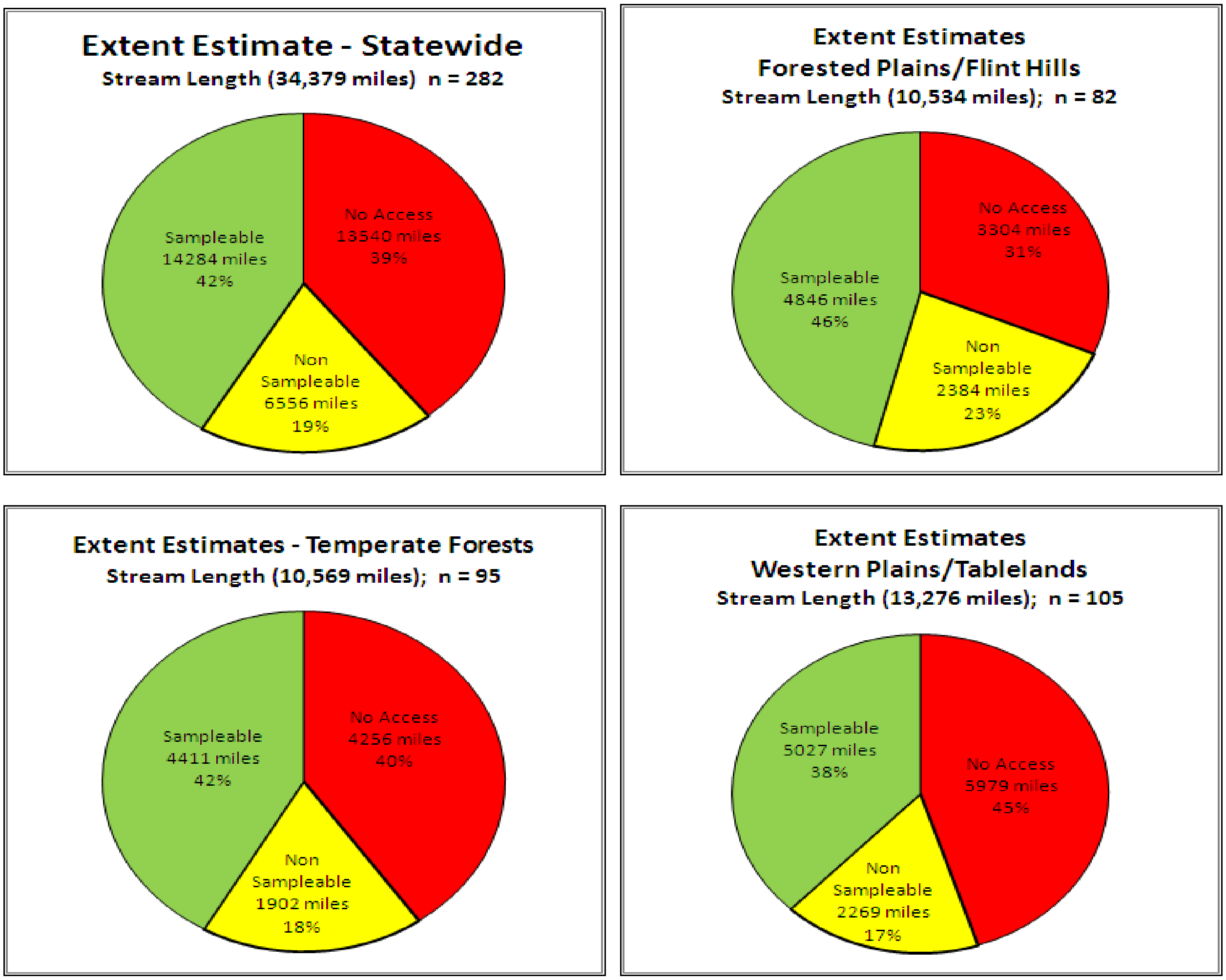



**Table 5. Index of biological integrity used to calculate scores for Oklahoma's biocriteria.** Referenced figures may be found in OAC 785:15: Appendix C (OWRB, 2008b).

| Metric | Value | Scoring 5 | Scoring 3 | Scoring 1 | Score |
|---|---|---|---|---|---|
| Total # of species | | fig 1 | fig 1 | fig 1 | |
| Shannon's Diversity based upon numbers | | >2.50 | 2.49-1.50 | <1.50 | |
| # of sunfish species | | >3 | 2 to 3 | <2 | |
| # of species comprising 75% of sample | | >5 | 3 to 4 | <3 | |
| Number of intolerant species | | fig 2 | fig 2 | fig 2 | |
| Percentage of tolerant species | | fig 3 | fig 3 | fig 3 | |
| TOTAL SCORE FOR SAMPLE COMPOSITION | | | | | 0 |
| Percentage of lithophils | | >36 | 18 to 36 | <18 | |
| Percentage of DELT anomalies | | <0.1 | 0.1-1.3 | >1.3 | |
| Total individuals | | >200 | 75 to 200 | <75 | |
| TOTAL SCORE FOR FISH CONDITION | | | | | 0 |
| TOTAL SCORE | | | | | 0 |

**Table 6. Metrics and scoring criteria used in the calculation of OCC's index of biological integrity (OCC, 2008).**

| Metrics | 5 | 3 | 1 |
|---|---|---|---|
| Number of species | >67% | 33-67% | <33% |
| Number of sensitive benthic species | >67% | 33-67% | <33% |
| Number of sunfish species | >67% | 33-67% | <33% |
| Number of intolerant species | >67% | 33-67% | <33% |
| Proportion tolerant individuals | <10% | 10-25% | >25% |
| Proportion insectivorous cyprinid individuals | >45% | 20-45% | <20% |
| Proportion individuals as lithophilic spawners | >36% | 18-36% | <18% |

**Table 7. Integrity classification scores and descriptions used with OCC's index of biological integrity (OCC, 2008).**

| % Comparison to the Reference Score | Integrity Class | Characteristics |
|---|---|---|
| >97% | Excellent | Comparable to pristine conditions, exceptional species assemblage |
| 80 - 87% | Good | Decreased species richness, especially intolerant species |
| 67 - 73% | Fair | Intolerant and sensitive species rare or absent |
| 47 - 57% | Poor | Top carnivores and many expected species absent or rare; omnivores and tolerant species dominant |
| 26 - 37% | Very Poor | Few species and individuals present; tolerant species dominant; diseased fish frequent |

Fish taxonomic results for each site were analyzed to produce a raw score for the OKFIBI and a percent of reference score for the OCCFIBI. From these scores, biological integrity classifications were assigned, and condition estimates calculated for each of the four previously discussed geographical scales. The OKFIBI condition estimates are presented using the three classifications discussed previously as well as estimates for "no biocriteria". Biocriteria do not exist for certain Omernik Level III ecoregions, including the Flint Hills, High Plains, and Southwestern Tablelands. Likewise, the OCCFIBI condition estimates are presented using three classifications. For ease of reporting condition estimates, fair is reported as a class, while certain classes are grouped, including excellent/good and poor/very poor. Additionally, estimates are given at each geographic scale for the four sites where no collections were made, which is approximately 3% of the total stream miles. The OCCIBI also includes one "no collection" estimate for a site that did not have a valid reference location. Each IBI gives a somewhat different statewide estimate (Figure 6). For the sampled target population (14,284 stream miles), the OKFIBI estimates that fish condition is supported in 49% of the population, not supported in 7% of the population, and undetermined in 30% of the population. An additional 11% of the population is lacking adequate biocriteria to determine condition. For the same sampled population, the OCCFIBI estimates an excellent/good condition of 49% and a poor/very poor condition of 17%, similar to the OKFIBI support and non support statuses. However, an estimated 29% are in fair condition, which could be comparable to the undetermined status above. In the three regional areas, more divergent estimates are seen between the IBI's. For the OKFIBI, supporting condition is estimated in a population range of 42-58%, which closely encompasses the statewide estimate (Figures 6 and 7). Likewise, the Forested Plains/Flint Hills and Western Plains/Tablelands closely mirror the statewide non-supporting estimate at 10%, whereas the Temperate Forests are estimated to have only 1% of the population not-supporting fish biocriteria. Undetermined status resembles the statewide estimate with a condition estimate range of 27% in the Forested Plains/Flint Hills to 33% in the Western Plains/Tablelands. On the other hand, the regional OCCIBI estimates do not resemble the statewide estimates. Excellent/good estimates range from 28% of the sampled target population in the Forested Plains/Flint Hills to 75% in the Temperate Forests, while the Western Plains/Tablelands estimate of 48% does closely resemble the statewide result of 50%. The estimates of poor/very poor condition are highly variant with a statewide condition estimate of 17% for the sampled population and a regional range of 4-32%. Fair condition is also disparate amongst regions. The Temperate Forests and Western Plains/Tablelands estimate 13 and 20% respectively, of the population in fair condition. However, over half (54%) of the Forested Plains/Flint Hills is estimated in fair condition. The statewide estimate of sampled stream miles is far condition is 29%.

## Analysis of Macroinvertebrate Biological Condition

Macroinvertebrate data were analyzed using a Benthic-IBI (B-IBI) developed for Oklahoma benthic communities (OCC, 2005a) and commonly used by the OCC and OWRB Water Quality Divisions (OCC, 2008; OWRB, 2009a). The metrics and scoring criteria (Table 8) are taken from the original "Rapid Bioassessment Protocols for Use in Streams and Rivers" (Plafkin et al., 1989) with slight modifications to the EPT/Total and Shannon-Weaver tolerance metrics (OCC, 2008). Metrics were calculated by EcoAnalysts, Inc., and IBI calculations were made using the OWRB's "B-IBI Assessment Workbook", an automated calculator built by OWRB Staff in Microsoft Excel (OWRB, 2008a).

Calculation of the B-IBI is similar to the fish OCC-IBI discussed previously. Metric scores are calculated in two ways for both the test site and the composite reference metric values of high-quality streams in each ecoregion (OCC, 2008). Species richness (total and EPT) and modified HBI values are compared to the composite reference value to obtain a "percent of reference". A score of 6, 4, 2 or 0 is then given the site depending on the percentages outlined in Table 8, while the reference composite is given a default score of 6. Proportional metrics (% dominant 2 taxa and %EPT of total) as well as the Shannon-Weaver Diversity Index are scored by comparing the base metric score for both the test site and the reference composite to the percentile ranges given in Table 8. After all metrics are scored, total scores are calculated for the test and composite reference sites. The site final score is then compared to the composite reference final score and a percent of reference is obtained. The percent of reference is compared to the percentages in Table 9 and an integrity classification is assigned with scores falling between assessment ranges classified in the closest scoring group.

Macroinvertebrate taxonomic results for each site were analyzed to produce a percent of reference score for the OKBIBI. From these scores, biological integrity classifications were assigned, and condition estimates calculated for each of the four previously discussed geographical scales (Figure 8). The OKBIBI condition estimates for the target population (total sampled stream miles) are presented using three classifications discussed previously, non-impaired, slightly impaired, and moderately impaired. None of the target population was ranked as severely impaired. Additionally, nearly 5% of the population was not sampled and is represented at each geographic scale. The OKBIBI estimates that 49% of the population has a supporting macroinvertebrate condition and that 32% and 14% of the population is either slightly or moderately impaired, respectively. Population estimates for the three regional areas present a range around the statewide estimates.

**Figure 6. Fish condition estimated statewide and in the Temperate Forests region using the OKFIBI and OCCFIBI. (Label represents total sampled miles in particular category).**

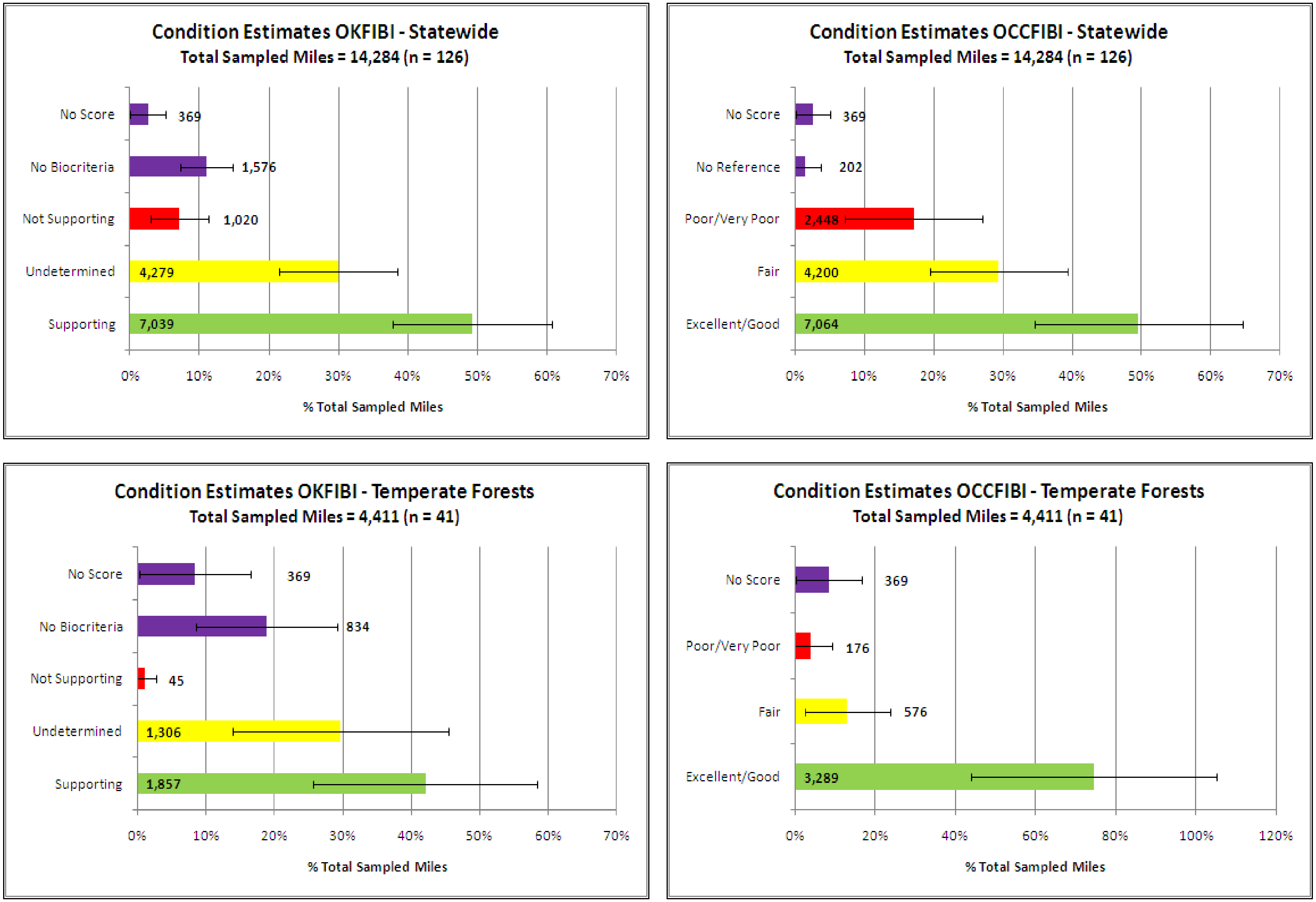
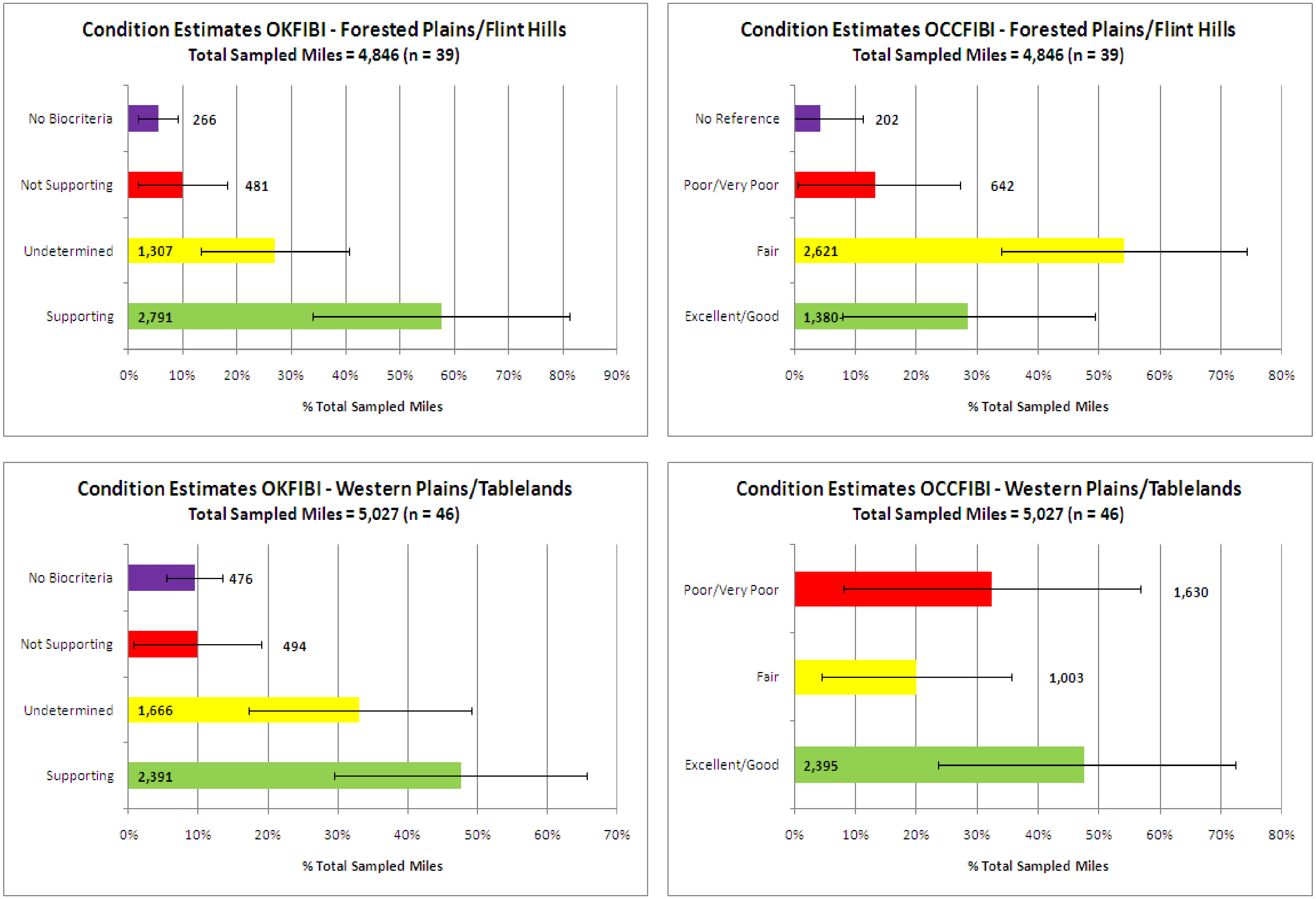


**Figure 7. Fish condition estimated in the Forested Plains/Flint Hills and Western Plains/Tablelands. (Label represents total sampled miles in particular category).**



Non-impaired condition estimates vary from 32% in the Forested Plains/Flint Hills to 67% in the Temperate Forests, while the 50% estimate for the Western Plains/Tablelands is nearly equivalent to the statewide estimate. Likewise, the slightly impaired condition varies drastically between geographical regions ranging from 12% of the population in the Temperate Forests to 48% in the Forested Plains/Flint Hills. The moderately impaired condition shows little variation ranging from 13-15% of the regional total stream miles.

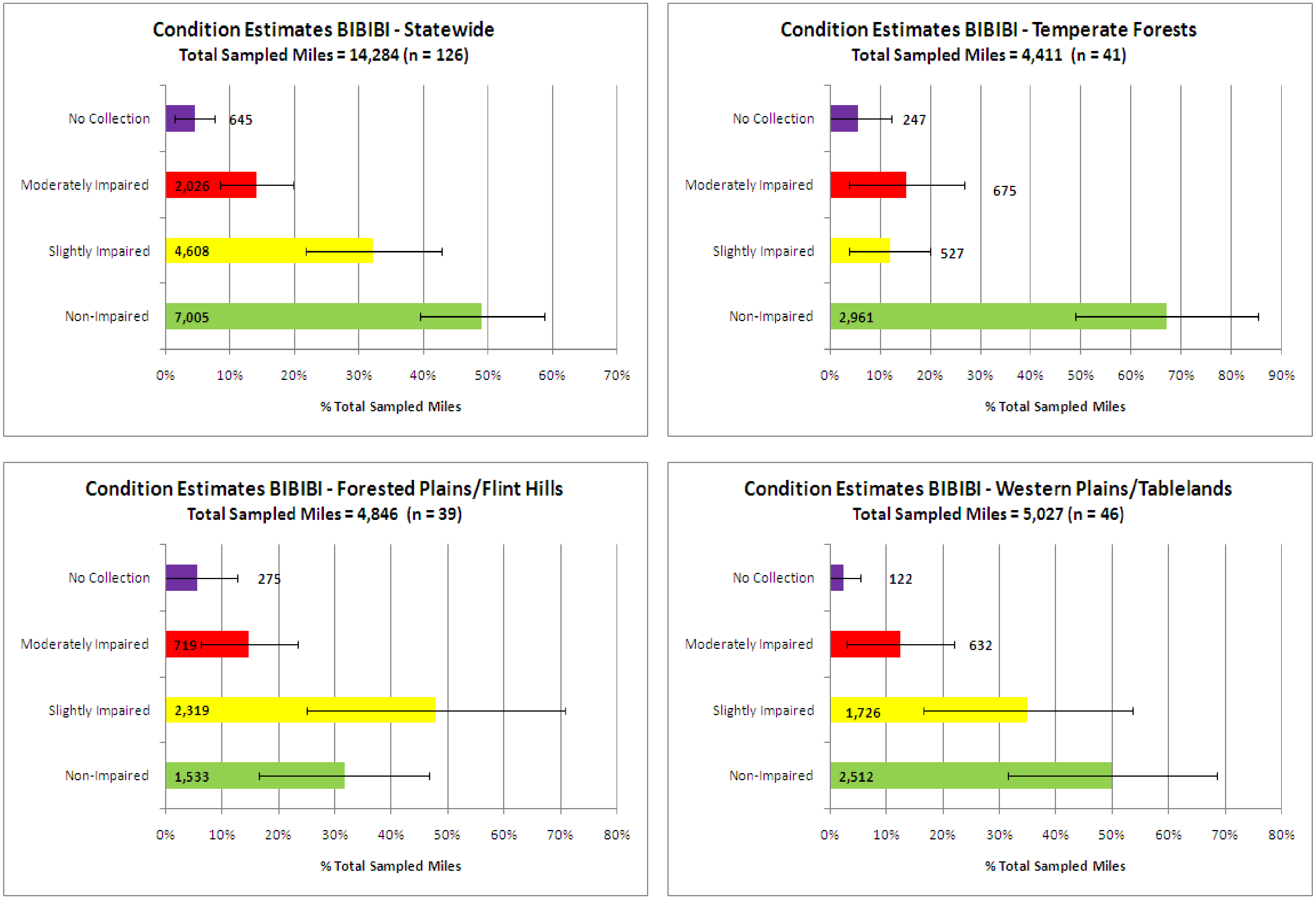
**Table 8. Metrics and scoring criteria used in the calculation of the B-IBI (OCC, 2008).**

| B-IBI Metrics | 6 | 4 | 2 | 0 |
|---|---|---|---|---|
| Taxa Richness | >80% | 60-80% | 40-60% | <40% |
| Modified HBI | >85% | 70-85% | 50-70% | <50% |
| EPT/Total | >30% | 20-30% | 10-20% | <10% |
| EPT Taxa | >90% | 80-90% | 70-80% | <70% |
| % Dominant 2 Taxa | <20% | 20-30% | 30-40% | >40% |
| Shannon-Weaver Diversity Index | >3.5 | 2.5-3.5 | 1.5-2.5 | <1.5 |

**Table 9. Integrity classification scores and descriptions used with the B-IBI (OCC, 2008).**

| % Comparison to the Reference Score | Biological Condition | Characteristics |
|---|---|---|
| >83% | Non-impaired | Comparable to the best situation expected in that ecoregion; balanced trophic and community structure for stream size |
| 54 - 79% | Slightly Impaired | Community structure and species richness less than expected; percent contribution of tolerant forms increased and loss of some intolerant species |
| 21 - 50% | Moderately Impaired | Fewer species due to loss of most intolerant forms; reduction in EPT index |
| <17% | Severely Impaired | Few species present; may have high densities of 1 or 2 taxa |

**Figure 8. Macroinvertebrate condition estimated Statewide and in the Temperate Forests, Forested Plains/Flint Hills, and Western Plains/Tablelands using OKBIBI. (Label represents total sampled miles in particular category).**



## Analysis of Algal Biomass

Algae are important in aquatic ecology acting as an important primary producer in aquatic food webs providing a food source for a wide variety of fish and macroinvertebrates. Furthermore, algae are indispensable producers of oxygen for aquatic organisms. However, algal blooms are also an important indicator of water quality perturbance and nutrient productivity. Introduction of nutrients to waterbodies occurs through a number of sources including runoff from urban and agricultural areas, wastewater treatment discharges, and a variety of other sources. As nutrient concentrations increase, uptake by primary producers increases and leads to algal blooms as well as an increased standing crop. As eutrophication happens, aquatic life and human health beneficial uses can become impaired as well as the aesthetic and recreational appeal of waterbodies being drastically reduced.

In order to quantify eutrophication, algal biomass was measured in both the benthic (i.e., periphyton) and water column (i.e., sestonic) areas of all study streams. Various measures exist to determine algal biomass including chlorophyll-a and ash free dry mass. For this study, chlorophyll-a concentrations were calculated because the OWQS (OWRB, 2008b) provides screening levels for both periphyton and sestonic chlorophyll-a. At each of the four geographical scales, the distributions are illustrated in boxplots for both periphyton and sestonic chlorophyll-a concentrations (Figure 9).

To estimate condition of algal biomass, chlorophyll-a concentrations were compared to multiple screening levels. For benthic chlorophyll-a, several screening levels were used. First, Oklahoma's Use Support Assessment Protocols (USAP) (OWRB, 2008b) provides a screening level for periphyton chlorophyll-a in the aesthetic beneficial use. A value of 100 mg/m$^2$ represents a nuisance level for periphyton algae (BenUSAPSL). Second, the OWRB has collected periphyton chlorophyll-a across the state for several programs throughout the years. To provide an alternate screening level, the 25$^{th}$ percentile of all OWRB benthic data was calculated at 45.7 mg/m$^2$ (BenP25). Similarly, three screening levels were established for sestonic chlorophyll-a. The Oklahoma Water Quality Standards (OWQS) includes a standard for sensitive water supplies of 10 mg/m$^3$ (SesChl10) of chlorophyll-a (OWRB, 2007a). Moreover, the USAP (OWRB, 2008b) provides a threshold trophic state index (TSI) of 62 under the aesthetics beneficial use. The threshold is based on chlorophyll-a concentration of 25 mg/m$^3$ (SesChl25). Last, as with benthic algae, the distribution of all OWRB sestonic chlorophyll-a data were considered as a screening level. The mean of all concentrations calculates at 19 mg/m$^3$ (SesChlMean).

Data from each site were compared to each screening level, and the results are presented in bar charts at each geographical scale for each screening level (Figure 10). For ease of viewing, benthic and sestonic values are grouped. Percentages represent the percent of the sites exceeding a particular screening limit, and estimates are not weighted. Included are estimates of the percentage of sites not exceeding any of the screening levels as well as an estimate of unassessed sites for benthic algae. For both benthic and sestonic populations, the greater majority of sites are not exceeding any screening limit, approximately 65-66% (+/-8%) statewide. Temperate Forests estimates exceed 80% (+/-14%), while in the Forested Plains/Flint Hills an estimated 81% of the sites do not exceed benthic screening limits. However, in the same region, more than an estimated 50% of the sites exceed some screening level. For the benthic population, the BenP25 is exceeded at a rate nearly twice that of the BenUSAPSL. The nuisance screening level is exceeded nearly 14% of the time statewide, but ranges broadly in areas across the state with estimates of only 3% in the Temperate Forests and 27% in the Western Plains/Tablelands. Similarly, the 25$^{th}$ percentile estimate shows extensive variation. At the statewide level, an estimated 29% of sites exceed, while 47% exceed in the Western Plains/Tablelands and 20% in the other two regions. For the sestonic screening limits, statewide estimated exceedances range from 15% (SesChl25) to 35% (SesChl10). The mean-based screening level estimates more closely favors SesChl25 (19%). The regional estimates vary somewhat. In the Forested Plains/Flint Hills, the SesChlMean and SesChl25 estimates are nearly identical to the statewide estimates, but the SesChl10 exceeds a 51% estimate. In the Western Plains/Tablelands, the divergence between the screening levels is similar to statewide estimates, but the percentages are 6-9% higher. Lastly, the Temperate Forests are the anomaly for sestonic estimates with screening levels at less than third of the statewide estimates.

**Figure 9. Boxplots depict distribution of benthic and sestonic chlorophyll-a at the statewide and regional scales.**

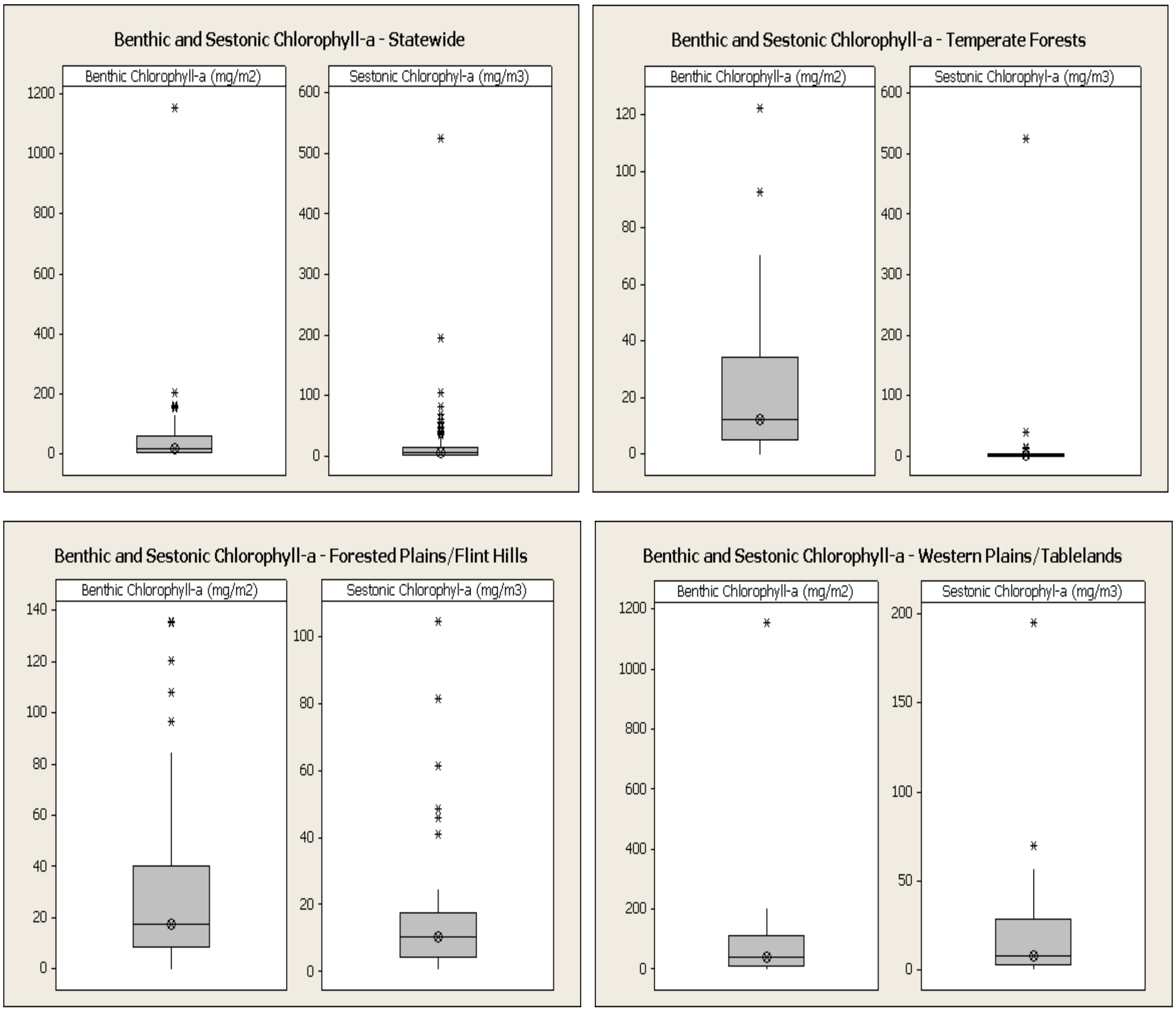
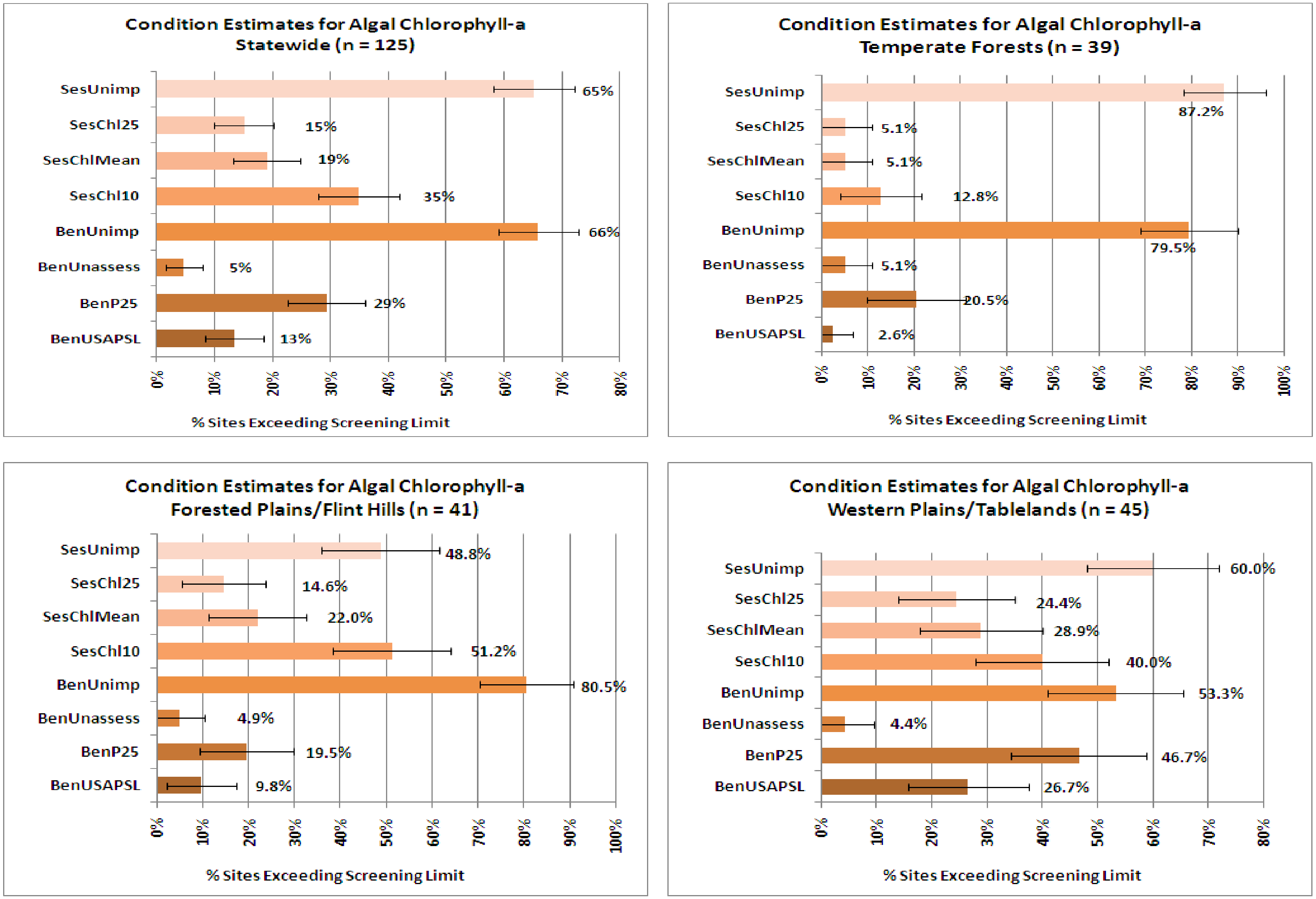


**Figure 10. Algal chlorophyll-a condition estimated for all geographic scales. Upper and lower bounds represent a 90% confidence interval. (Refer to Table 10 for stressor descriptions.)**

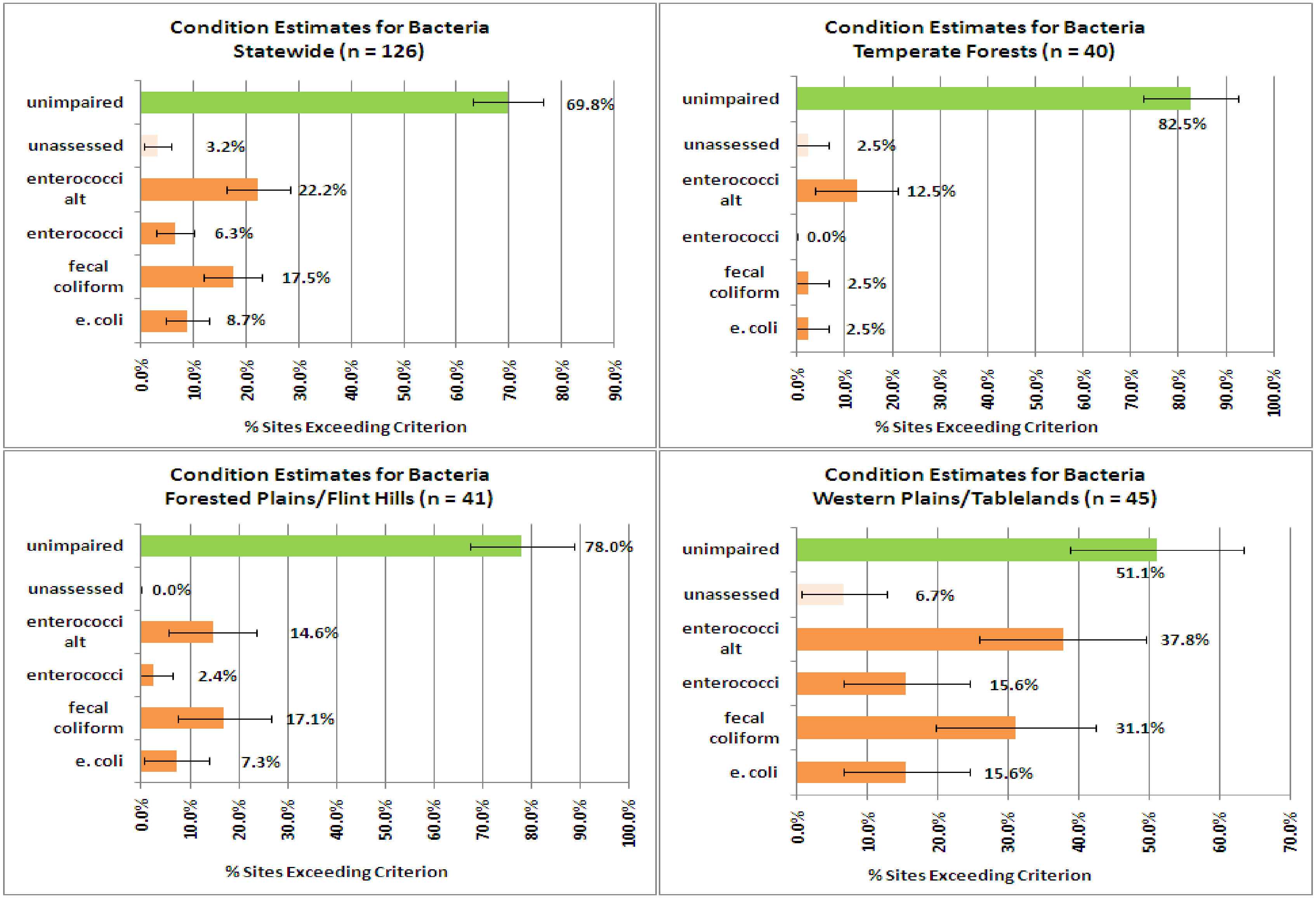


**Analysis of Bacteria**

Presence of indicator bacteria in rivers and streams is an important marker of potential human health impacts during recreational activities. Under the body contact recreation beneficial use, the OWQS (2007a) and USAP (OWRB, 2008b) provide criteria and screening levels for two indicator groups and one indicator organism. The screening levels represent single sample maximums and are assessed by comparison individual samples. Fecal coliform bacteria have both a standard and screening limit of 400 cfu/mL, while the *Escherichia coli* standard and screening limit are set at 406 cfu/mL. The second indicator group is enterococci, which have a screening level set at 406 cfu/mL and a single sample standard of 108 cfu/mL. Each indicator also has a geometric mean set in standards and USAP, however it is not applicable because of the nature of the dataset.

To create condition estimates, bacteria data were compared to the applicable screening limits, and for enterococci to the OWQS standard. (Figure 11). Estimates are based on percentages that represent the number of sites exceeding the applicable screening limit and are not weighted. Included are estimates of the percentage of the sites not exceeding the screening levels for any indicator bacteria as well as an estimate of the unassessed proportion of the population. The estimate for not exceeding any indicator screening level or standard is nearly 70% (+/-8%) statewide and approximately 80% (+/-14%) in the Forested Plains/Flint Hills and Temperate Forests regions. In contrast, the number of unimpaired waterbodies is only 51% for the Western Plains/Tablelands. Of the three indicators, *E. coli* shows the smallest estimate of impairment at 9% statewide, with an estimated high of 16% in the Western Plains/Tablelands and 3% in the Temperate Forests. Fecal coliform bacteria have a moderate impairment estimate of 18% statewide, with an estimated high of 31% in the Western Plains/Tablelands and 3% in the Temperate Forests. Enterococci have variable estimates depending on whether the screening limit or standard is applied. When the screening limit is used, the estimates are similar to the *E. coli* indicator and are generally smaller. For the Temperate Forests, no impairment exists, and in the Forested Plains/Flint Hills, only an estimated 2% of the population is impaired. On the contrary, when the enterococci standard is used, the highest estimates of impairment are generally seen. An estimated 22% of streams statewide are impaired, while in the Western Plains/Tablelands the estimate increases to 38% of streams. In the Temperate Forests, the estimate of 13% is relatively low in comparison to other areas, but the estimate is nearly five times that of any other indicator in the region. In only the Forested Plains/Flint Hills does the estimate (15%) rank below another indicator (Fecal Coliform = 17%).

**Figure 11. Bacteria condition estimated for all geographic scales. Enterococci alternate represents the water quality standard. Upper and lower bounds represent a 90% confidence interval.**



## Stressor Methodology

During each visit a number of physical and water quality parameters were collected. These included nutrients, *in situ* measurements, metals, and measures of salinity. Each of these may have some effect on the conditions analyzed in the previous results section. This effect can lead to decreased biological integrity (e.g., the effect of nutrients on fish condition) or may be responsible for the increase in a negative condition (e.g., the effect of total phosphorus on algal biomass concentration). Quantifying stressor extent is important for a variety of reasons including development and refinement of water quality screening levels and criteria, location of hotspots, and understanding the cause and effect relationship between stressors and indicators of biological integrity and human health concerns. The following analyses compare these parameters to a variety of criteria and screening levels. Weighted extent estimates of exceedances are then developed for the population. For each set of stressors, statewide extent estimates were developed as well as regional extent estimates for the Forested Plains/Flint Hills, Temperate Forests, and Western Plains/Tablelands regions. Stressor descriptions are given in Table 12.

## Analysis of Nutrient Stressors

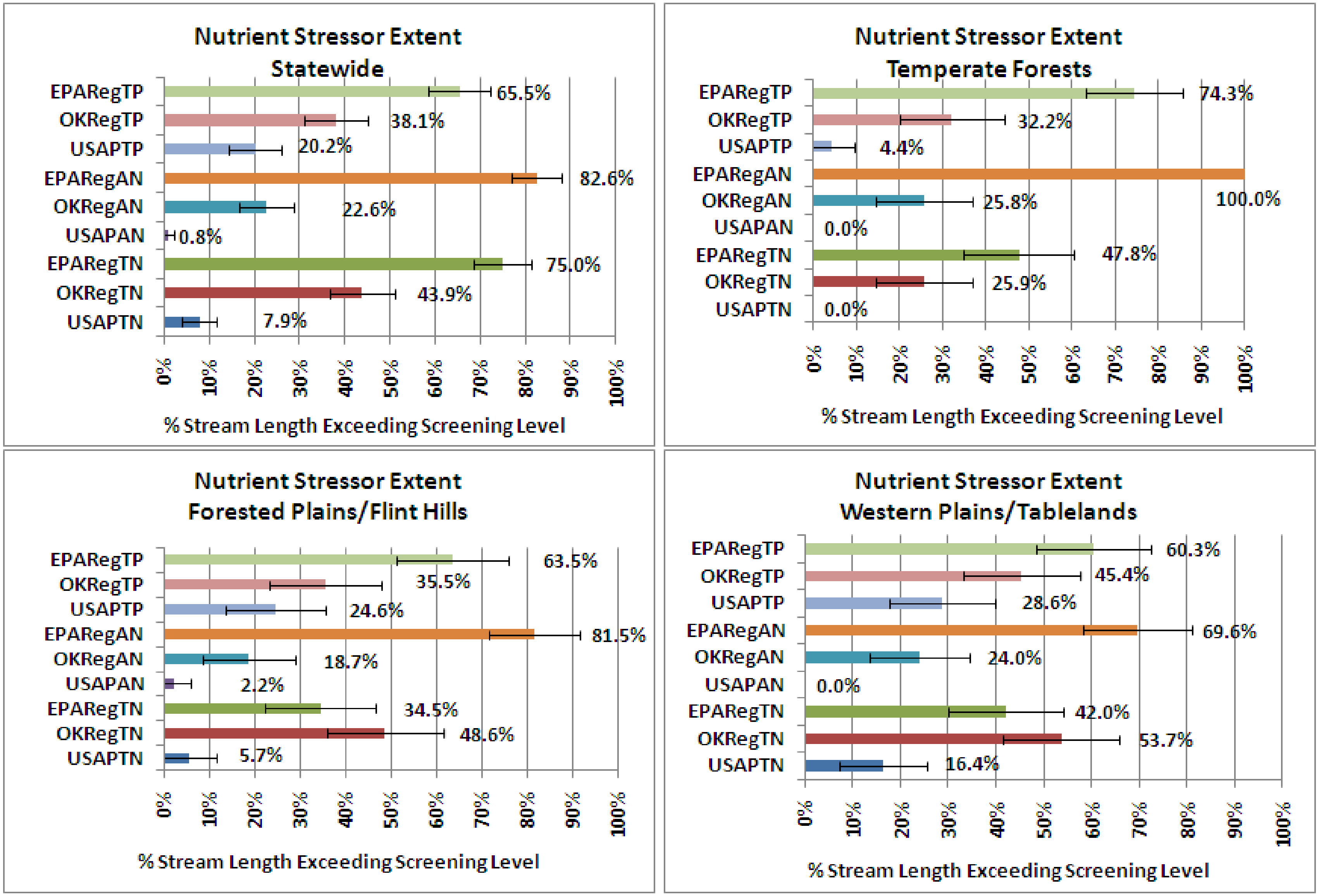
Nutrient stressors include measures of total phosphorus, total nitrogen (nitrate + nitrite + total Kjeldahl nitrogen), and available nitrogen (nitrate + nitrite + ammonia). For comparison, three sources were used to determine screening levels for each parameter giving a variety of nutrient levels based upon stream characteristics and/or regional variation (Table 12). Housed under the aesthetics beneficial use, the Oklahoma USAP has screening limits for both nitrogen and phosphorus, which are based upon Strahler order and gradient (OWRB, 2008b). Although the nitrogen limits are for nitrate/nitrite, the following analyses will use the screening levels to compare to total nitrogen and available nitrogen. Oklahoma regional nutrient screening levels were developed by the OCC (OCC, 2005b, 2006a, 2006b, 2007, 2008). They are Omernik Level III ecoregion specific and represent the mean of all data collected at high quality sites. They are also specific to warm water and cool water aquatic life tiers. USEPA regional nutrient criteria were also developed based on Omernik Level III ecoregions and represent the 25$^{th}$ percentile of data from a variety of sources (USEPA, 2000a, 2000b, 2001a, 2001b). However, the reports do not delineate criteria for the separate aquatic life tiers.

Weighted extents of all nutrient stressors are illustrated by bar graphs in Figure 12. Stressors were weighted using final weights given each site during calculation of extent and condition estimates. Weights are based upon an individual site's stream miles in relation to the sampled population. Three general patterns are noteworthy across all geographical scales. First, with the exception of total nitrogen, extent estimates increase in a consistent pattern for all test parameters. The USAP screening limits produce the smallest estimates of extent, while USEPA regional criteria the largest. In both the Forested Plains/Flint Hills and Western Plains/Tablelands, the OKRegTN has the highest extent estimates for the parameter group. Second, nearly all Oklahoma regional screening limits and USEPA regional criteria as well as the USAP total phosphorus screening limit are consistently estimated above 20%. Exceptions to this include OKRegAN in the Forested Plains/Flint Hills (19%) and the USAPTP in the Temperate Forests. Conversely, the USAP nitrogen screening limit estimates are inordinately low at less than 10% for all estimates except the USAPTN in the Western Plains/Tablelands. Additionally, several stressors produce unrealistic 0% estimates. Third, USEPA regional criteria produce the only extent estimates greater than 50%, with the exception of OKRegTN in the Western Plains/Tablelands (54%). Furthermore, across all geographical scales, all EPARegTP and EPARegTN estimates are greater than 60% and 70%, respectively, and have highs in the Temperate Forests region of 74% (TP) and 100% (TN). On the whole, the Oklahoma regional criteria seem to represent the most reasonable estimates of extent for each parameter.

**Table 10. Descriptions of stressors affecting biological condition.**

| Stressor Description | Stressor (code) | Source |
|---|---|---|
| Total nitrogen SL housed in Oklahoma's USAP | USAPTN | OWRB |
| Total nitrogen SL based on regional high quality sites | OKRegTN | OCC |
| Total nitrogen SL based on USEPA's regional nutrient criteria development | EPARegTN | USEPA |
| Available nitrogen SL housed in Oklahoma's USAP | USAPAN | OWRB |
| Available nitrogen SL based on regional high quality sites | OKRegAN | OCC |
| Available nitrogen SL based on USEPA's regional nutrient criteria development | EPARegAN | USEPA |
| Total phosphorus SL housed in Oklahoma's USAP | USAPTP | OWRB |
| Total phosphorus SL based on regional high quality sites | OKRegTP | OCC |
| Total phosphorus SL based on USEPA's regional nutrient criteria development | EPARegTP | USEPA |
| Dissolved oxgyen SL housed in USAP and based on 1 mg/L excursion from OWQS | DO | OWRB |
| pH criteria housed in OWQS | pH | OWRB |
| Turbidity criteria housed in OWQS | Turb | OWRB |
| Water temperature criteria housed in OWQS | WTemp | OWRB |
| Conductivity SL based on regional OWRB historical data | OKRegCond | OWRB |
| Chloride criteria based on water quality management segments; housed in App F of OWQS | USAPCl | OWRB |
| Chloride SL based on regional high quality sites | OKRegCl | OCC |
| Sulfate criteria based on water quality management segments; housed in App F of OWQS | USAPSu | OWRB |
| Sulfate SL based on regional high quality sites | OKRegSu | OCC |
| TDS criteria based on water quality management segments; housed in App F of OWQS | USAPTDS | OWRB |
| Habitat total points scored from Oklahoma's Rapid Bioassessment Protocol (ORBP) | HTPts | OWRB/OCC |
| Percent loose bed substrate metric from ORBP and used in Sediment USAP by scoring against regional reference condition | %LBS | OWRB/OCC |
| Percent embeddedness metric from ORBP and used in Sediment USAP by scoring against regional reference condition | %Emb | OWRB/OCC |
| Percent deep pool metric from ORBP and used in Sediment USAP by scoring against regional reference condition | %DP | OWRB/OCC |
| Percent non-vegetated point bar metric from ORBP and used in Sediment USAP by scoring against regional reference condition | %NVPB | OWRB/OCC |
| Sediment assess. prot. based on 1 of 4 metrics deviating from reference; housed in USAP | USAPSed1 | OWRB/OCC |
| Sediment assess. prot. based on 2 of 4 metrics deviating from reference; housed in USAP | USAPSed2 | OWRB/OCC |
| Metals acute criteria for fish/wildlife prop. ben. use housed in App. G, Table 2 of OWQS | XxAcute | OWRB |
| Metals chronic criteria for fish/wildlife prop. ben. use housed in App. G, Table 2 of OWQS | XxChronic | OWRB |
| Metals criteria for public/private water supply ben. use housed in App. G, Table 2 of OWQS | XxPPWS | OWRB |
| Metals criteria for fish consumption-water column in App. G, Tab. 2 of OWQS | XxFCW | OWRB |

**Figure 12. Nutrient stressors extent estimated for all geographic scales. Upper and lower bounds represent a 90% confidence interval. (Refer to Table 10 for stressor descriptions.)**



**Analysis of General Water Quality Stressors**

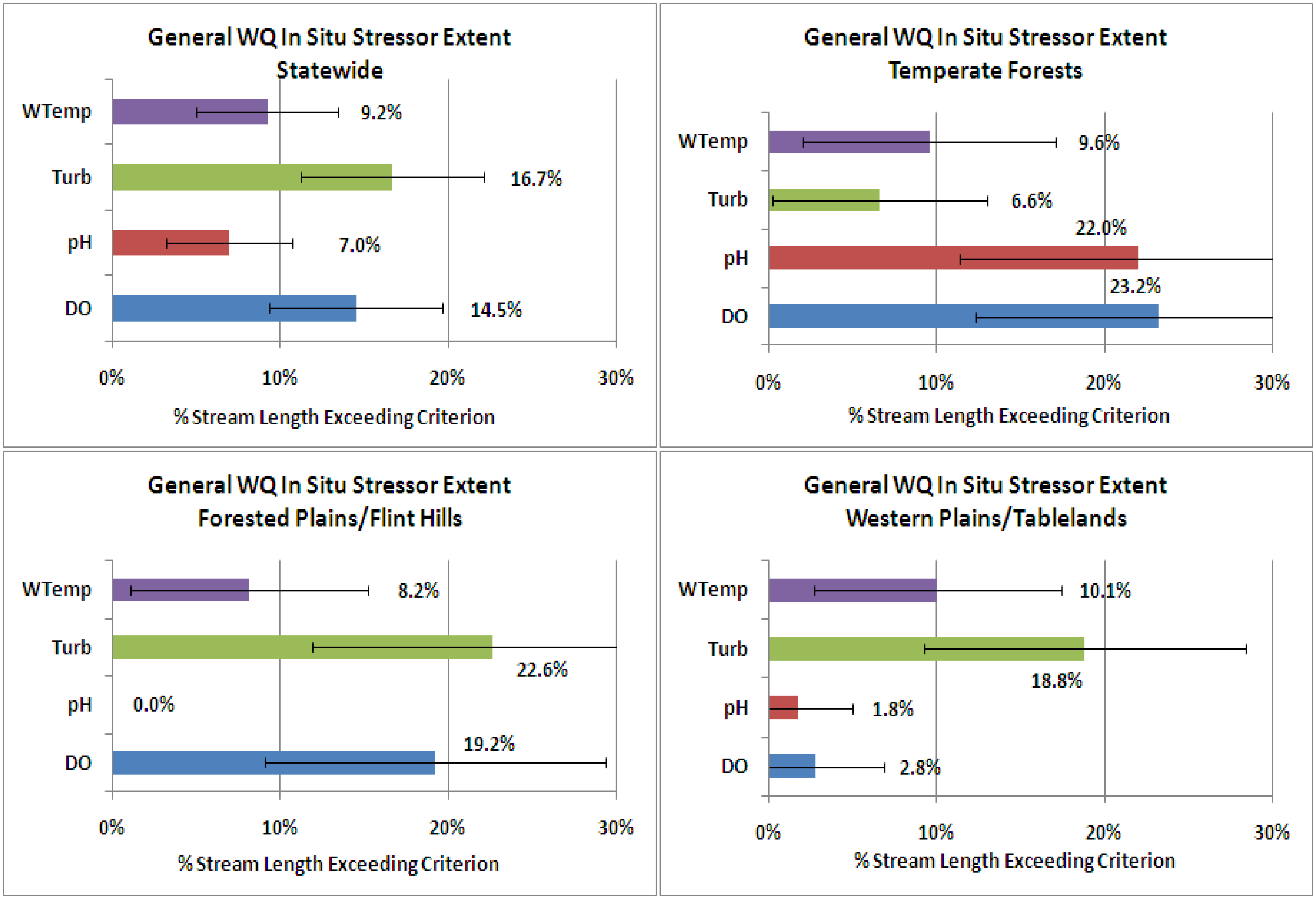
General water quality stressors represent a diverse group of parameters. For analysis purposes, the parameters will be discussed in two groups—*in situ* and salinity-related parameters (Table 12). The discussion of salinity-related parameters provides insight into both the extent of exceedances of sample standards housed in the agriculture beneficial use of the OWQS (OWRB, 2007a) as well as stressors that may affect biological condition.

*In situ* parameters include pH, dissolved oxygen, turbidity, and water temperature. Criteria for each of these are housed under the fish/wildlife propagation beneficial use of the OWQS (OWRB, 2007a), and protocols for assessment are included in Oklahoma's USAP (OWRB, 2008b). Because these criteria are commonly accepted for various aquatic life tiers, no regionally based criteria are included in this report. For pH, the OWQS gives a statewide range of 6.5-9.0 standard units statewide, but does allow for variance outside this range if due to naturally occurring conditions. Recently, a study published by the OWRB (2009a) determined pH values of less than 6.5 as being naturally occurring in three areas of the Ouachita Mountains level III ecoregion—the Little, Kiamichi, and Upper Mountain Fork River watersheds. Furthermore, evidence suggests that low levels of dissolved oxygen may be naturally occurring in the far eastern portion of the South Central Plains (OCC, 2009). Dissolved oxygen (DO) criteria are varied based on aquatic life tiers and time of year. Screening levels housed in the USAP are based on a 1 mg/L excursion from criteria. With the lower value being applicable during warmer months, warm water communities vary between 4 and 5 mg/L, cool water communities between 5 and 6 mg/L, and habitat limited communities between 3 and 4 mg/L. Turbidity and water temperature criteria are based upon aquatic life tiers. The criteria are 50 NTU and 32.2 $^{o}$C for warm water and habitat limited communities and 10 NTU and 29.8$^{o}$C for cool water communities.

Population extents for the four *in situ* stressors are illustrated by bar graphs in Figure 14. Several notable patterns are detectable. First, turbidity and DO generally have the highest extent of criteria exceedance with statewide estimates of 17% and 15%, respectively. In the Forested Plains/Flint Hills, this pattern holds with estimates of 23% for turbidity and 19% for DO. In the other two regions, the pattern is the same for one of the two parameters, with DO at 23% in the Temperate Forests and Turbidity at 19% in the Western Plains/Tablelands. Second, pH extent is usually the lowest with nearly non-detectable levels and Western Plains/Tablelands (2%) and an estimate of 0% in the Forested Plains/Flint Hills, while statewide only 7% of the population are estimated to be outside the acceptable range of pH. The Temperate Forests have a comparatively high level of pH and DO exceedances (22-23%), but as discussed earlier, parts of this area are considered to have naturally occurring low pH levels and may have naturally occurring low DO. Lastly, water temperature extent estimates are consistently between 8-10% across all geographical levels.

Salinity-related parameters include conductivity, chloride, sulfate, and total dissolved solids (TDS). For comparison, two sources were used to determine criteria or screening levels for each parameter. Criteria for chloride (USAPCl), sulfate (USAPSu), and TDS (USAPTDS) are housed in Appendix F of OWQS (OWRB, 2007a), and protocols for assessment of the agriculture beneficial use are included in Oklahoma's USAP (OWRB, 2008b). They are based upon the 6-digit management segments, as defined in Appendix A of OWQS. Both yearly mean standards and sample standards were developed from data at one or more stations located in each 6-digit segment. Because the sample standard is compared to single samples as defined by the USAP, it is used to determine extent estimates. Given that Appendix F standards were developed for assessment of the agricultural beneficial use, screening levels were developed for this report based on OCC high quality site data (OCC, 2005a). Levels are based on Omernick Level III ecoregions and represent the 75$^{th}$ percentile of all data for conductivity (OKRegCond), chloride (OKRegCl), and sulfate (OKRegSu) (Table 11). Two ecoregions have alternate levels based on regional variation.

**Figure 13. General water quality (*in situ*) stressors extent estimated for all geographic scales. Upper and lower bounds represent a 90% confidence interval. (Refer to Table 10 for stressor descriptions.)**



Extent of the six salinity-related stressors is illustrated by bar graphs in Figure 13. A number of noteworthy trends are apparent. First, extent estimates based upon USAP standards are generally at or below 15%, except in the Western Plains/Tablelands. In this region noted for higher salinity, all USAP standards are at or near a 20% estimate. Second, regional screening levels are estimated to be much higher in relation to USAP standards. Compared to the USAPCl, the OKRegCl, estimates are six times higher statewide and nearly forty times higher in the Temperate Forests. Likewise, the OKRegSu estimates, when compared to the USAPSu, are four times higher statewide. In the Temperate Forests region, the USAPSu is never exceeded while the regional sulfate screening level has a 95% exceedance estimate. Similarly, the conductivity screening level estimates are consistently three to four times higher than the USAPTDS estimates. Third, OKRegCl estimates are higher than OKRegSu estimates, with the exception of the Temperate Forests. And last, conductivity and TDS estimates are consistent across all geographic scales.

**Table 11. Screening levels OKRegCond, OKRegCl, and OKRegSU based on The 75$^{th}$ percentile of OCC High Quality Data.**

| Omernick Level III Ecoregion Name | Conductivity (umhos/cm) | Chloride (mg/l) | Sulfate (mg/l) |
|---|---|---|---|
| Southwest Tablelands | 2298.0 | 147.3 | 882.5 |
| Central Great Plains | 2925.8 | 189.8 | 1424.9 |
| Central Great Plains-Broken Red Plains | 274.2 | 8.8 | 20.3 |
| Flint Hills | 451.7 | 11.0 | 21.2 |
| Cross Timbers | 547.0 | 47.0 | 27.0 |
| Cross Timbers-Arbuckle Uplift | 496.5 | 18.0 | 10.0 |
| South Central Plains | 178.0 | 9.5 | 10.5 |
| Ouachita Mountains | 63.6 | 6.0 | 6.2 |
| Arkansas Valley | 159.0 | 10.3 | 14.0 |
| Boston Mountains | 213.0 | 5.0 | 15.3 |
| Ozark Highlands | 286.0 | 10.0 | 7.5 |
| Central Irregular Plains | 461.7 | 28.5 | 88.4 |

**Analysis of Metal Stressors**

Numerical criteria for metals are housed in Appendix G, Table 2 of the OWQS (OWRB, 2007a). The OWQS provides criteria for a number of metals but only those listed in Table 10 are considered for this study. This discussion provides insight into stressors related to biological condition as well as those related human health beneficial uses—public/private water supply and fish consumption.

Extents of metals stressors related to biological condition are illustrated by bar graphs in Figure 15. Notably, only chronic lead, chronic and acute selenium, and chronic and acute zinc exceed their respective criteria and generally less than 6% of the time. Acute and chronic zinc criteria as well as acute selenium criteria are only exceeded once at different sites in the Western Plains/Tablelands. Chronic selenium and lead criteria are exceeded at six sites spread over the Forested Plains/Flint Hills and Western Plains/Tablelands. No metals exceed criteria in the Temperate Forests.

Extent of metals stressors related to human health criteria are illustrated by bar graphs in Figure 16. As was the case with biological condition, very few parameters show any exceedances of their respective criteria. The selenium public/private water supply is exceeded by only two sites, one each in the Forested Plains/Flint Hills and Western Plains/Tablelands. Similarly, the lead fish consumption-water is exceeded at four and two sites in the same regions, respectively. And, no metals exceed criteria in the Temperate Forests.

**Figure 14. General water quality (salinity-related) stressors extent estimated for all geographic scales. Upper and lower bounds represent a 90% confidence interval. (Refer to Table 10 for stressor descriptions.)**

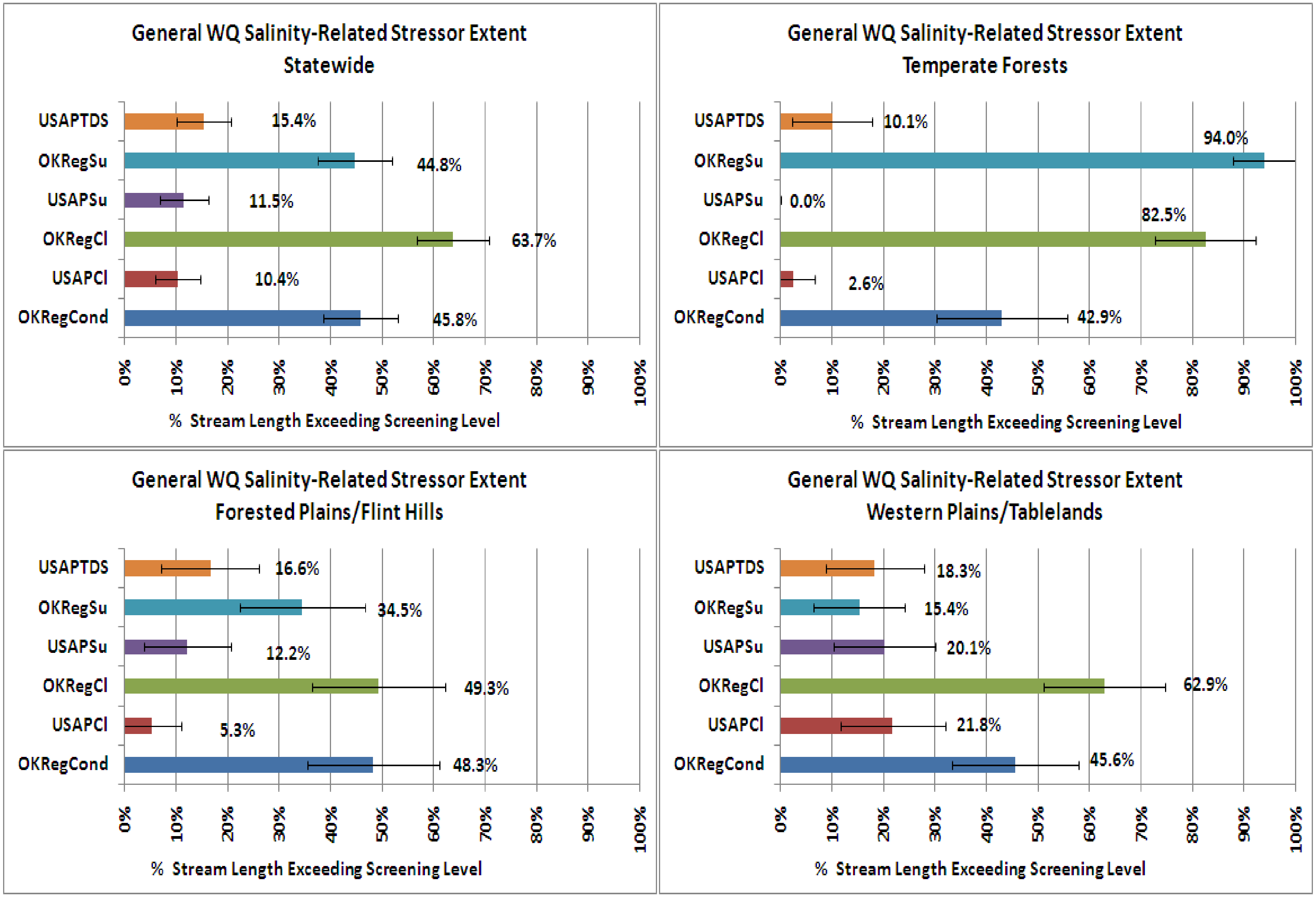


**Figure 15. Metal stressors related to biological condition with extent estimated for all geographic scales. (Refer to Table 10 for stressor descriptions.)**

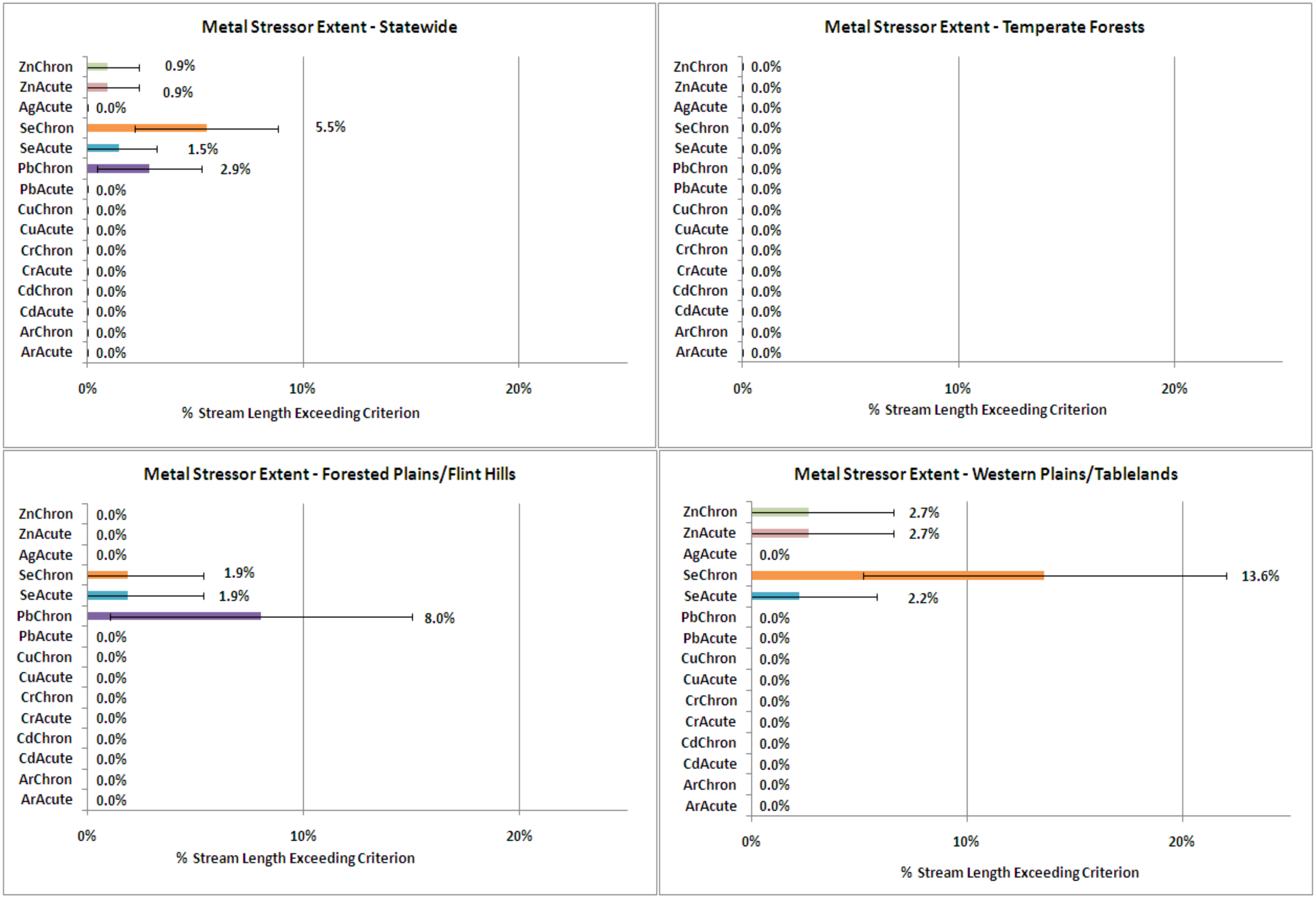
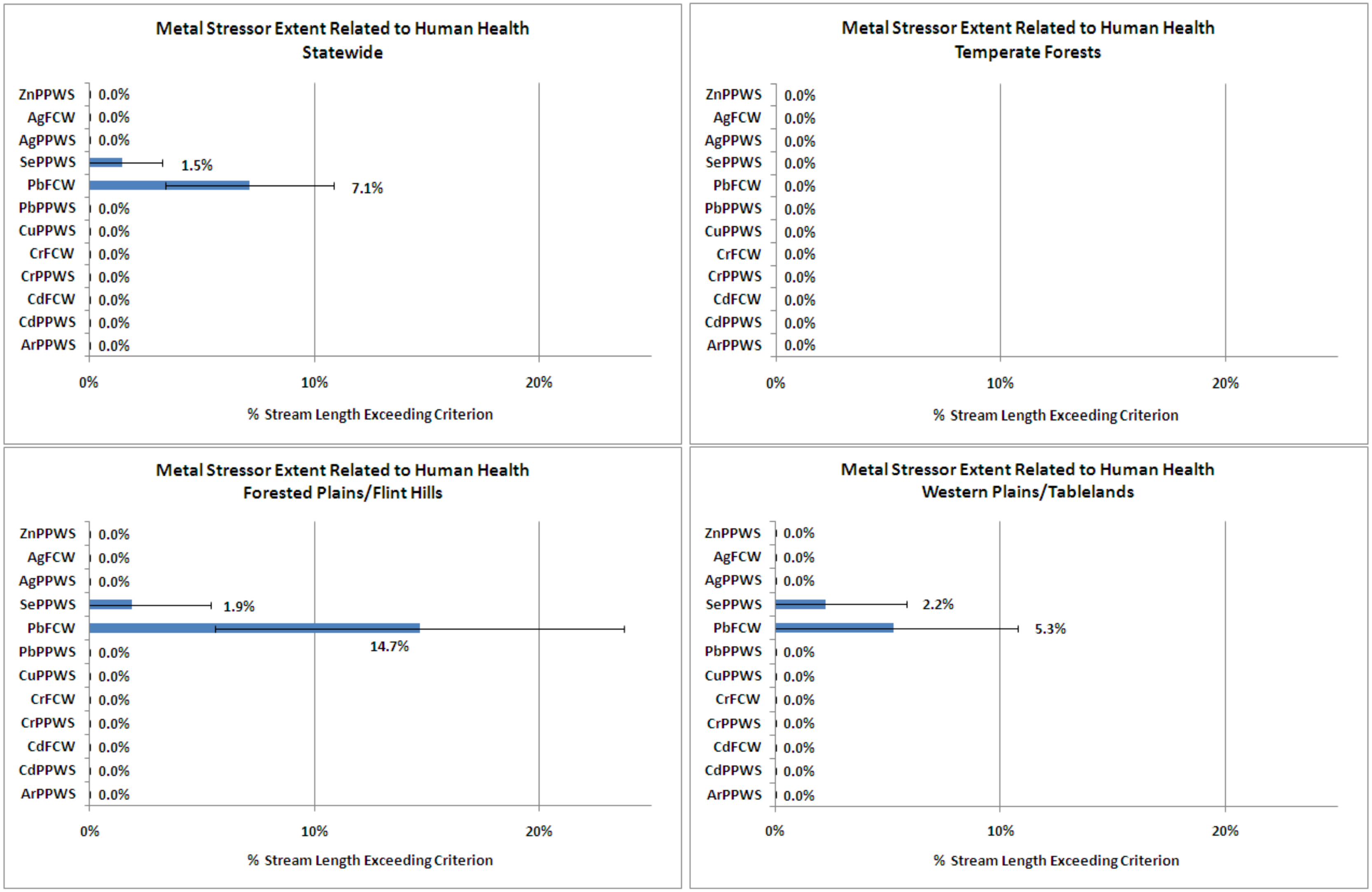


**Figure 16. Metal stressors related to human health with extent estimated for all geographic scales. (Refer to Table 10 for stressor descriptions.)**

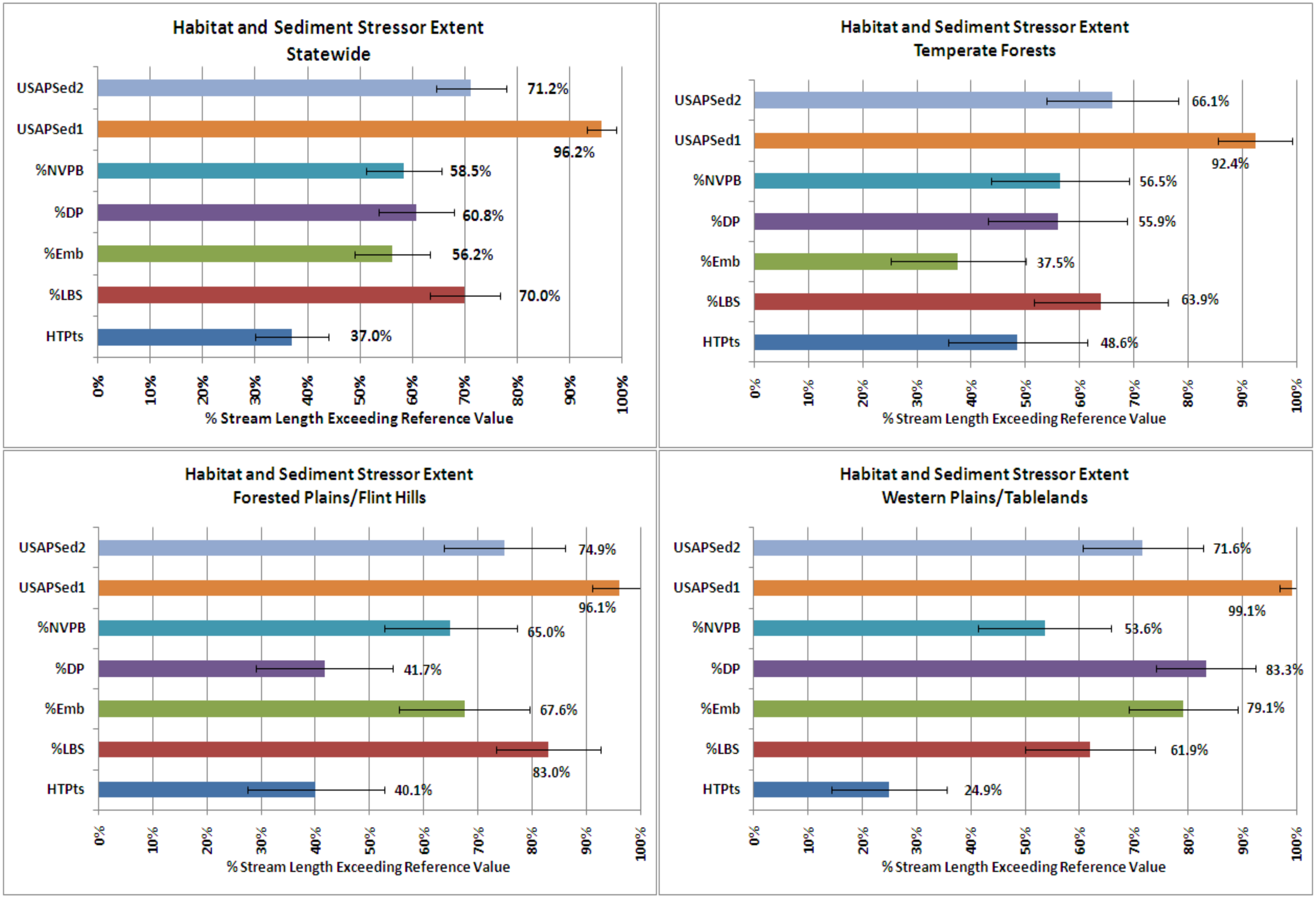


**Analysis of Habitat Stressors**

Habitat stressors include total habitat score, several individual habitat metrics, and an index for sedimentation (Table 10). Total habitat score (HTPts) was calculated for each site based on habitat metrics in Oklahoma's Rapid Bioassessment Protocol (OWRB, 1999, 2005b). The assessment consists of a variety of measures including flow, stream width and depth, substrates, embeddedness, habitat classification (i.e., pool, run, and riffle), fish cover, presence of point bars, erosion, and riparian structure. Metrics are scored based on predetermined ranges and a total score is obtained. Additionally several metrics used to calculate HTPts were included as stressors. Oklahoma's USAP (OWRB, 2008b) contains a protocol for determining sedimentation based upon loose bottom substrates (%LBS), embeddedness (%Emb), presence of deep pools (%DP), and presence of non-vegetated point bars (%NVPB). Screening levels for habitat scores and sedimentation metrics are determined by comparing final site scores to a percent of reference condition. The reference condition is derived from the habitat scores for ecoregionally based high quality sites developed by the OCC (2005a). For the most part, all high quality sites in a Omernik Level III ecoregion were used to develop reference condition. However, in certain ecoregions, some Omernik Level IV ecoregions were broken out from the whole. Omernik Level IV ecoregions used are the Broken Red Plains and Cross Timbers Transition of the Central Great Plains and the Arbuckle Uplift of the Cross Timbers. Additionally, the reference condition used is separated by aquatic life tier, and sites used to determine reference condition are required to be within 2 Strahler orders of the test stream. Finally, sedimentation is deemed to be impaired if one or more habitat metrics deviate from reference conditions. For this study, two additional stressors are included based upon sedimentation. The USAPSed1 and USAPSed2 are based upon 1 or 2 habitat metrics deviating from reference.

Extent of the seven habitat stressors are illustrated by bar graphs in Figure 17. Three general patterns are noteworthy. First, the score for total habitat points typically has the lowest estimated extent with all geographical scales scoring below 50%. Second, it is expected that USAPSed1 would have a greater extent estimate than USAPSed2. However, the ratio of extent estimates is consistent across all geographic scales, and the sedimentation extents are similar over the several geographic regions. This may validate the concept of using a combination of metrics to determine if sedimentation is impairing biological condition. Third, unlike other stressor groups, the individual habitat metrics influence each geographic region differently. In the Forested Plains/Flint Hills, %LBS has the largest deviation from reference (83%) and %DP the lowest (42%). Conversely, the Western Plains/Tablelands are most heavily influence by %DP (83%) and least by %NVPB (54%), with %LBS at a much lower extent (62%) than in the Forested Plains/Flint Hills. In the Temperate Forests, habitat metric extents generally score lower than in the other two regions. Within the region, there are similar extents for %NVPB (57%), %DP (56%), and %LBS (64%), with %Emb (38%) being much lower in extent than the other three metrics. Interestingly, the extent of total habitat score deviating from reference is the highest in the Temperate Forests, indicating that high quality sites in the region have exceptional habitat.

**Figure 17. Habitat and sediment stressors extent estimated for all geographic scales. Upper and lower bounds represent a 90% confidence interval. (Refer to Table 10 for stressor descriptions.)**



**Relative Risk Methodology**

The concept of using relative risk to develop a relationship between biological condition and stressor extent was developed initially for the USEPA's National Wadeable Streams Assessment (USEPA, 2006). Van Sickle et al. (2006) drew upon a practice commonly used in medical sciences to determine the relationship of a stressor (e.g., high cholesterol) to a medical condition (e.g., heart disease). The method calculates a ratio between the number of streams with poor biological condition/high stressor concentration and those with poor biological condition/low stressor concentration. If the ratio is above 1, it indicates that biological condition is likely affected by high stressor concentrations (i.e., concentrations above a preset level). As the ratio increases beyond 1, the relative risk of the stressor increases.

The following analyses include a comparison of a variety of stressors to biological conditions for fish, macroinvertebrates, and algal biomass. Additionally, relative risk is determined for each condition at each geographical scale. The analysis uses a binomial designation of good/poor for condition and high/low for stressor concentration. These binomial designations are then placed in a two-way contingency table to determine relative risk. Two initial ratios are determined. The ratio for poor condition given high stressor concentration is compared to the total number of sites having high stressor concentration, regardless of condition. Likewise, the ratio for poor condition given low stressor concentration is compared to the total number of sites having low stressor concentrations, regardless of condition. These two ratios are then used to calculate relative risk.

For the following analysis, relative risk results will be analyzed in several ways. First of all, significant relative risk will be determined by first determining if the resulting value is greater than one, and secondly, using a 90% confidence interval to establish significance. Although a 95% confidence level is generally more accepted, the 90% level is valid for water quality studies (Helsel an Hirsch, 1995) because data are affected by a variety of uncontrollable factors. Secondly, the magnitude of the upper confidence bound will be considered. The upper confidence bound increases as the number of sites with good condition and good water quality increase. Recognition of this is important to understanding the relationships of stressor extent to biological condition. Also, relative risks above 1 are often not significant when confidence intervals are applied. Considering the upper bound does not completely exclude certain hidden values that may exist in the analysis.

**Relative Risk to Fish Biological Condition**

To determine relative risk for fish biological condition, the OKFIBI and OCCFIBI were combined to produce a final fish condition classification of good or poor for all sites. This was necessitated because of the large number of sites (approximately 43%) that either have no biocriteria or have an undetermined support status using the OKFIBI. For the OCCFIBI, poor condition was set at a percent of reference score of 75, which is the breakpoint between the good and fair classification. The final breakdown was 92 sites ranked as good and 31 sites ranked as poor. To determine binomial condition, the following rules were used:

1. If the OKFIBI is supporting and the OCCFIBI final percent of reference score is greater than 74, then the site is considered "good";
2. If the OKFIBI is not supporting and the OCCFIBI final percent of reference score is less than 75, then the site is considered "poor";
3. If the OKFIBI is undetermined and the OCCFIBI final percent of reference score is greater than 74, then the site is considered "good";
4. If the OKFIBI is undetermined and the OCCFIBI final percent of reference score is less than 75, then the site is considered "poor"; and,

5. If the OKFIBI and OCCFIBI give disparate results, consideration is given to how close the numerical score was for each IBI was in relation to change of classification.

Statewide relative risk for nutrients, general water quality, and habitat/sediment are illustrated in Figure 18. For nutrients, the only significant risk is USAPTN which is likely to affect fish 2.5 times more when above the screening level. Several other risks exceed 1.0 but are not significant. On the whole, general water quality parameters demonstrate no significant risk to fish condition, although both turbidity and dissolved oxygen have relative risks above 1.0 with high upper confidence bounds. Likewise, no sediment or habitat stressor has significant associated risk. Notably, USAPSed1 (RR = 1.51) is not significantly related to fish condition but has an extremely high upper confidence bound of nearly 7.0.

Relative risk of stressors to fish condition in the Temperate Forests region is illustrated in Figure 19. No stressor is linked significantly to fish condition. However, several parameters across all stressor groups have relative risks exceeding 1.0 associated with high upper confidence bounds. These include the nutrient stressors OKRegTN, OKRegTP, and EPARegTP. Sediment stressors with high confidence bounds are %DP and % Emb. Finally, a number of general water quality parameters have extremely high confidence bounds—DO, pH, OKRegCond, and OKRegSu.

Relative risk for nutrients, general water quality, and habitat/sediment for the Forested Plains/Flint Hills region are illustrated in Figure 20. Much like the Temperate Forests, nearly all stressors relationships are insignificant, except total habitat points. Fish condition is 3.7 times more likely to be affected when HTPts scores below the regional average. Insignificant stressors with noticeably high upper confidence bounds include USAPTN, %Emb, turbidity, and water temperature.

Relative risk in the Western Plains/Tablelands region is illustrated in Figure 21. Significant risk is associated with USAPTN, which is 2.18 times more likely to affect fish condition. The other two total nitrogen stressors are insignificant but have upper confidence bounds above 3.0 and relative risks above 1.5. Several general water quality stressors demonstrate significantly associated risk for decreased fish condition. High conductivity and dissolved oxygen are 2.2 and 2.3 times more likely to negatively affect fish condition. Finally, no sediment or habitat stressors are significant, but %LBS and %Emb display upper confidence bounds above 3.0 and have relative risks greater than 1.0.

**Figure 18. Relative risk of nutrient, general water quality, habitat, and sediment stressors affecting fish condition at statewide scale. Upper and lower bounds represent a 90% confidence interval. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

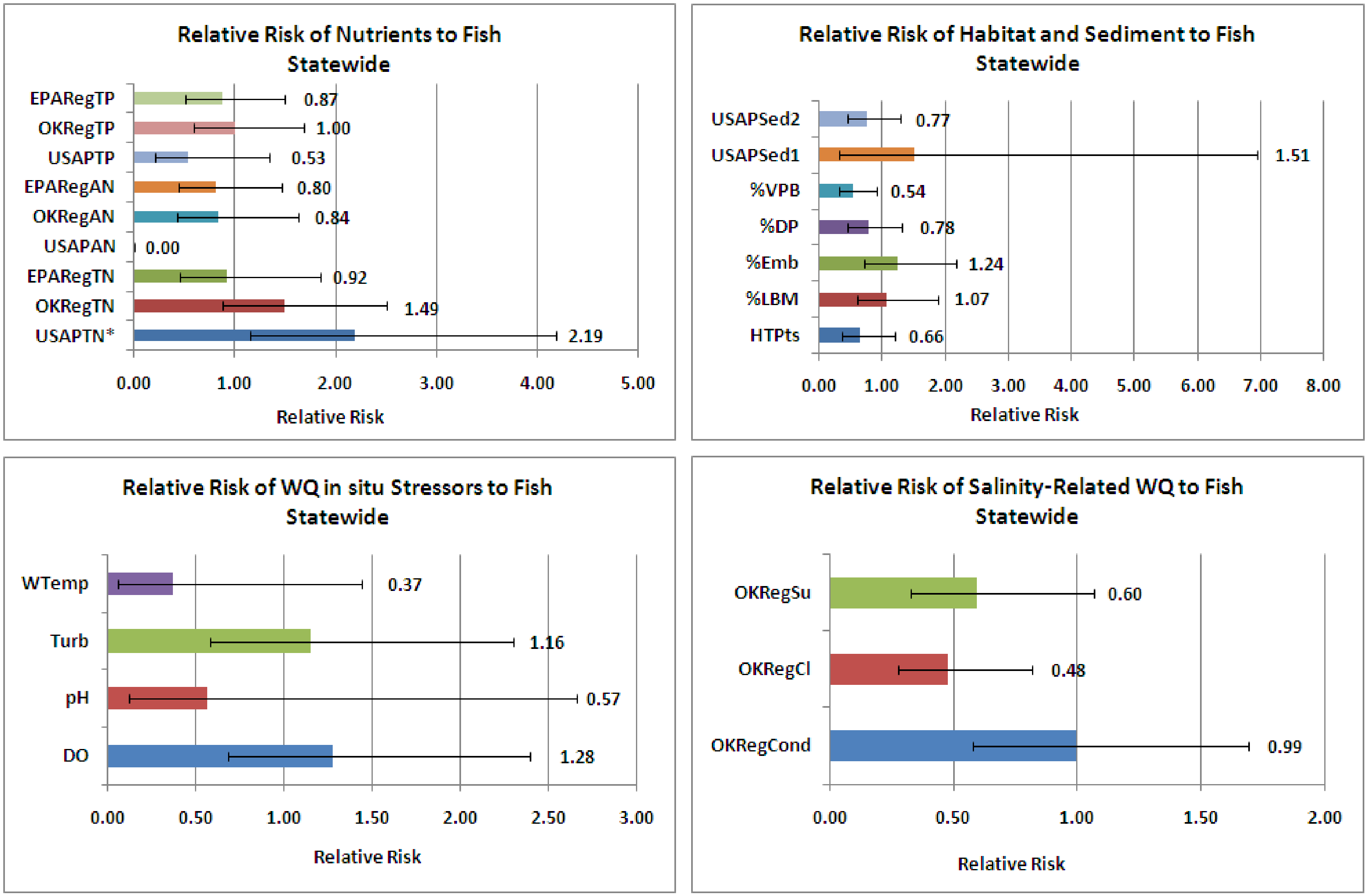


**Figure 19. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting fish condition in Temperate Forests region. Upper and lower bounds represent 90% confidence interval. Red values estimated. (No significant relative risk) (Refer to Table 10 for stressor descriptions.)**

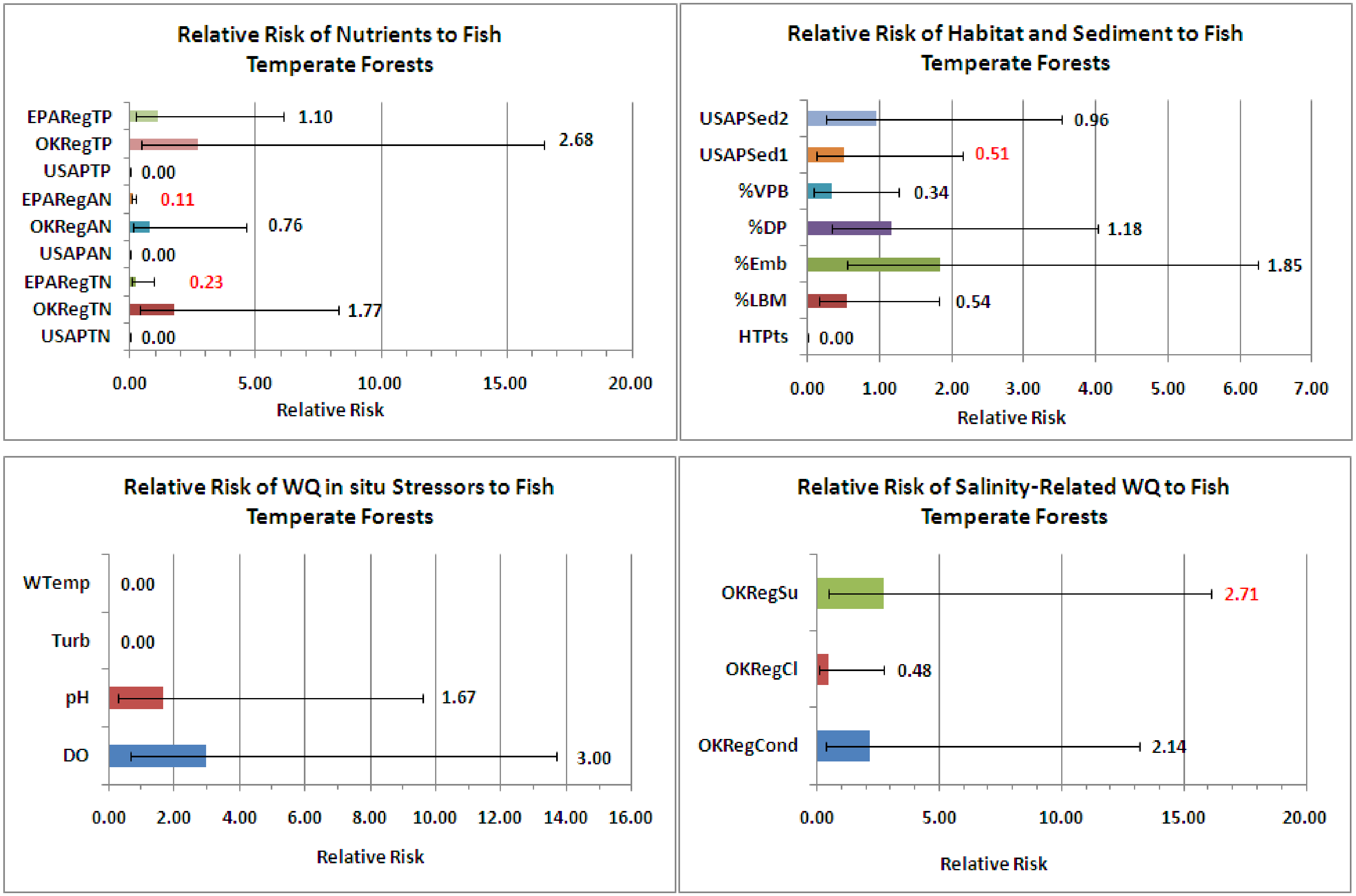


**Figure 20. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting fish condition in Forested Plains/Flint Hills region. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

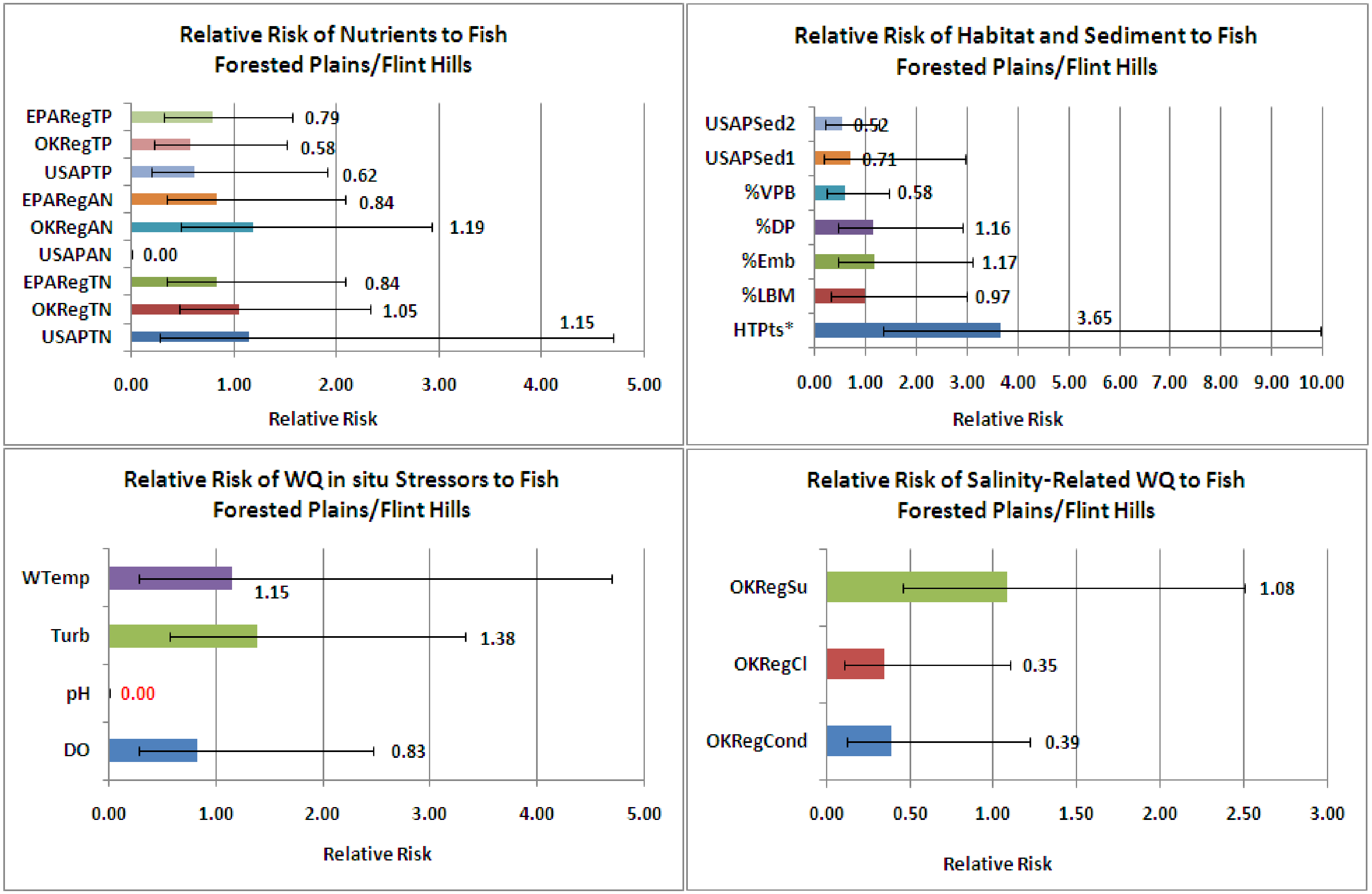
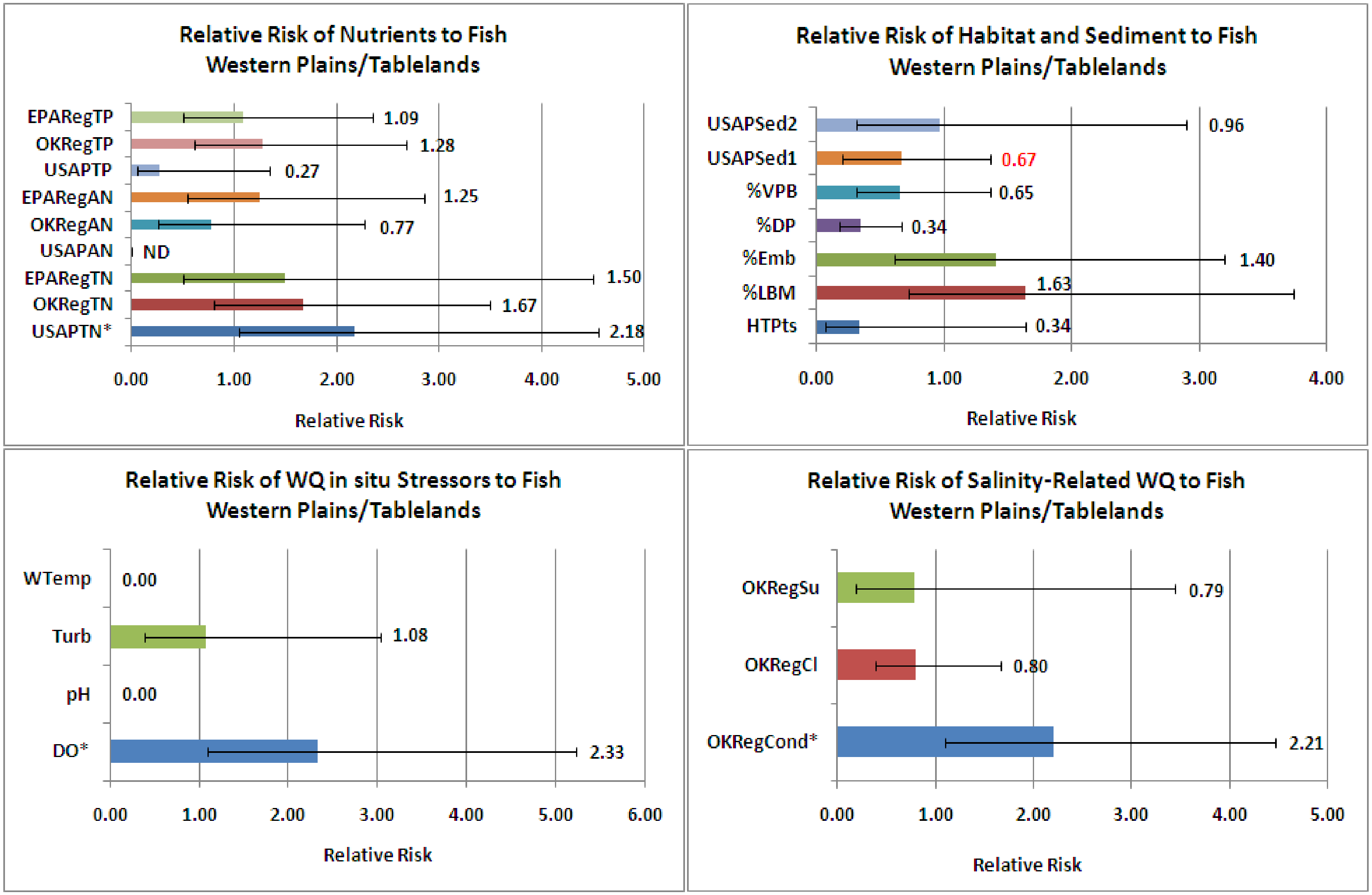


**Figure 21. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting fish condition in Western Plains/Tablelands. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at 0.90) (Refer to Table 10 for stressor descriptions.)**



## Relative Risk to Macroinvertebrate Biological Condition

As with fish, relative risk to macroinvertebrate condition is considered for a variety of stressors. To create a good/poor classification for macroinvertebrate condition, a percent of reference score of 75 was used. The final breakdown was 72 sites ranked as good and 46 sites ranked as poor. Also, the following analysis will be separated by geographical scale.

Statewide relative risk for nutrients, general water quality, and habitat/sediment are illustrated in Figure 22. In contrast to fish, many nutrient stressors may significantly affect macroinvertebrate condition. The OKRegTN and USAPTN stressors are 1.8 to 2.5 times more likely to lower condition, while the USAPAN is 2.6 times more likely to do the same. And, although the EPARegTN stressor is not significant, it does have a relative risk of 1.9 and a high upper confidence bound. Likewise, the OKRegTP and USAPTP stressors are 1.5 to 2.0 times more likely to significantly affect condition. Overall, general water quality parameters have low relative risks. However, low dissolved oxygen is 1.7 times more likely to significantly affect macroinvertebrate condition. No sediment or habitat stressor is significant, although USAPSed1 has a high upper confidence bound.

Stressor related risk in the Temperate Forests is graphically shown in Figure 23. Several general water quality parameters demonstrate significant associated risk. Macroinvertebrate condition is 9.3 times more likely to be affected when dissolved oxygen is below applicable screening levels. Likewise, high conductivity is 6.0 times more likely to lower condition. Additionally, each of the regional nutrient stressors developed from Oklahoma data, as well as chloride, have high upper confidence bounds even thought they carry no significantly associated risk to macroinvertebrate condition.

Relative risks in the Forested Plains/Flint Hills are given in Figure 24. Similar to the statewide nutrient risk assessment, all phosphorus and total nitrogen stressors as well as USAPAN carry significant risk to macroinvertebrate condition. Notably, EPARegTN is 5.9 times more likely to affect condition when above the prescribed ecoregion criteria. Other total nitrogen parameters carry associated risks of 1.7 to 2.1. Phosphorus levels above all three screening limits are 1.6 to 2.0 times more likely to significantly affect condition. Furthermore, when total habitat points are below regional reference score, condition is 2.5 times more likely to be significantly affected. And, although not significant, %LBS (RR = 3.2) and USAPSed1 (RR = 1.0) have high upper confidence bounds. No general water quality stressors have significant risk.

Lastly, stressor risk in the Western Plains/Tablelands are displayed in Figure 25. When above the screening limit, the USAPTN stressor is significant and 2.2 times more likely to result in poor macroinvertebrate condition. Except USAPAN, all other nutrient stressors have relative risks greater than 1.0 and upper confidence bounds approaching 3.0, but are not significant. Several general water quality parameters demonstrate significantly linked risk to condition, including pH (RR = 2.5), turbidity (RR = 1.8), and OKRegSu (RR = 2.0). Also, dissolved oxygen, though insignificant, has a relatively high upper confidence bound. No habitat stressors are significant. The two USAPSed stressors are also insignificant, but have high upper confidence bounds.

**Figure 22. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting macroinvertebrate condition statewide. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

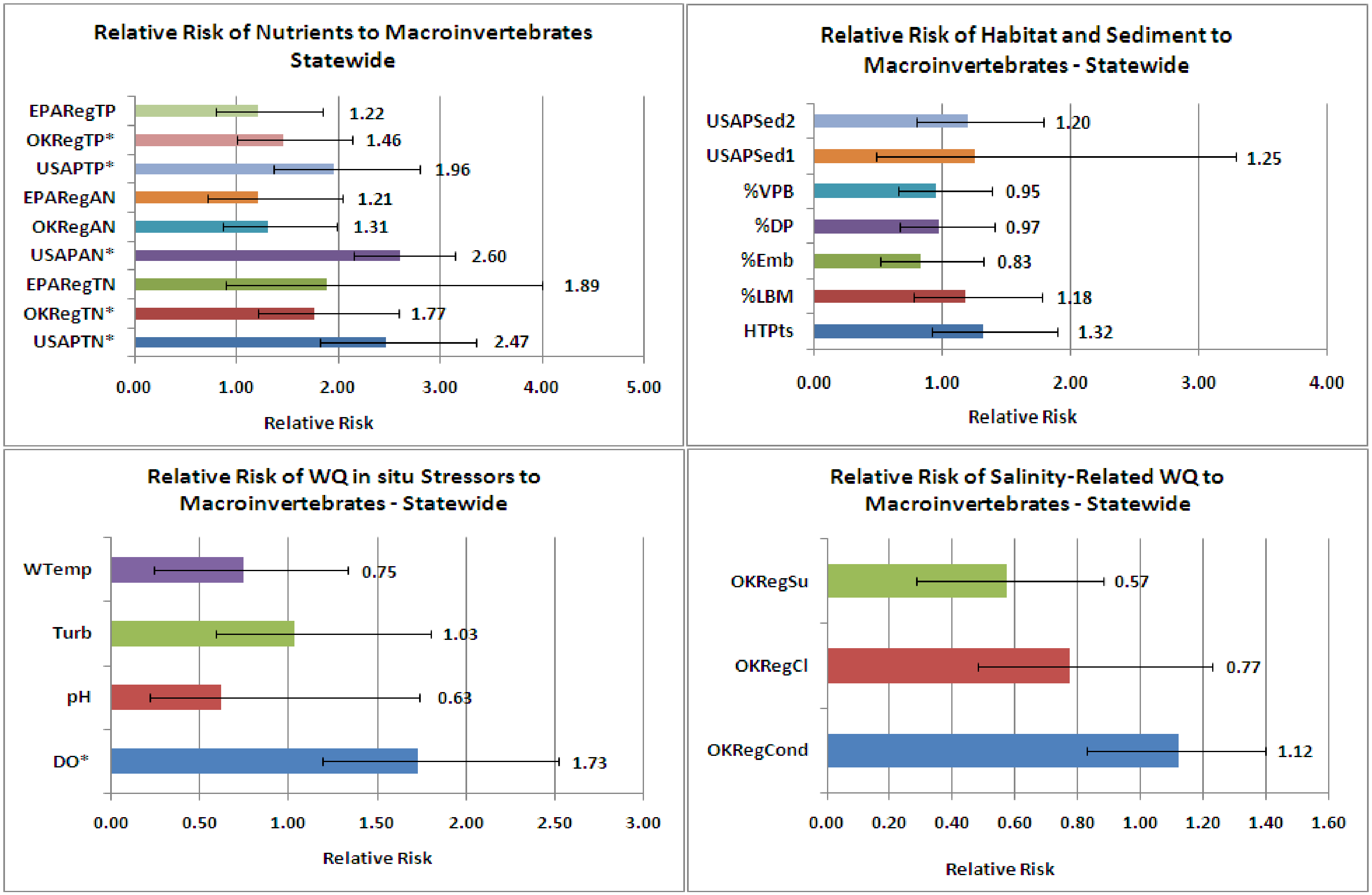


**Figure 23. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting macroinvertebrate condition in Temperate Forests. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at 0.90) (Refer to Table 10 for stressor descriptions.)**

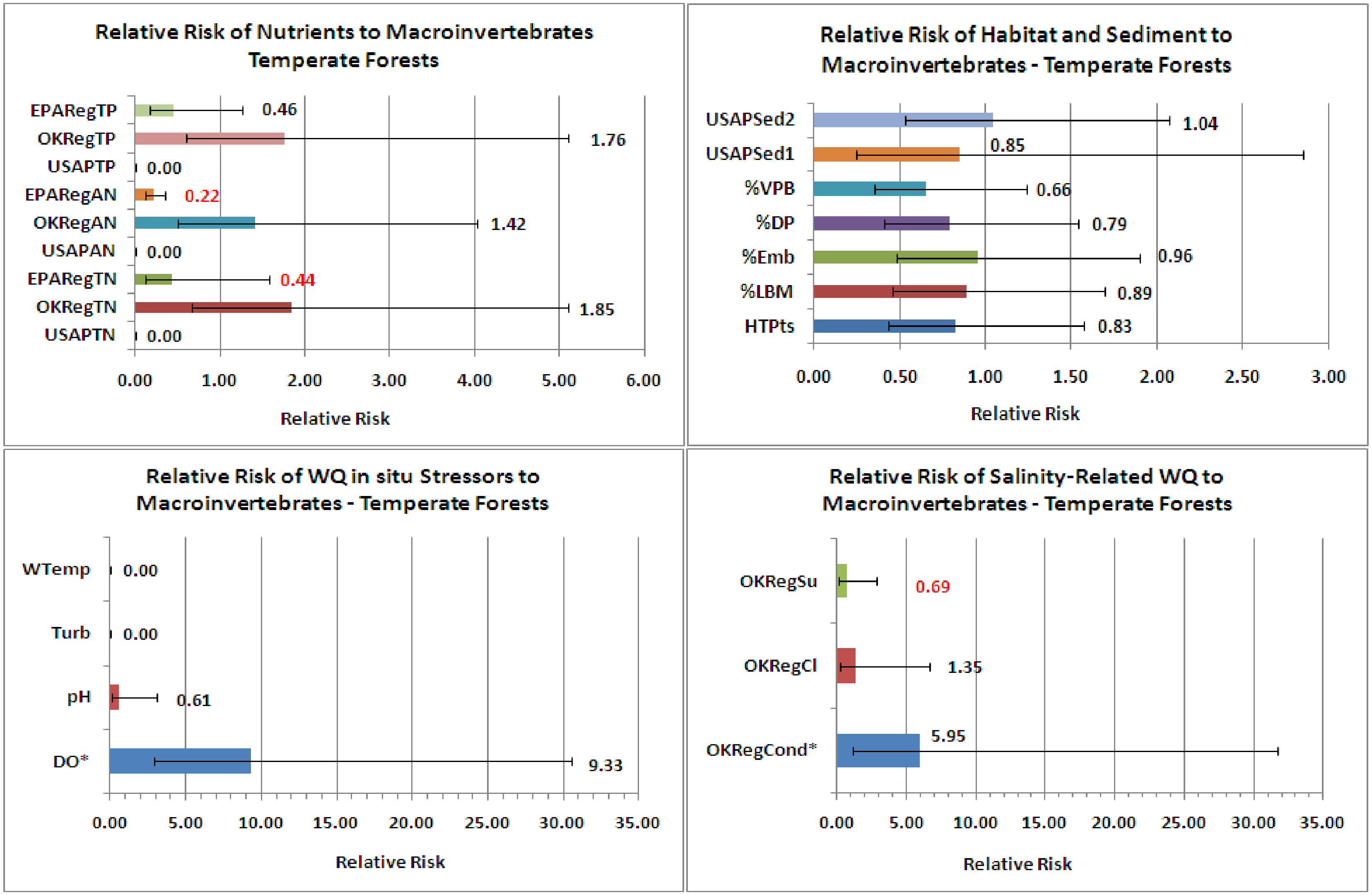


**Figure 24. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting macroinvertebrate condition in Forested Plains/Flint Hills. Upper/lower bounds represent 90% confidence interval. Red values estimated. (* = significant at 0.90) (Refer to Table 10 for stressor descriptions.)**

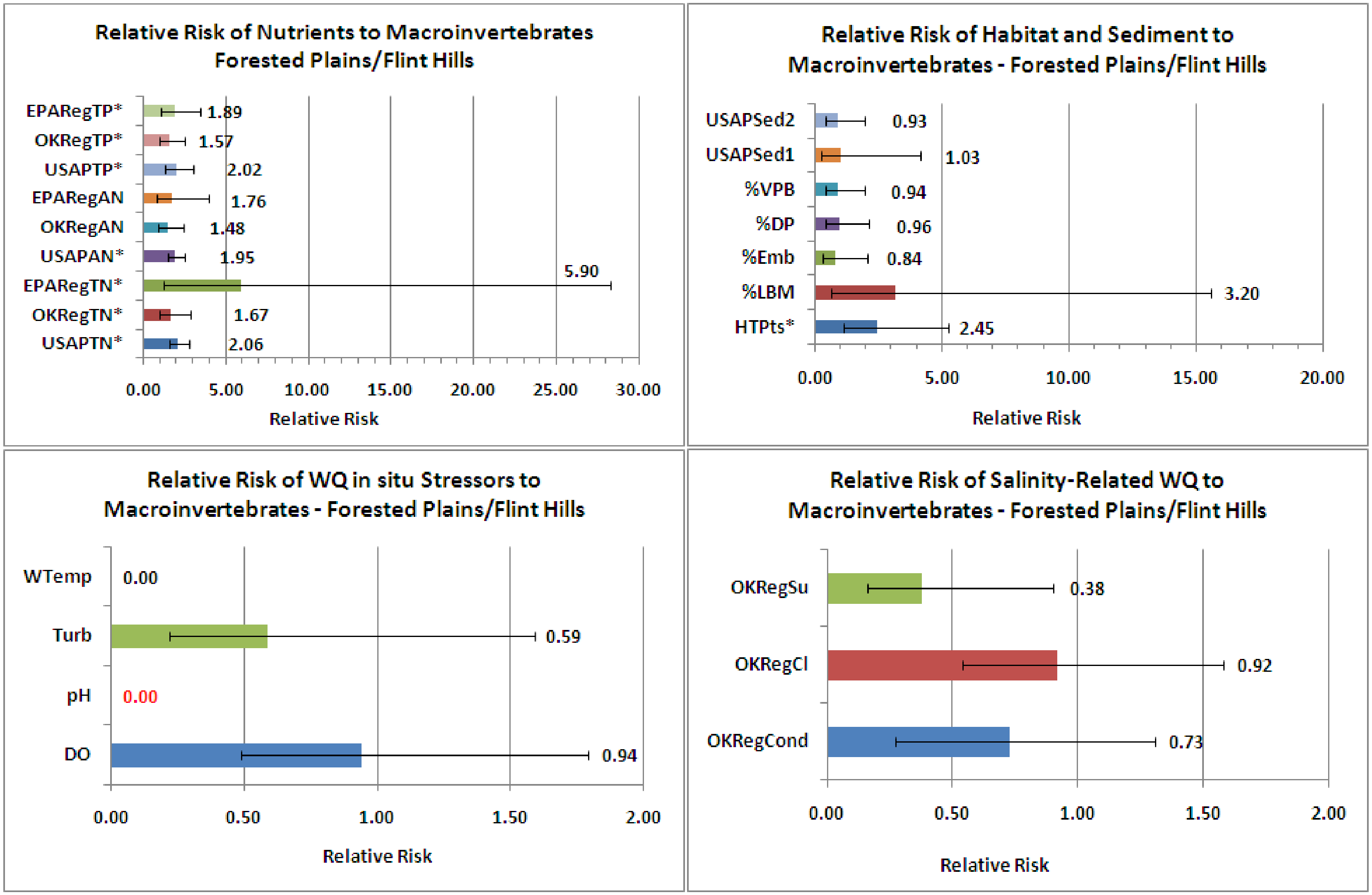
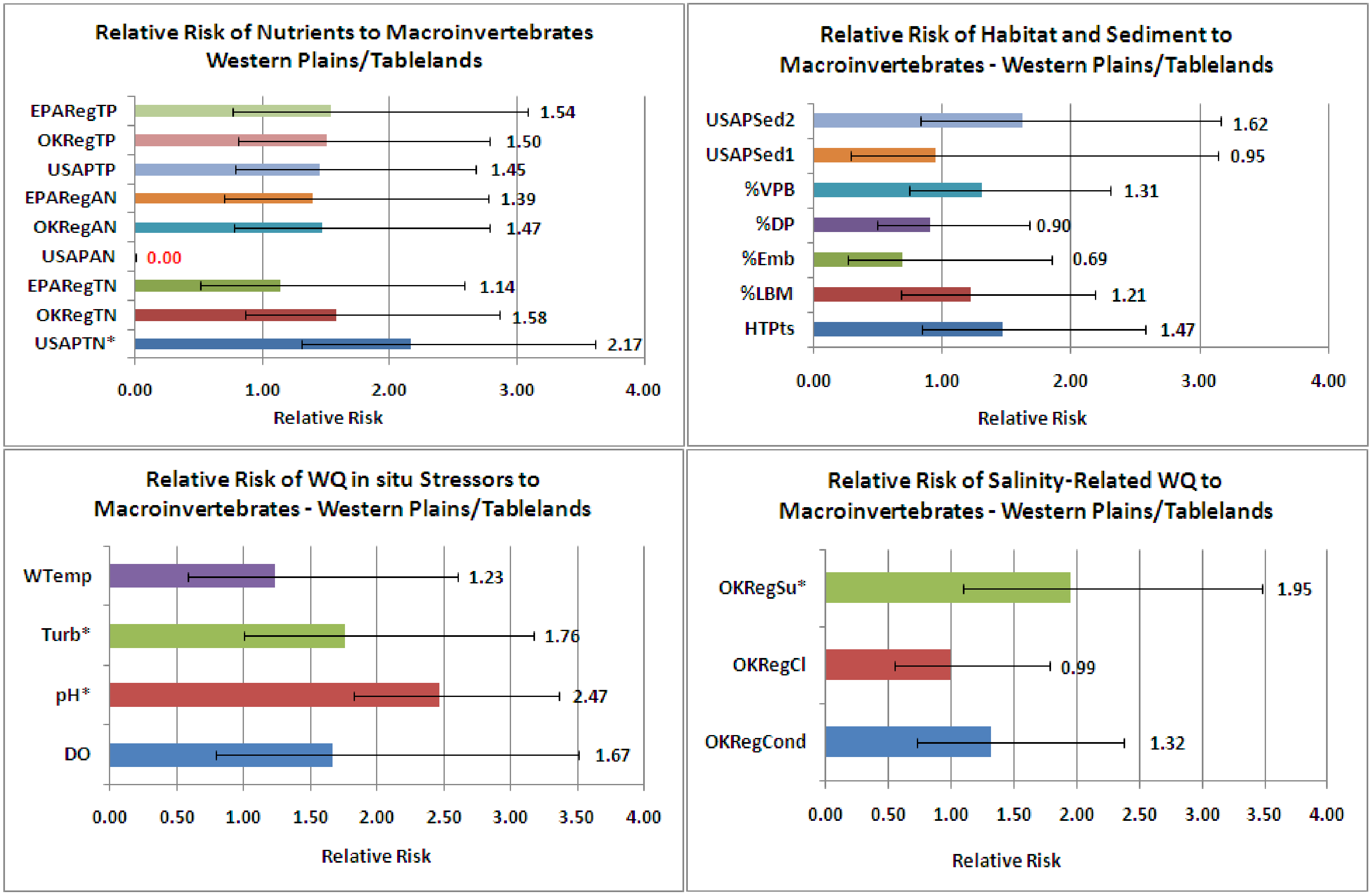


**Figure 25. Relative risk of nutrient, water quality, habitat, and sediment stressors affecting macroinvertebrate condition in Western Plains/Tablelands. Upper and lower bounds represent 90% CI. Red values estimated. (* = significant at 0.90) (Refer to Table 10 for stressor descriptions.)**



**Relative Risk to Algal Biomass**

Relative risk to both benthic and sestonic algal condition is considered for all nutrient stressors. Condition for algal biomass was based upon whether a particular sample was above or below a variety of screening levels. For benthic algae, these include the 100 mg/m$^2$ nuisance level found in Oklahoma's USAP and a screening level based on the 25$^{th}$ percentile of OWRB historical data (45.7 mg/m$^2$). The following analysis will be separated by geographical scale. For both the Temperate Forests and the Forested Plains/Flint Hills (Figures 26 and 27), no stressor significantly affected benthic algal biomass. A variety of parameters did show high upper confidence bounds.

Statewide relative risk to benthic algae is illustrated in Figure 26. For the BenP25 screening level, both the OKRegTP (RR= 1.7) and the EPARegTP (RR= 1.8) were significantly related to excessive benthic algal biomass. No other nutrient stressors using the 25$^{th}$ percentile or the USAP nuisance screening level as a condition significantly affected algal condition. However, several stressors returned relatively high upper confidence bounds. The BenUSAPSL was significantly affected by none of the stressors.

Lastly, stressor/benthic algal relationships for the Western Plains/Tablelands are displayed in Figure 27. Like the statewide results, the significant relationships are associated with 25$^{th}$ percentile condition. The condition is 1.7 to 2.5 times more likely to be above the screening level when phosphorus values exceed regional screening levels. Moreover, the 25$^{th}$ percentile of benthic algal data is 2.1 times more likely to be exceeded when the OKRegAN screening limit is high. No other stressors are significantly related to benthic algal condition in this region although several have high upper confidence bounds.

Sestonic algal relationships to stressors are illustrated in Figures 28-31. Unlike other condition versus stressor risk estimates, the majority of the relationships are significant across all screening levels. Furthermore, the pattern can be seen across all geographic scales except the Temperate Plains region (Figure 29). Many parameters across condition levels are at or near a value of 0 for relative risk. Interestingly, the Oklahoma regional stressors, although insignificant, have relatively high upper confidence bounds.

For statewide estimates (Figure 28), every total phosphorus stressor at each screening level is significantly related to excess sestonic algal growth, with relative risks as high as 9.1 for the SesChl25. Risk trends upward as the screening level increases with the lowest risks associated with SesChl10 (RR = 1.9 to 2.7) and the highest linked to SesChl25 (RR = 4.6 to 9.1). Likewise, at every screening level, two the total nitrogen parameters (USAPTN and OKRegTN) demonstrate significant risks to condition. Relative risks associated with total nitrogen vary with relative risk values ranging from 2.8 (USAPTN vs. SesChl10) to 22.9 (OKRegTN vs. SesChl25). Other notable values are 7.7 (EPARegTN vs. SesChl10), 6.8 (USAPTN vs. SesChl25, and 6.4 (OKRegTN vs. SesChlMean. Also, when trying to compare both stressor and algal condition level, there seems to be no clear pattern for total nitrogen, with the exception of the extremely high values associated with OKRegTN in relation to two algal conditions. All perform well as a predictor of risk at each level. Also, when available nitrogen exceeds the OKRegAN screening level, there is associated relative risk for increased sestonic algae at each condition level. Lastly, the USAPAN stressor scored 0 at each condition level.

**Figure 26. Relative risk of nutrient stressors affecting benthic algal condition Statewide and in the Temperate Forests region. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

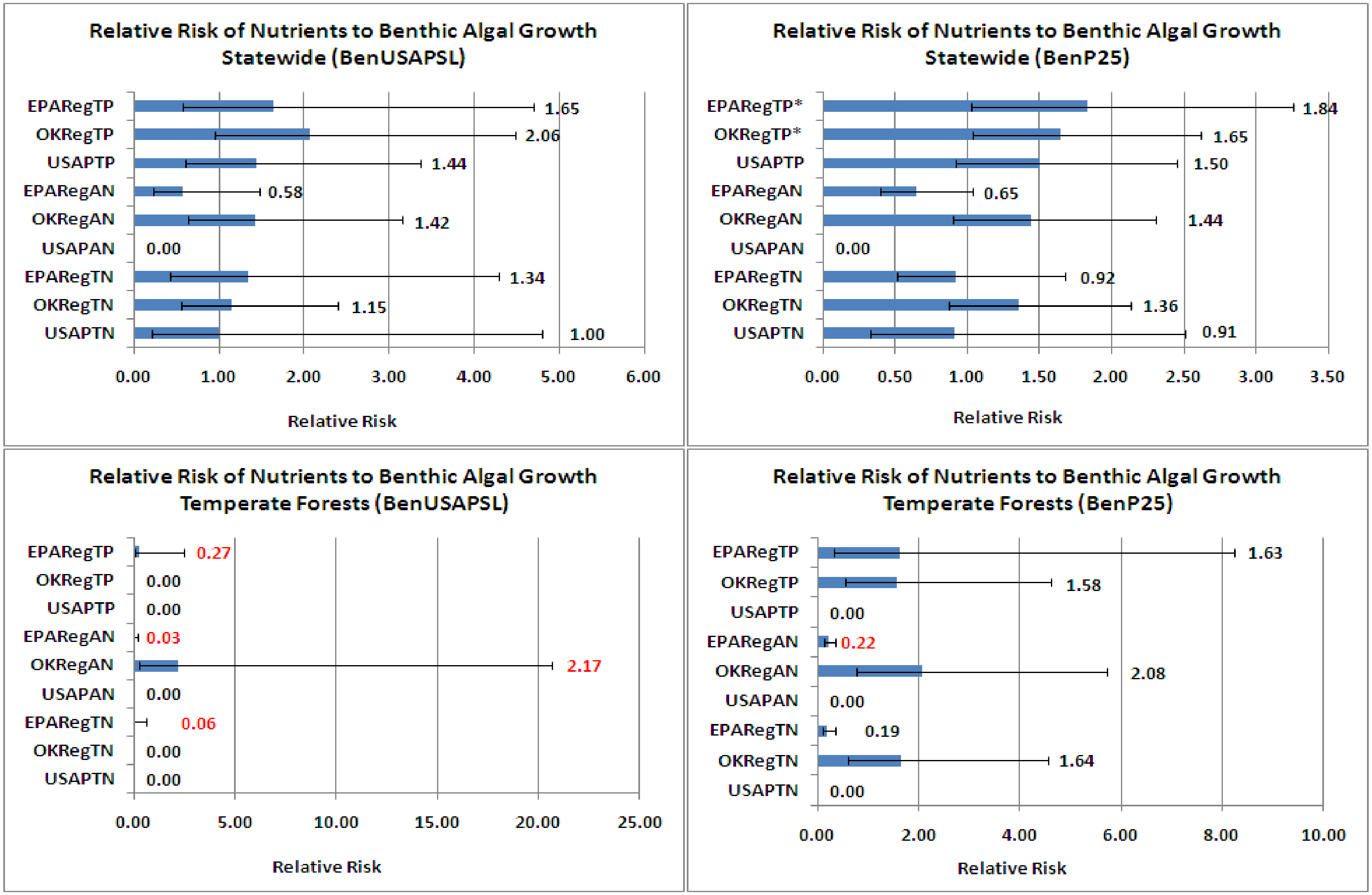
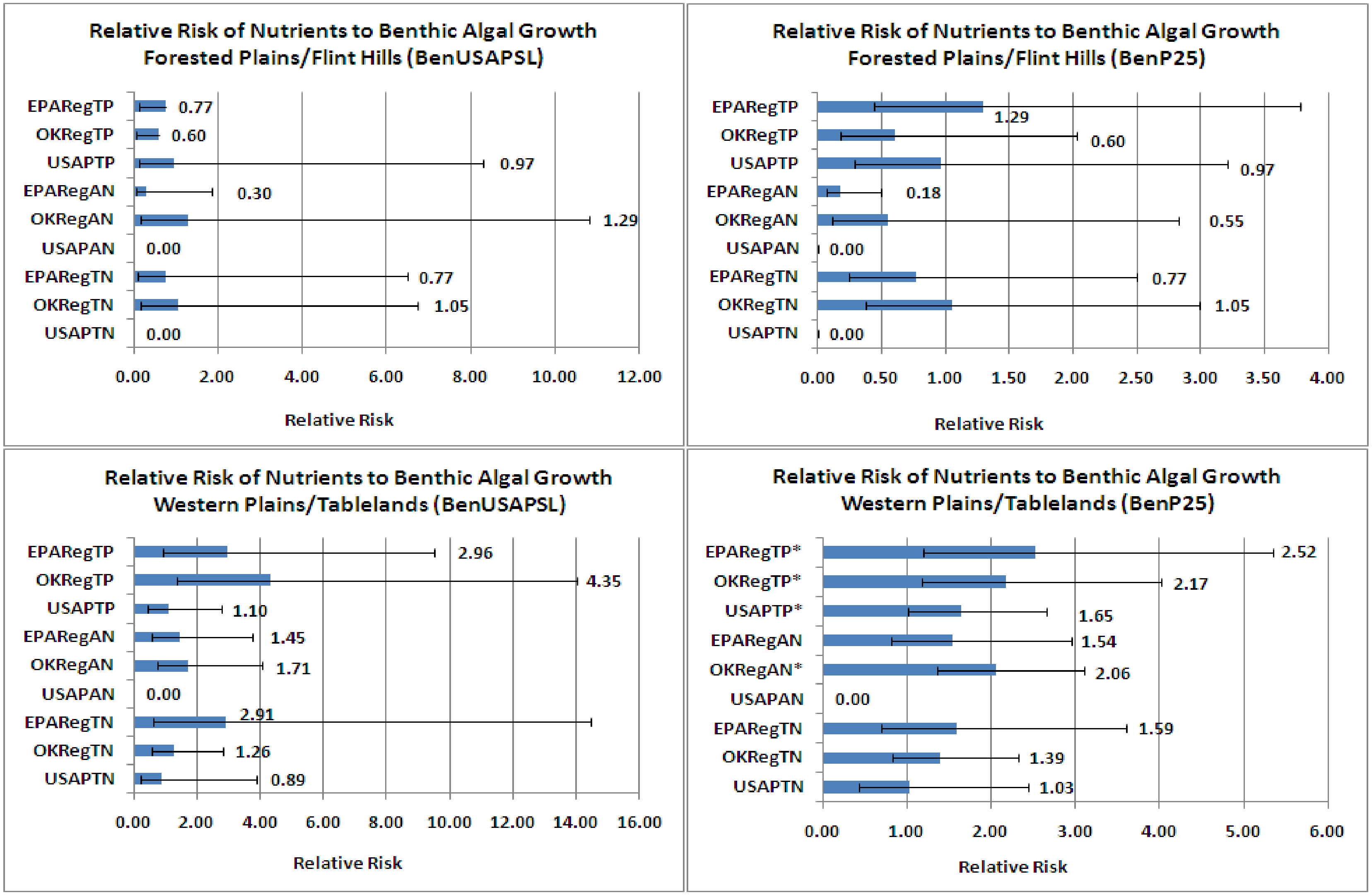


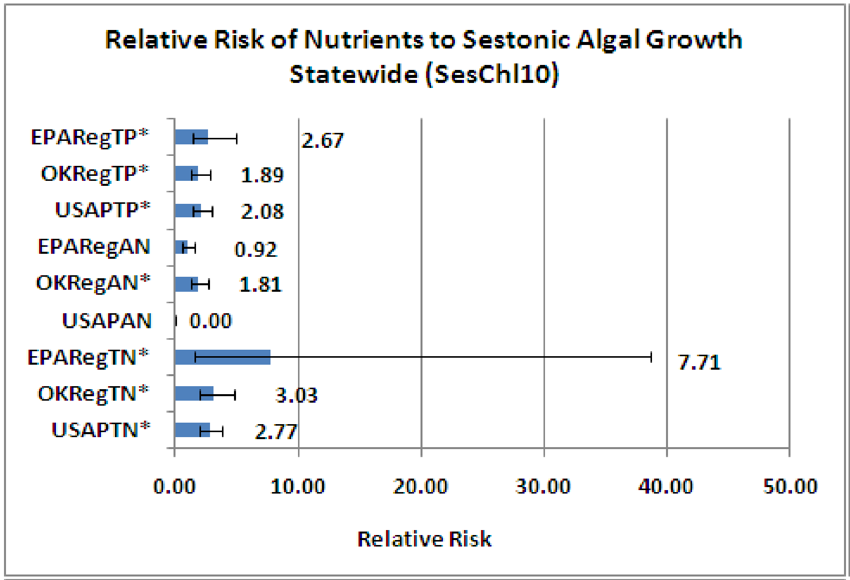
**Figure 27. Relative risk of nutrient stressors affecting benthic algal condition in the Forested Plains/Flint Hills and Western Plains/Tablelands regions. Upper and lower bounds represent 90% confidence interval. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

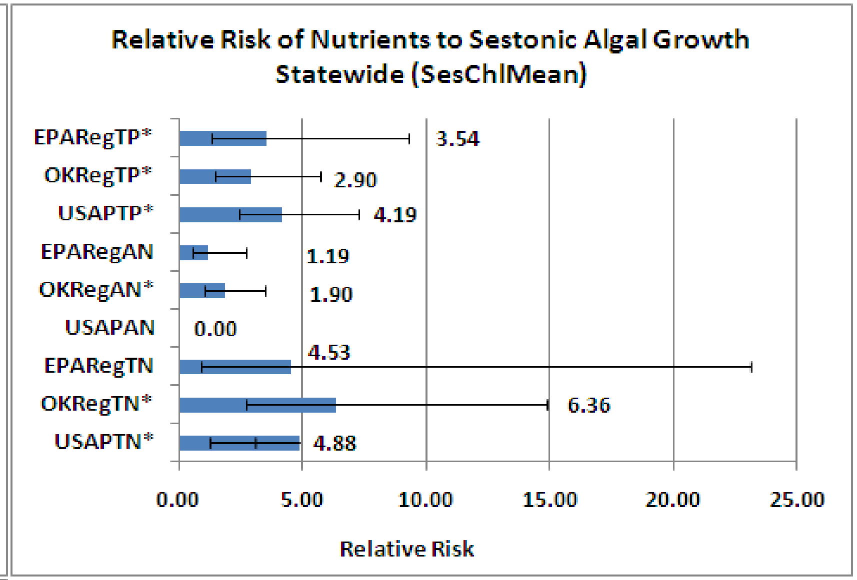


The Forested Plains/Flint Hills is very similar to the statewide estimates of relative risk (Figure 30). All phosphorus stressors are associated with risk of increased sestonic algae at each condition level, with relative risk values ranging from 1.9 to 15.5 and commonly above a value of 3.0 for relative risk. Likewise, at least two total nitrogen parameters are associated with significant relative risk for each algal condition. Range of relative risk is 1.3 to 6.6, and again, the regional Oklahoma stressor is associated at each condition level. Additionally, when available nitrogen (OKRegAN) values are above screening levels, algal biomass is 1.8 times more likely to be above the SesChl10 and SesChlMean condition levels and is 3.6 times more likely to be above a concentration of 25 $mg/m^3$. Again, all USAPAN values show 0 relative risk to algal condition.

In the Western Plains/Tablelands region, stressors do not perform as thoroughly, but at least one stressor in each parameter group demonstrates significant associated risk to increased algal growth at each condition level (Figure 31). Patterns that are the same include: 1) at least 2 total nitrogen parameters showing significant risks at all condition levels, 2) the OKRegAN being significant across all conditions, 3) several high total nitrogen relative risk values including 14.3 (SesChl25 vs.OKRegTN) and 15.0 (SesChlMean vs.OKRegTN), and 4) no relative risk associated with USAPAN, and 5) no significant risk associated with EPARegAN but extremely high upper bounds. Notably, the Oklahoma regional values again performed well across the board with the exception of the total phosphorus screening limit compared to SesChl10.

**Figure 28. Relative risk of nutrient stressors affecting sestonic algal condition Statewide. Upper and lower bounds represent 90% confidence interval. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**



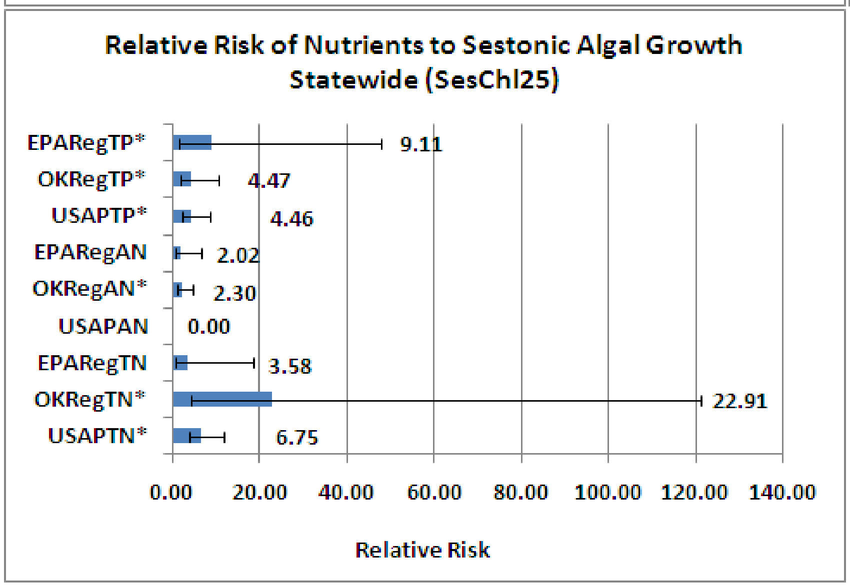



**Figure 29. Relative risk of nutrient stressors affecting sestonic algal condition in the Temperate Forest region. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**

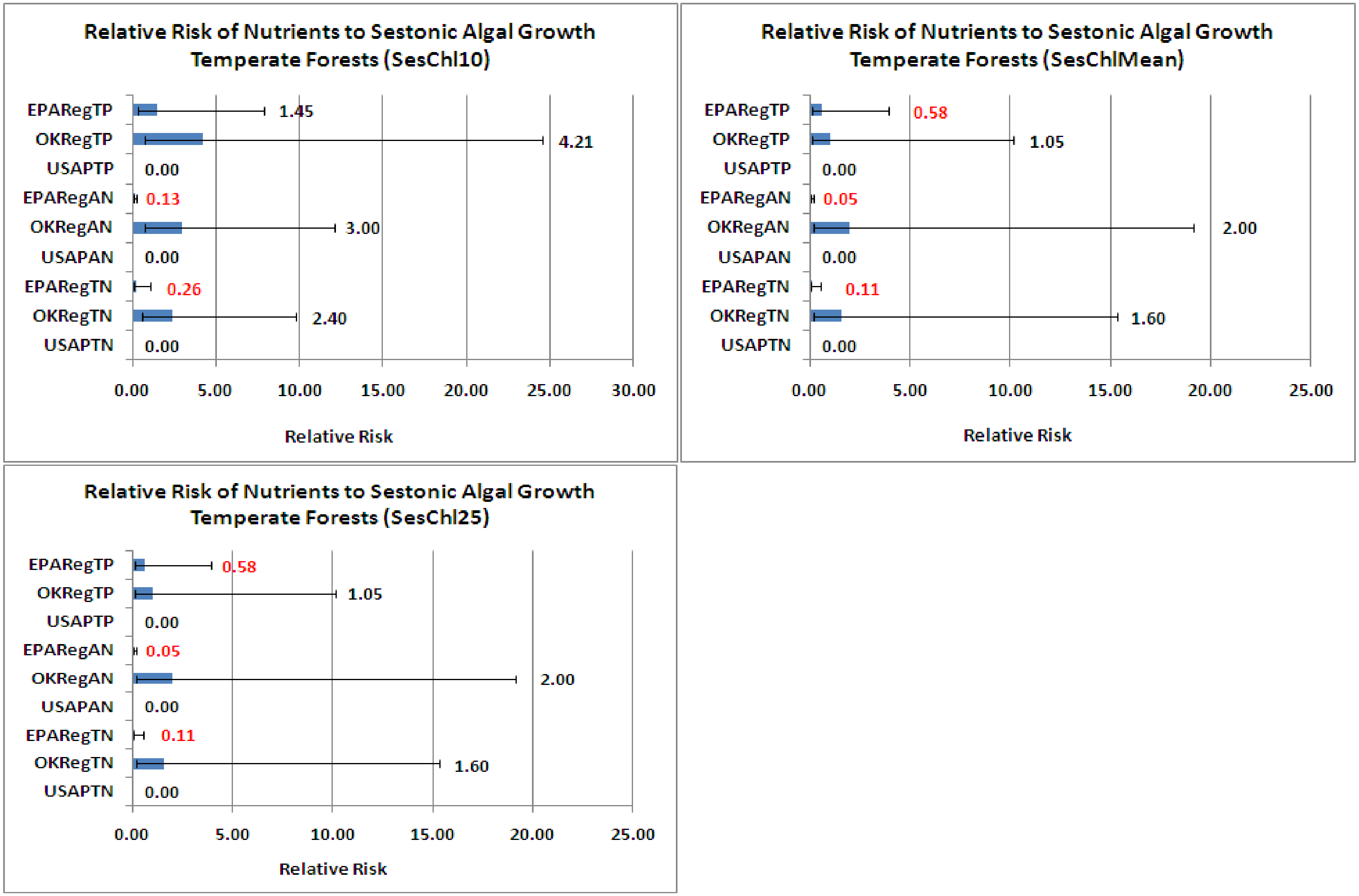


**Figure 30. Relative risk of nutrient stressors affecting sestonic algal condition in the Forested Plains/Flint Hills region. Upper and lower bounds represent 90% confidence interval. (* = significant at alpha of 0.90)**

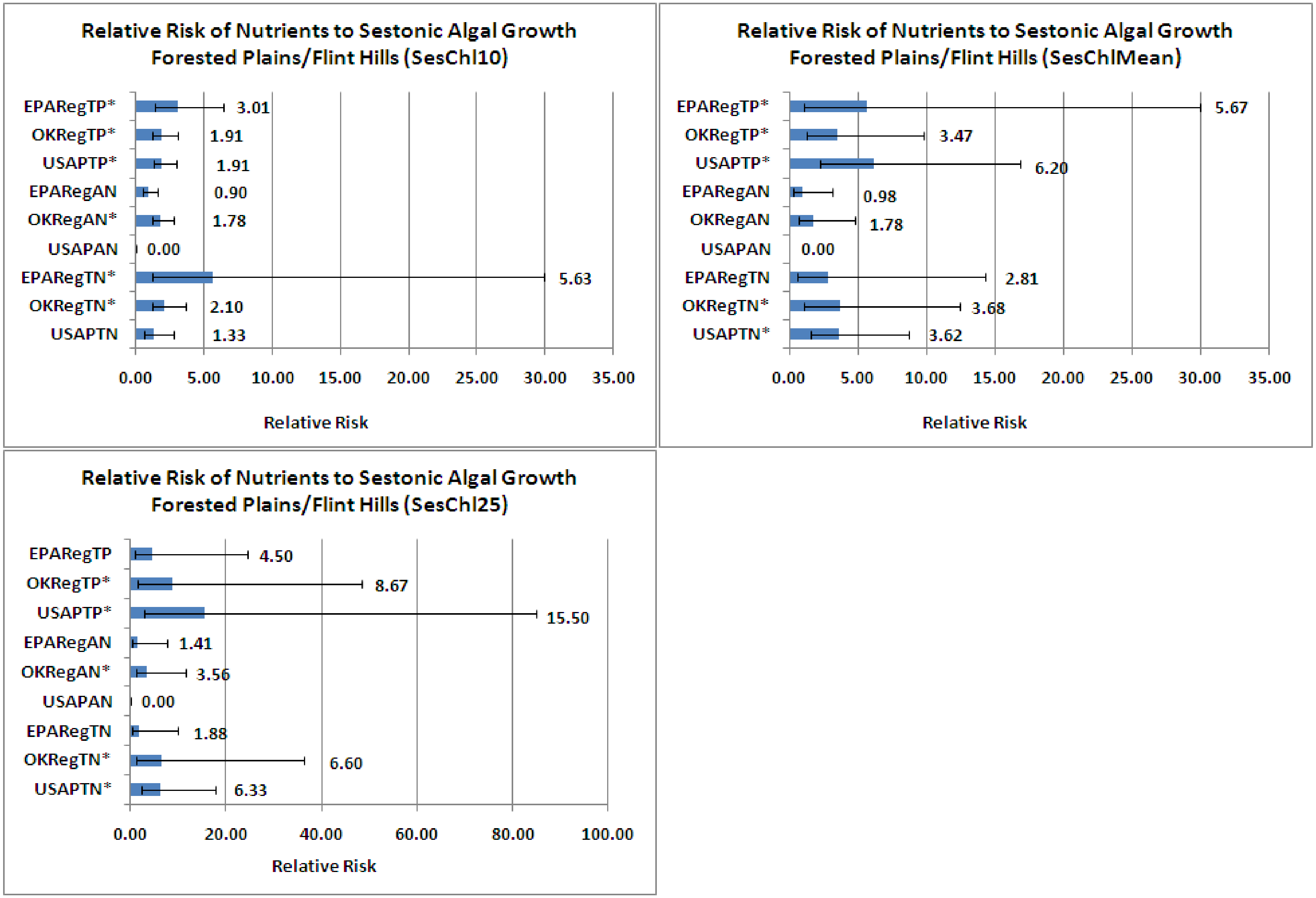
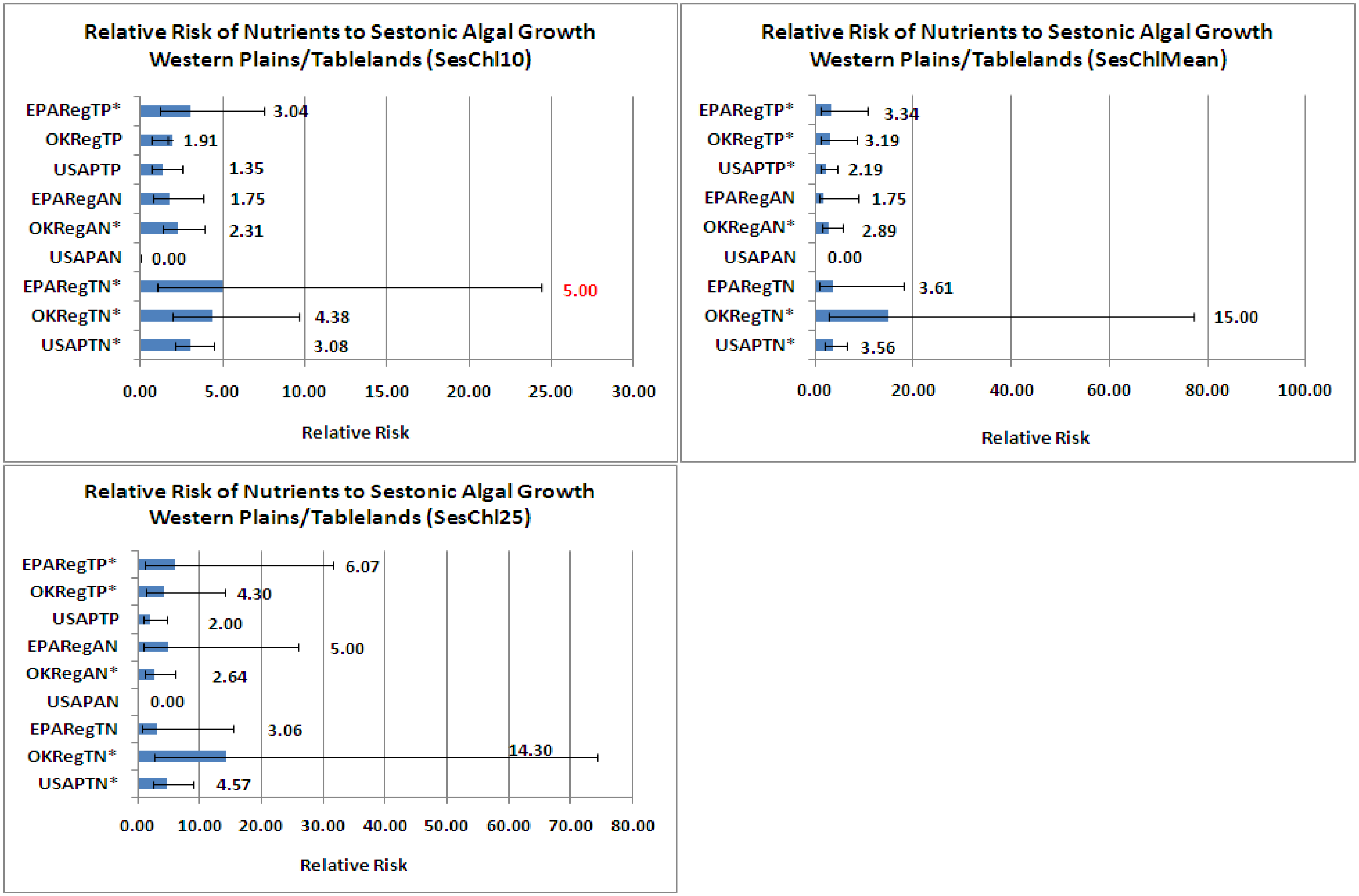


**Figure 31. Relative risk of nutrient stressors affecting sestonic algal condition in the Western Plains/Tablelands region. Upper and lower bounds represent 90% confidence interval. Red values estimated. (* = significant at alpha of 0.90) (Refer to Table 10 for stressor descriptions.)**



**Oklahoma's Integrated Water Quality Report**

Oklahoma's environmental agencies gather and assess data across the state for a wide variety of biological, chemical, and physical water quality indicators. One purpose of these data collections is to meet federal Clean Water Act requirements to compile a list of impaired waterbodies and determine the condition of all of these waters. These reports are compiled to the biannual Oklahoma Water Quality Assessment Integrated Report (ODEQ, 2008b).

The current study benefits this report in several ways. First, this report marks Oklahoma's first attempt at making a statistically based assessment of the condition of Oklahoma's waters. The OWRB recommends that this report be adopted into the 305(b) section of the integrated report. Included graphics can be used to show overall statewide and regional condition. Second, individual waterbodies not yet included in Oklahoma's Integrated Report (ODEQ, 2008) now have some level of assessment. The OWRB regularly submits waters for inclusion on Oklahoma's 303(d) list, and will do so again in October 2009. As a part of OWRB's submission, waterbodies assessed as part of this study will be included for consideration as not only category 5 (impaired), but as category 3 (not impaired for some uses). Because of assessment rules housed in Oklahoma's Continuing Planning Process (CPP; ODEQ, 2008a) and USAP (OWRB, 2008a), certain water quality parameters will not be included as part of the assessment. Most of Oklahoma's assessment protocols require that certain data requirements be met including the number of samples required to make an assessment determination. Protocols were developed to either assess short-term or long-term exposure. Short-term exposure protocols are written as percent exceedances, with typically a minimum of ten samples required. Long-term exposure protocols are based upon some measure of central tendency, but typically require a minimum number of samples to calculate the applicable descriptive statistic. Some exceptions to these rules include biological assessments, application of the sediment criteria, and a single sample maximum of 200 $mg/m^3$ for benthic chlorophyll-a. All other parameters included in this study will not be included in assessments for the impaired waters list but will be made publicly available in the event that another entity can include the data in their assessment.

**Relative Risk-Fish and Macroinvertebrates**

The relative risk analyses produced widely variable results depending upon both condition and stressor. To explore potential outcomes, matrices for the various conditions and stressors were developed (Tables 12, 13, and 14). Comparisons between the two groups have implications for criteria development, not only at the stressor level, but for biological condition as well. Standards development and implementation is an ongoing process affected by growing understanding of appropriate biological metrics and index application as well as stressor levels and how they interact.

For the most part, the attempt to draw relationships of stressors to fish condition using relative risk produced mostly unsuccessful results (Table 12). In all, only four parameters demonstrated significantly increased risk to fish condition. For nutrients, risk of increased total nitrogen associates significantly both statewide and in the west, although only for the highest of the three screening levels. No other parameter or geographic area demonstrated significant risk although nutrient extent estimates for all regions were extremely high. This could be the result of IBI's calculating fish condition too high or nutrient screening levels not being appropriate. Relative risk compares the difference of bad condition/low stressor versus bad condition/high stressor. In this case, regional stressors were calculated as extensive throughout the population (rarely below 30%), while the USAP stressors had typically low extents, only once greater than 20% and typically less than 10%.

Inevitably the ratio expressed above would near 1.0 because stressors are not sensitive enough given the comparative condition, or vice-versa. When significant relationships did exist, it was when stressor extent was less than 20% (USAPTN both statewide and in the west). Unfortunately, the problem likely lies on both ends. A logical next step would be to take various percentiles of the Oklahoma nutrient dataset and apply them to various fish metrics or score ranges of the two IBI's. Also, reference condition likely needs refinement on a regional basis.

Relative risk of nutrient stressors to macroinvertebrate condition produced more tangible results than with fish (Table 12). For nutrients, a broad range of parameters expressed relative risk both statewide and in the Forested Plains/Flint Hills. The USAP, Oklahoma regional, and EPA regional screening levels performed exceptionally well at both geographic scales as all but two parameters (OKRegAN and EPARegAN) showed significantly increased risk to lowered condition, although it should be noted that the USAP parameters show relatively low extent. On the other hand, the Oklahoma and EPA regional screening levels generally had high extents at both geographic scales. For the Western Plains/Tablelands, USAP total nitrogen was again significantly related. Finally, as with fish, the Temperate Forests region did not have a nutrient parameter significantly related to condition. Unlike fish, there seems to be a promising relationship between the current IBI and proposed stressor levels in at least the western ¾ of the state. On the other hand, the eastern highlands and forests still are producing confounding results. For the Oklahoma regional screening levels, relative risks coupled with high upper confidence bounds suggests that a number of sites are rating as good for both condition and stressor extent. Also, the USAP relative risks and extents are all at 0 or near to it. This may suggest that the problem is reference condition. A number of streams in the region are cool water aquatic communities and have exceptional habitat, when compared to the rest of the state. Refining the reference condition will likely produce a better relationship between known stressors (Figure 12) and condition.

For general water quality parameters in comparison to fish, several results were expected including the significant risk of low dissolved oxygen and high conductivity in the Western Plains/Tablelands region (Table 12). Low dissolved oxygen is likely a product of riparian condition and stream depth. Most riparian areas are composed of a mixed grass/light forest with very little shading in most waterbodies, and because streams usually have long and shallow sandy bottom runs, they are prone to increased heating. Couple that with increased nutrient loading (Figure 12), and the risk for low DO affecting condition certainly exists. It should be noted that the extent of the population with DO below screening levels (3%) is moderately low in the western region. In relation to other parts of Oklahoma, conductivity is relatively high in western Oklahoma. Conductivity throughout the region typically ranges from 1,000-3,000 microsiemens (OCC, 2005a, 2005b, 2006a, 2007; OWRB, 2008). In the Red Prairie and Red River Tablelands of southwestern Oklahoma, conductivity ranges from 2,500 up to greater than 75,000 below the gypsum outcroppings of the Elm Fork River. In northwestern Oklahoma along both the Cimarron and Beaver Rivers, similar conductivity ranges are present. Predictably, the extent of conductivity above regional screening values is high (47%) although not abnormal when compared to the rest of the state (Figure 13). However, in western Oklahoma, the extent of the stressor coupled with the potential for abnormally high values creates a significant associated relative risk to fish condition, which it does not in the rest of the state. Why other stressors are not related is likely due to several reasons. First, naturally occurring conditions exist for a variety of water quality parameters including pH and turbidity. A study recently completed by OWRB (2009a) revealed that low pH in southeastern Oklahoma is likely a naturally occurring condition. This was further borne out by results from this study. In the Temperate Forests, the extent of pH below criterion is 22%, yet there is zero relative risk of low pH to fish condition in the area. Other potential candidates for study based on data presented here as well as results from other programs include turbidity throughout Oklahoma and dissolved oxygen in parts of southeastern Oklahoma.

**Table 12. Matrix showing results of relative risk studies for fish and bacteria. (* = significant at alpha of 0.90; NS = not significant) (Refer to Table 10 for stressor descriptions.)**

| | Condition | Fish | | | | Macroinvertebrates | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stressor Group | Stressor/ Geographic Region | Statewide | Temperate Forests | Forested Plains/ Flint Hills | Western Plains/ Tablelands | Statewide | Temperate Forests | Forested Plains/ Flint Hills | Western Plains/ Tablelands |
| Total Nitrogen | USAPTN | * (2.19) | NS | NS | * (2.18) | * (2.47) | NS | * (2.06) | * (2.17) |
| | OKRegTN | NS | NS | NS | NS | * (1.77) | NS | * (1.67) | NS |
| | EPARegTN | NS | NS | NS | NS | NS | NS | * (5.90) | NS |
| Available Nitrogen | USAPAN | NS | NS | NS | NS | * (2.60) | NS | * (1.95) | NS |
| | OKRegAN | NS | NS | NS | NS | NS | NS | NS | NS |
| | EPARegAN | NS | NS | NS | NS | NS | NS | NS | NS |
| Total Phosphorus | USAPTP | NS | NS | NS | NS | * (1.96) | NS | * (2.02) | NS |
| | OKRegTP | NS | NS | NS | NS | * (1.46) | NS | * (1.57) | NS |
| | EPARegTP | NS | NS | NS | NS | NS | NS | * (1.89) | NS |
| General WQ in situ | DO | NS | NS | NS | * (2.33) | * (1.73) | * (9.33) | NS | NS |
| | pH | NS | NS | NS | NS | NS | NS | NS | * (2.47) |
| | Turb | NS | NS | NS | NS | NS | NS | NS | * (1.76) |
| | WTemp | NS | NS | NS | NS | NS | NS | NS | NS |
| General WQ - Salinity | OKRegCond | NS | NS | NS | * (2.21) | NS | * (5.95) | NS | NS |
| | OKRegCl | NS | NS | NS | NS | NS | NS | NS | NS |
| | OKRegSu | NS | NS | NS | NS | NS | NS | NS | * (1.95) |
| Habitat and Sediment | HTPts | NS | NS | * (3.65) | NS | NS | NS | * (2.45) | NS |
| | %LBM | NS | NS | NS | NS | NS | NS | NS | NS |
| | %Emb | NS | NS | NS | NS | NS | NS | NS | NS |
| | %DP | NS | NS | NS | NS | NS | NS | NS | NS |
| | %VPB | NS | NS | NS | NS | NS | NS | NS | NS |
| | USAPSed1 | NS | NS | NS | NS | NS | NS | NS | NS |
| | USAPSed2 | NS | NS | NS | NS | NS | NS | NS | NS |

As with pH, the extent of DO in southeastern Oklahoma is relatively high (23% compared to 15% statewide), but the risk is below 1.0, whereas it is above 1.0 in all other parts of the state and significant in the west. Turbidity has extents near to or slightly above 20% in the western three-quarters of the state as well as relative risks above 1.0 but never significant. Furthermore, the upper confidence bounds of relative risk indicate that a number of sites with good fish condition also have high turbidity. This may be in part due to the sensitivity of the fish IBI's but is also likely due to naturally occurring high turbidity in some parts of Oklahoma.

General water quality for macroinvertebrates is a mixed bag (Table 12). Statewide, only DO has associated significant relative risk, coupled with moderate extent of 17% (Figure 13). In the Temperate Forests, only DO and conductivity demonstrate significant risk to condition. Dissolved oxygen has a relatively high extent at 23%, while conductivity at 43% is in line with other regions and the statewide extent estimate (Figure 14). Interestingly, both relative risk values have extremely high upper confidence bounds (Figure 23), suggesting that the condition estimate is able to delineate sites with good water quality. In the Western Plains/Tablelands, condition is significantly affected by pH, turbidity, and sulfate. While the turbidity and sulfate extents are above 15% (Figures 13 and 14), the pH extent is extremely low. Moreover, each risk calculation is coupled with a relatively high upper confidence bound, suggesting that when each of the stressors is above criteria or screening level, condition is likely stressed. Finally, in the Forested Plains/Flint Hills, no significant relative risk exists for any general water quality parameter. As mentioned in the introduction, this area is a mix of eastern forests and western plains in habitat and water quality. This could indicate that more work should be done at the Omernik Level IV ecoregion scale to produce a more viable reference condition.

Finally, habitat and sediment stressors performed poorly. Only one stressor (HTPts) is significantly related to lowered condition, for fish and macroinvertebrates in the Forested Plains/Flint Hills (Table 12). However, stressors are exceeding reference condition at high extents throughout the state (Figure 17). Several parameters have relatively high upper confidence bounds including %Emb in the east, USAPSed1 statewide and in the west and east, and %LBS (fish) in the west. This means that a number of streams in good condition also have low stressor extents, indicating that either the IBI's or the stressor screening levels are not sensitive enough to detect risk. Increasing sensitivity of the IBI's through more refined reference condition could solve this issue because both the stressor and IBI are related to reference. Also, Oklahoma should explore the use of relative bed stability (RBS) as a measure of sedimentation. Data already exists from the WSA (USEPA, 2006) and is being gathered statewide as part of the National Rivers and Streams Assessment. Furthermore, the OWRB as part of its biological collection programs will begin next year to routinely collect habitat measures needed to calculate RBS.

**<u>Relative Risk-Benthic and Sestonic Algae</u>**

Relationships between benthic algal condition and nutrient stressors are summarized in Table 13. For all geographic regions and stressors, the benthic nuisance level in Oklahoma's USAP (OWRB, 2008b) is not significantly related to poor algal condition. However, several parameters had high upper confidence bounds including regional phosphorus screening levels both statewide and in the west, a mix of total nitrogen parameters statewide and in the western three-quarters of the state, and the Oklahoma regional available nitrogen stressor throughout the state and in every region. For the BenP25 screening level (which is less than half of the USAP level), the same general pattern of insignificant relative risks greater than 1 coupled with high upper confidence bounds is present to a lesser extent in the Forested Plains/Flint Hills, but more prevalently in the Temperate Forests region. In the west and statewide, increased total phosphorus is nearly always a significant predictor of decreased algal condition when based on the 25$^{th}$ percentile. The same is true in the west for the Oklahoma regional available nitrogen stressor. Based on available information, several conclusions can be drawn. First, the current USAP screening level may not be an adequate measure of benthic nuisance algal condition. When using wide ranging nutrient screening levels for both phosphorus and nitrogen, the indicator performs poorly in attempting to determine when high nutrient concentrations are affecting condition. Second, the 25$^{th}$ percentile seems to be a good indicator of phosphorus condition in the west and generally statewide. However, it is poorly associated with nitrogen concentrations. The population tends to be above the level regardless of nitrogen stressor extent. The lack of any risk association in the eastern two-thirds of the state suggests that regional nuisance benthic algal screening levels may be needed. As more data are gathered throughout the state, the screening level can potentially be refined to one that is more regionally based.

The relationship between sestonic algal growth and nutrient concentration is perhaps the most promising of any of the four biological condition/stressor relationship analyses (Table 14). At first glance, several general conclusions are evident in the data. First, biological condition in the Temperate Forests again performs low when compared to stressor extent, confirming that this region of the state needs to be dealt with separately when creating either nutrient criteria or biological indices/screening levels. Regardless of condition level, the presence of many high upper confidence bounds for the regional criteria suggests the inability of the lower screening limits to predict sestonic algal growth in the region. On the other hand, the USAP nutrient screening levels had 0 relative risks, suggesting that an appropriate nutrient screening level is somewhere between the regional levels and the USAP nutrient levels. Second, total nitrogen and phosphorus generally performed well as an indicator of increased algal growth at each screening level over the rest of the state. And, the Oklahoma regional screening level consistently performed well regardless of the condition level. Finally, an appropriate screening level for the western three-quarters of the state might lie between 10 and 19 mg/m$^3$. When viewing the relative tightness of confidence bounds for phosphorus and total nitrogen at each condition level, generally the narrowest are present in the SesChl10 and SesChlMean.

**Other Condition Estimates**

Metals were included in this study as both an indicator of ecological condition and human health. For both analyses, only lead, selenium and zinc were above criteria, and with the exception of lead, exceedances were regionally associated. These results are in accordance with what has been found through ambient monitoring programs in the state (OWRB, 2008c), and included in Oklahoma's 303(d) list of impaired waters (ODEQ, 2008). Other metals that sometimes occur on a regional basis and are listed as impaired are cadmium, copper, and silver. Based on this information, several recommendations can be made for ambient surface water quality programs in Oklahoma. First, all metals listed in the OWQS (OWRB, 2007a) but not occurring above criteria in ambient monitoring programs should not be monitored further. These include arsenic, chromium, nickel, and thallium. Second, since most metals occur regionally, a table specifying regional metals of concern should be created and included in either USAP (OWRB, 2008b) or the CPP (ODEQ, 2006a). This would benefit agencies in planning and allow for better use of often limited funds.

**Table 13. Matrix showing results of relative risk studies for benthic algae. (* = significant at alpha of 0.90; NS = not significant) (Refer to Table 10 for stressor descriptions.)**

| | Geographic Region | Statewide | | Temperate Forests | | Forested Plains/Flint Hills | | Western Plains/ Tablelands | |
|---|---|---|---|---|---|---|---|---|---|
| Stressor Group | Stressor/Condition | BenUSAPSL | BenP25 | BenUSAPSL | BenP25 | BenUSAPSL | BenP25 | BenUSAPSL | BenP25 |
| Total Nitrogen | USAPTN | NS | NS | NS | NS | NS | NS | NS | NS |
| | OKRegTN | NS | NS | NS | NS | NS | NS | NS | NS |
| | EPARegTN | NS | NS | NS | NS | NS | NS | NS | NS |
| Available Nitrogen | USAPAN | NS | NS | NS | NS | NS | NS | NS | NS |
| | OKRegAN | NS | NS | NS | NS | NS | NS | NS | * (2.06) |
| | EPARegAN | NS | NS | NS | NS | NS | NS | NS | NS |
| Total Phosphorus | USAPTP | NS | NS | NS | NS | NS | NS | NS | * (1.65) |
| | OKRegTP | NS | * (1.65) | NS | NS | NS | NS | NS | * (2.17) |
| | EPARegTP | NS | * (1.84) | NS | NS | NS | NS | NS | * (2.52) |

**Table 14. Matrix showing results of relative risk studies for sestonic algae. (* = significant at alpha of 0.90; NS = not significant) (Refer to Table 10 for stressor descriptions.)**

| | Geographic Region | Statewide | | | Temperate Forests | | | Forested Plains/Flint Hills | | | Western Plains/ Tablelands | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stressor Group | Stressor/Condition | SesChl 10 | SesChl Mean | SesChl 25 | SesChl 10 | SesChl Mean | SesChl 25 | SesChl 10 | SesChl Mean | SesChl 25 | SesChl 10 | SesChl Mean | SesChl 25 |
| Total Nitrogen | USAPTN | *2.77 | *4.88 | *6.75 | NS | NS | NS | NS | *3.62 | *6.33 | *3.08 | *3.56 | *4.57 |
| | OKRegTN | *3.03 | *6.36 | *22.91 | NS | NS | NS | *2.10 | *3.68 | *6.60 | *4.38 | *15.00 | *14.30 |
| | EPARegTN | *7.71 | NS | NS | NS | NS | NS | *5.63 | NS | NS | *5.00 | NS | NS |
| Available Nitrogen | USAPAN | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | OKRegAN | *1.81 | *1.90 | *2.30 | NS | NS | NS | *1.78 | NS | *3.56 | *2.31 | *2.89 | *2.64 |
| | EPARegAN | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Total Phophorus | USAPTP | *2.08 | *4.19 | *4.46 | NS | NS | NS | *1.91 | *6.20 | *15.50 | NS | *2.19 | NS |
| | OKRegTP | *1.89 | *2.90 | *4.47 | NS | NS | NS | *1.91 | *3.47 | *8.67 | NS | *3.19 | *4.30 |
| | EPARegTP | *2.67 | *3.54 | *9.11 | NS | NS | NS | *3.01 | *5.67 | NS | *3.04 | *3.34 | *6.07 |

Bacteria were also included as an indicator of human health. The results produced some disparate results when compared to ambient water quality data (OCC, 2005b, 2006a, 2006b, 2007, 2008; OWRB, 2008c; ODEQ, 2008). Oklahoma's integrated report lists upwards of 85% of Oklahoma's streams as impaired for some indicator organism. Conversely, data collected as part of this program indicate that nearly 70% of the population is not exceeding any indicator. Why the difference in data? First, the ambient programs collect multiple samples during the recreational season over multiple years and at various flow regimes, whereas this program collected a single sample at baseflow condition. Second, the real condition probably lies somewhere in the middle. Two things could make these results come more into line. First, better criteria and potentially better indicators are being developed by the USEPA and due out for public review in 2012. High impairment percentages are likely due in part to potentially inappropriate criteria. Second, the contact recreation use should be a tiered use much like the aquatic life uses. Tiers could be based on probabilities of waters to serve as a recreational source as well as other regional characteristics. However, the study design used is not likely the best for determining bacteria impairments, but may be useful for determining baseline bacteria concentrations at baseflow.

Lastly, the agriculture beneficial use was considered only nominally in this report. However, much information can potentially be drawn from probabilistic data to refine criteria for the use. Results from this study are generally in line with what is seen in ambient programs (OCC, 2005b, 2006a, 2006b, 2007, 2008; OWRB, 2008c; ODEQ, 2008). However, refining the criteria to include conductivity as a surrogate for TDS could save programs money and would likely provide an improved measure in regards to repeatability and accuracy. By combining probabilistic data with the wealth of ambient data, conductivity could be compared to TDS data and regional conversion factors for conductivity could be produced. Or, regional criteria could be developed for conductivity and adopted into the agriculture beneficial use in place of TDS.

## Future Plans

In terms of monitoring, probabilistic design has been completely integrated into both the OWRB and OCC monitoring programs (OWRB, 2009b). The OWRB is currently participating in the National Rivers and Streams Assessment and will use data from it to provide an update to the current report. Also, the third two-year statewide study will begin in winter or summer 2009 and include 50 sites. Substantive changes to the program will include: 1) use of the NRSA protocols for large Wadeable and non-wadeable waterbodies, 2) use of NRSA habitat protocols for wadeable streams in concert with the current RBP habitat protocol, 3) inclusion of a second winter macroinvertebrate index period, 4) inclusion of dissolved metals for some analytes, and 5) exclusion of bacteria from program. The OCC initiated a probabilistic program during 2008 that will provide estimates for planning basins throughout the state. Fifty random sites are being monitored per basin over the five-year rotating basin cycle. Lastly, the OWRB will conclude the Illinois River Probabilistic Monitoring Survey in 2009-2010. It is the first regionally based probabilistic study in Oklahoma, and is centered on setting a baseline biological condition to assist in implementation of nutrient criteria in Oklahoma's scenic rivers. Additional plans are in the works for future regionally based studies.

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## Table 15. Appendix A—Metadata for All Sites.

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-003 | North Fork of the Red River | 2005 | 7 | KIOWA | Central Great Plains | Western Plains | Upper Red | 2684.19 | 35.1032 | -99.3973 | 202.328 | 311510 | WWAC |
| OKPB01-005 | Bird Creek | 2005 | 3 | OSAGE | Flint Hills | Forested Plains | Grand Neosho | 162.99 | 36.6708 | -96.306 | 83.919 | 121300 | WWAC |
| OKPB01-008 | Grayson Creek | 2005 | 1 | PONTOTOC | Cross Timbers | Forested Plains | Lower Canadian | 1.93 | 34.8526 | -96.7574 | 117.691 | 520600 | WWAC |
| OKPB01-009 | North Fork of Walnut Creek | 2005 | 3 | MCCLAIN | Central Great Plains | Western Plains | Upper Canadian | 50.20 | 35.1619 | -97.6086 | 79.394 | 520610 | WWAC |
| OKPB01-010 | Red River | 2005 | 8 | LOVE | Cross Timbers | Forested Plains | Upper Red | 29295.77 | 33.9195 | -97.4927 | 202.328 | 311100 | WWAC |
| OKPB01-011 | Lyon Creek | 2005 | 4 | KINGFISHER | Central Great Plains | Western Plains | Cimarron | 33.86 | 36.1325 | -97.7438 | 103.691 | 620910 | WWAC |
| OKPB01-013 | Sweetwater Creek | 2005 | 4 | BECKHAM | Central Great Plains | Western Plains | Upper Red | 541.84 | 35.3071 | -99.9547 | 263.026 | 311510 | WWAC |
| OKPB01-015 | Haystack Creek | 2005 | 3 | GREER | Central Great Plains | Western Plains | Upper Red | 43.52 | 35.1029 | -99.6376 | 404.660 | 311800 | WWAC |
| OKPB01-017 | Turkey Creek | 2005 | 4 | KINGFISHER | Central Great Plains | Western Plains | Cimarron | 407.99 | 36.007 | -97.9337 | 103.691 | 620910 | WWAC |
| OKPB01-019 | Coal Creek | 2005 | 2 | TULSA | Cross Timbers | Forested Plains | Lower Arkansas | 13.19 | 36.0067 | -95.9927 | 339.297 | 120420 | WWAC |
| OKPB01-021 | Canadian River | 2005 | 3 | CANADIAN | Central Great Plains | Western Plains | Upper Canadian | 5262.99 | 35.3463 | -97.8566 | 79.394 | 520610 | HLAC |
| OKPB01-022 | Mud Creek | 2005 | 4 | JEFFERSON | Cross Timbers | Forested Plains | Upper Red | 294.58 | 34.1052 | -97.6641 | 263.026 | 311100 | WWAC |
| OKPB01-024 | Baron Fork River | 2005 | 4 | ADAIR | Ozark Highlands | Temperate Forests | Lower Arkansas | 191.18 | 35.951 | -94.658 | 203.577 | 121700 | CWAC |
| OKPB01-026 | Holly Creek | 2005 | 1 | PUSHMATAHA | Ouachita Mountains | Temperate Forests | Lower Red | 1.41 | 34.3518 | -95.113 | 155.176 | 410210 | WWAC |
| OKPB01-027 | Bitter Creek | 2006 | 4 | JACKSON | Central Great Plains | Western Plains | Upper Red | 18.84 | 34.7808 | -99.3919 | 263.026 | 311600 | HLAC |
| OKPB01-028 | Clear Boggy Creek | 2005 | 5 | CHOCTAW | South Central Plains | Temperate Forests | Lower Red | 998.88 | 34.0681 | -95.8144 | 47.023 | 410400 | WWAC |
| OKPB01-029 | Red Rock Creek | 2006 | 3 | GARFIELD | Central Great Plains | Western Plains | Upper Arkansas | 63.83 | 36.5185 | -97.6146 | 118.396 | 621200 | WWAC |
| OKPB01-031 | Opossum Creek | 2006 | 3 | OKLAHOMA | Cross Timbers | Forested Plains | Lower North Canadian | 23.52 | 35.7202 | -97.1826 | 465.146 | 520700 | WWAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-032 | Neosho River | 2006 | 7 | OTTAWA | Central Irregular Plains | Forested Plains | Grand Neosho | 5982.71 | 36.8783 | -94.8928 | 41.959 | 121600 | WWAC |
| OKPB01-033 | Polecat Creek | 2006 | 4 | CREEK | Cross Timbers | Forested Plains | Lower Arkansas | 51.20 | 35.9648 | -96.4018 | 203.577 | 120420 | WWAC |
| OKPB01-034 | Crooked Creek | 2005 | 2 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 4.05 | 34.0852 | -94.7231 | 129.313 | 410200 | WWAC |
| OKPB01-035 | Unnamed Creek | 2006 | 1 | ALFALFA | Central Great Plains | Western Plains | Upper Arkansas | 1.92 | 36.7534 | -98.248 | 153.914 | 621010 | WWAC |
| OKPB01-036 | Caston Creek | 2006 | 4 | LE FLORE | Arkansas Valley | Temperate Forests | Lower Arkansas | 33.58 | 34.9599 | -94.7379 | 203.577 | 220100 | WWAC |
| OKPB01-038 | Mountain Fork River | 2005 | 6 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 322.03 | 34.4613 | -94.6344 | 47.023 | 410210 | CWAC |
| OKPB01-043 | Chikaskia River | 2006 | 6 | KAY | Central Great Plains | Western Plains | Upper Arkansas | 1694.85 | 36.9098 | -97.3649 | 46.641 | 621100 | WWAC |
| OKPB01-044 | Kiamichi River | 2005 | 6 | PUSHMATAHA | Ouachita Mountains | Temperate Forests | Lower Red | 1133.15 | 34.2393 | -95.5818 | 47.023 | 410300 | WWAC |
| OKPB01-046 | Unnamed Tributary | 2005 | 1 | LE FLORE | Ouachita Mountains | Temperate Forests | Lower Red | 0.54 | 34.5826 | -94.6989 | 155.176 | 410210 | WWAC |
| OKPB01-050 | Sand Creek | 2006 | 2 | OSAGE | Flint Hills | Forested Plains | Grand Neosho | 39.60 | 36.7868 | -96.3393 | 90.911 | 121400 | WWAC |
| OKPB01-051 | Greenleaf Creek | 2006 | 2 | WOODS | Central Great Plains | Western Plains | Upper Arkansas | 15.98 | 36.9334 | -98.8725 | 128.262 | 621010 | WWAC |
| OKPB01-052 | Fourche Maline | 2006 | 5 | LE FLORE | Arkansas Valley | Temperate Forests | Lower Arkansas | 265.49 | 34.9165 | -94.9483 | 123.382 | 220100 | WWAC |
| OKPB01-054 | South Fork of Dirty Creek | 2006 | 4 | MUSKOGEE | Central Irregular Plains | Forested Plains | Lower Arkansas | 46.14 | 35.4528 | -95.2143 | 203.577 | 120400 | WWAC |
| OKPB01-056 | Little Sandy Creek | 2005 | 1 | JOHNSTON | Cross Timbers | Forested Plains | Lower Red | 2.40 | 34.3041 | -96.5545 | 155.176 | 410600 | WWAC |
| OKPB01-059 | Deep Fork of the Canadian River | 2007 | 6 | OKMULGEE | Cross Timbers | Forested Plains | Lower North Canadian | 2164.07 | 35.5694 | -95.9386 | 183.239 | 520700 | WWAC |
| OKPB01-060 | Bird Creek | 2007 | 1 | HUGHES | Cross Timbers | Forested Plains | Lower Canadian | 13.18 | 35.0399 | -96.4654 | 117.691 | 520800 | HLAC |
| OKPB01-064 | Caney River | 2007 | 6 | WASHINGTON | Cross Timbers | Forested Plains | Grand Neosho | 1708.04 | 36.6841 | -95.9796 | 33.059 | 121400 | WWAC |
| OKPB01-072 | Big Cabin Creek | 2007 | 3 | CRAIG | Central Irregular Plains | Forested Plains | Grand Neosho | 71.51 | 36.7939 | -95.1727 | 83.919 | 121600 | WWAC |
| OKPB01-073 | Wolf Creek | 2007 | 7 | ELLIS | Southwestern Tablelands | Western Plains | Upper North Canadian | 1179.45 | 36.287 | -99.9496 | 42.171 | 720500 | WWAC |
| OKPB01-076 | Shady Grove Creek | 2007 | 4 | MCINTOSH | Central Irregular Plains | Forested Plains | Lower Arkansas | 15.48 | 35.4706 | -95.4584 | 203.577 | 120400 | WWAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-078 | Glover River | 2005 | 5 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 300.40 | 34.1362 | -94.9147 | 47.023 | 410210 | CWAC |
| OKPB01-081 | Jim Creek | 2007 | 1 | POTTAWATOMIE | Cross Timbers | Forested Plains | Lower Canadian | 7.73 | 35.2192 | -97.0665 | 117.691 | 520800 | WWAC |
| OKPB01-084 | Peterson Creek | 2005 | 1 | PUSHMATAHA | Ouachita Mountains | Temperate Forests | Lower Red | 2.22 | 34.5405 | -95.3897 | 155.176 | 410300 | WWAC |
| OKPB01-085 | Deep Fork of the Canadian River | 2007 | 5 | LINCOLN | Cross Timbers | Forested Plains | Lower North Canadian | 588.62 | 35.6401 | -96.9079 | 183.239 | 520700 | WWAC |
| OKPB01-092 | Big Creek | 2007 | 3 | LE FLORE | Ouachita Mountains | Temperate Forests | Lower Arkansas | 21.15 | 34.7073 | -94.5338 | 313.200 | 220100 | CWAC |
| OKPB01-098 | Norwood Creek | 2005 | 2 | MCCURTAIN | South Central Plains | Temperate Forests | Lower Red | 7.88 | 33.8276 | -94.6621 | 129.313 | 410100 | WWAC |
| OKPB01-099 | North Fork of the Red River | 2007 | 8 | KIOWA | Central Great Plains | Western Plains | Upper Red | 3708.99 | 34.8671 | -99.3119 | 202.328 | 311510 | WWAC |
| OKPB01-118 | Caney Creek | 2005 | 3 | ATOKA | South Central Plains | Temperate Forests | Lower Red | 42.70 | 34.2253 | -96.2489 | 119.367 | 410400 | WWAC |
| OKPB01-130 | Blue River | 2005 | 4 | BRYAN | South Central Plains | Temperate Forests | Lower Red | 671.00 | 33.8829 | -95.9645 | 77.588 | 410600 | WWAC |
| OKPB01-134 | Buck Creek | 2005 | 4 | PUSHMATAHA | Ouachita Mountains | Temperate Forests | Lower Red | 81.29 | 34.3942 | -95.6783 | 77.588 | 410300 | WWAC |
| OKPB01-136 | Sand Springs Branch | 2005 | 2 | MCCURTAIN | South Central Plains | Temperate Forests | Lower Red | 4.08 | 34.0206 | -95.0469 | 129.313 | 410210 | WWAC |
| OKPB01-138 | Unnamed Tributary | 2005 | 2 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 10.29 | 34.2474 | -94.8462 | 129.313 | 410210 | WWAC |
| OKPB01-144 | Boktuklo Creek | 2005 | 1 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 12.74 | 34.3909 | -94.7378 | 155.176 | 410210 | CWAC |
| OKPB01-148 | Kiamichi River | 2005 | 4 | LE FLORE | Ouachita Mountains | Temperate Forests | Lower Red | 36.67 | 34.6405 | -94.6094 | 77.588 | 410310 | WWAC |
| OKPB01-154 | Blue River | 2005 | 4 | BRYAN | Cross Timbers | Forested Plains | Lower Red | 367.17 | 34.0866 | -96.361 | 77.588 | 410600 | WWAC |
| OKPB01-156 | Beck Creek | 2005 | 2 | ATOKA | Arkansas Valley | Temperate Forests | Lower Red | 3.70 | 34.5808 | -96.02 | 129.313 | 410400 | WWAC |
| OKPB01-170 | Clear Boggy Creek | 2005 | 5 | COAL | Arkansas Valley | Temperate Forests | Lower Red | 367.59 | 34.49 | -96.3484 | 47.023 | 410400 | WWAC |
| OKPB01-196 | Buffalo Creek | 2005 | 3 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 110.38 | 34.3626 | -94.6418 | 119.367 | 410210 | CWAC |
| OKPB01-210 | Big Cedar Creek | 2005 | 2 | LE FLORE | Ouachita Mountains | Temperate Forests | Lower Red | 4.77 | 34.6822 | -94.6476 | 129.313 | 410310 | WWAC |
| OKPB01-212 | Cimarron River | 2007 | 5 | CIMARRON | Southwestern Tablelands | Western Plains | Cimarron | 1197.08 | 36.906 | -102.9753 | 62.844 | 720900 | WWAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-213 | Wolf Creek | 2006 | 7 | ELLIS | Southwestern Tablelands | Western Plains | Upper North Canadian | 1611.98 | 36.3504 | -99.6978 | 42.171 | 720500 | WWAC |
| OKPB01-216 | Muddy Boggy Creek | 2005 | 6 | COAL | Arkansas Valley | Temperate Forests | Lower Red | 339.61 | 34.6016 | -96.1695 | 47.023 | 410400 | WWAC |
| OKPB01-220 | Curl Creek | 2006 | 2 | WASHINGTON | Central Irregular Plains | Forested Plains | Grand Neosho | 47.75 | 36.5975 | -95.8608 | 90.911 | 121400 | WWAC |
| OKPB01-223 | Gar Creek | 2006 | 3 | WAGONER | Central Irregular Plains | Forested Plains | Grand Neosho | 15.49 | 35.9588 | -95.5495 | 83.919 | 121500 | WWAC |
| OKPB01-224 | Carnasaw Creek | 2005 | 1 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 3.05 | 34.1243 | -94.6546 | 155.176 | 410210 | WWAC |
| OKPB01-227 | Unnamed Tributary | 2007 | 1 | OKLAHOMA | Central Great Plains | Western Plains | Cimarron | 0.63 | 35.5983 | -97.5663 | 207.384 | 620910 | WWAC |
| OKPB01-229 | Cimarron River | 2007 | 7 | WOODS | Central Great Plains | Western Plains | Cimarron | 10203.28 | 36.8746 | -99.3596 | 79.763 | 620920 | WWAC |
| OKPB01-232 | Julian Creek | 2007 | 2 | POTTAWATOMIE | Cross Timbers | Forested Plains | Lower Canadian | 5.36 | 34.9696 | -96.9737 | 98.075 | 520600 | WWAC |
| OKPB01-235 | Turkey Creek | 2007 | 2 | PAWNEE | Central Great Plains | Western Plains | Upper Arkansas | 10.47 | 36.359 | -96.9242 | 128.262 | 621200 | WWAC |
| OKPB01-236 | California Creek | 2006 | 1 | NOWATA | Central Irregular Plains | Forested Plains | Grand Neosho | 7.86 | 36.8983 | -95.7366 | 109.094 | 121510 | WWAC |
| OKPB01-239 | Crooked Creek | 2007 | 5 | BEAVER | Southwestern Tablelands | Western Plains | Cimarron | 1437.68 | 36.9827 | -100.134 | 62.844 | 620930 | WWAC |
| OKPB01-247 | Tyner Creek | 2006 | 2 | WASHINGTON | Central Irregular Plains | Forested Plains | Grand Neosho | 8.79 | 36.4379 | -95.9961 | 90.911 | 121300 | WWAC |
| OKPB01-251 | Cooper Creek | 2007 | 3 | KINGFISHER | Central Great Plains | Western Plains | Cimarron | 60.17 | 35.9733 | -98.1311 | 159.527 | 620910 | WWAC |
| OKPB01-255 | Turkey Creek | 2007 | 2 | LINCOLN | Central Great Plains | Western Plains | Cimarron | 4.25 | 35.903 | -96.7257 | 172.820 | 620900 | WWAC |
| OKPB01-256 | Carpenter Branch | 2005 | 1 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 2.42 | 34.3874 | -94.8576 | 155.176 | 410210 | WWAC |
| OKPB01-260 | Madden Creek | 2006 | 1 | CRAIG | Central Irregular Plains | Forested Plains | Grand Neosho | 6.81 | 36.703 | -95.4179 | 109.094 | 121510 | WWAC |
| OKPB01-266 | Mayhew Creek | 2005 | 1 | CHOCTAW | South Central Plains | Temperate Forests | Lower Red | 4.51 | 34.0555 | -95.9209 | 155.176 | 410400 | WWAC |
| OKPB01-267 | Arkansas River | 2007 | 7 | OSAGE | Central Great Plains | Western Plains | Upper Arkansas | 18055.04 | 36.6752 | -97.0639 | 59.198 | 621200 | WWAC |
| OKPB01-282 | Tomike Creek | 2007 | 2 | MCCLAIN | Central Great Plains | Western Plains | Lower Canadian | 5.42 | 34.9252 | -97.1582 | 98.075 | 520610 | WWAC |
| OKPB01-283 | Skeleton Creek | 2007 | 4 | GARFIELD | Central Great Plains | Western Plains | Cimarron | 157.40 | 36.2347 | -97.7575 | 103.691 | 620910 | HLAC |
| OKPB01-284 | Rock Creek | 2006 | 1 | MAYES | Central Irregular Plains | Forested Plains | Grand Neosho | 5.55 | 36.5021 | -95.2672 | 109.094 | 121600 | WWAC |
| OKPB01-292 | Little Cabin Creek | 2006 | 2 | CRAIG | Central Irregular Plains | Forested Plains | Grand Neosho | 14.26 | 36.8256 | -95.0763 | 90.911 | 121600 | WWAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-293 | Driftwood Creek | 2007 | 5 | ALFALFA | Central Great Plains | Western Plains | Upper Arkansas | 225.78 | 36.8961 | -98.4374 | 46.641 | 621010 | WWAC |
| OKPB01-298 | Mineral Bayou | 2005 | 2 | BRYAN | Cross Timbers | Forested Plains | Lower Red | 21.15 | 34.0058 | -96.3646 | 129.313 | 410600 | WWAC |
| OKPB01-299 | Doga Creek | 2007 | 2 | OSAGE | Flint Hills | Forested Plains | Upper Arkansas | 14.07 | 36.6074 | -96.8196 | 128.262 | 621200 | WWAC |
| OKPB01-302 | Kiamichi River | 2005 | 4 | LE FLORE | Ouachita Mountains | Temperate Forests | Lower Red | 68.80 | 34.6431 | -94.7142 | 77.588 | 410310 | WWAC |
| OKPB01-311 | Ranch creek | 2006 | 1 | TULSA | Central Irregular Plains | Forested Plains | Grand Neosho | 2.57 | 36.3017 | -95.8742 | 109.094 | 121300 | WWAC |
| OKPB01-317 | Unnamed Creek | 2006 | 2 | ELLIS | Central Great Plains | Western Plains | Upper Canadian | 4.29 | 35.9847 | -99.7932 | 86.009 | 520620 | WWAC |
| OKPB01-323 | Skeleton Creek | 2007 | 5 | LOGAN | Central Great Plains | Western Plains | Cimarron | 553.52 | 36.0506 | -97.5419 | 62.844 | 620910 | WWAC |
| OKPB01-327 | Verdigris River | 2006 | 7 | ROGERS | Central Irregular Plains | Forested Plains | Grand Neosho | 7653.28 | 36.1981 | -95.7008 | 41.959 | 121500 | WWAC |
| OKPB01-328 | Glover River | 2006 | 5 | MCCURTAIN | Ouachita Mountains | Temperate Forests | Lower Red | 208.20 | 34.2806 | -94.9079 | 47.023 | 410210 | CWAC |
| OKPB01-330 | Clear Boggy Creek | 2006 | 5 | ATOKA | South Central Plains | Temperate Forests | Lower Red | 813.48 | 34.1683 | -96.0575 | 47.023 | 410400 | WWAC |
| OKPB01-335 | Beaver River | 2006 | 7 | BEAVER | Southwestern Tablelands | Western Plains | Upper North Canadian | 8610.00 | 36.8001 | -100.0195 | 42.171 | 720500 | WWAC |
| OKPB01-336 | Beaverdam Creek | 2006 | 2 | CHOCTAW | South Central Plains | Temperate Forests | Lower Red | 10.44 | 34.0918 | -95.7549 | 129.313 | 410400 | WWAC |
| OKPB01-342 | Cedar Creek | 2006 | 4 | PUSHMATAHA | Ouachita Mountains | Temperate Forests | Lower Red | 173.89 | 34.2578 | -95.5377 | 77.588 | 410300 | CWAC |
| OKPB01-343 | Bitter Creek | 2007 | 4 | KAY | Central Great Plains | Western Plains | Upper Arkansas | 136.77 | 36.8228 | -97.2685 | 76.957 | 621100 | WWAC |
| OKPB01-344 | Muddy Boggy Creek | 2007 | 6 | COAL | Arkansas Valley | Temperate Forests | Lower Red | 505.94 | 34.4567 | -96.1734 | 47.023 | 410400 | WWAC |
| OKPB01-347 | Black Bear Creek | 2007 | 3 | GARFIELD | Central Great Plains | Western Plains | Upper Arkansas | 93.18 | 36.3685 | -97.5052 | 118.396 | 621200 | WWAC |
| OKPB01-348 | Fish Creek | 2006 | 1 | WASHINGTON | Central Irregular Plains | Forested Plains | Grand Neosho | 3.90 | 36.7092 | -95.8843 | 109.094 | 121400 | WWAC |
| OKPB01-355 | Cottonwood Creek | 2007 | 4 | LOGAN | Central Great Plains | Western Plains | Cimarron | 67.54 | 35.7684 | -97.6302 | 103.691 | 620910 | WWAC |
| OKPB01-357 | Eagle Chief Creek | 2007 | 3 | WOODS | Central Great Plains | Western Plains | Cimarron | 83.28 | 36.6972 | -98.6977 | 159.527 | 620920 | WWAC |
| OKPB01-360 | Little River | 2007 | 4 | SEMINOLE | Cross Timbers | Forested Plains | Lower Canadian | 600.64 | 35.0219 | -96.6106 | 58.845 | 520800 | WWAC |
| OKPB01-363 | Black Bear Creek | 2007 | 4 | NOBLE | Central Great Plains | Western Plains | Upper Arkansas | 289.47 | 36.3451 | -97.1902 | 76.957 | 621200 | WWAC |
| OKPB01-369 | Canadian River | 2006 | 4 | CLEVELAND | Central Great Plains | Western Plains | Upper Canadian | 5599.86 | 35.0354 | -97.3565 | 51.605 | 520610 | HLAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-372 | Beaty Creek | 2006 | 3 | DELAWARE | Ozark Highlands | Temperate Forests | Grand Neosho | 51.30 | 36.3668 | -94.7314 | 83.919 | 121600 | CWAC |
| OKPB01-376 | Peaceable Creek | 2007 | 4 | PITTSBURG | Arkansas Valley | Temperate Forests | Lower Canadian | 98.26 | 34.8233 | -95.7716 | 58.845 | 220600 | WWAC |
| OKPB01-389 | Salt Fork of Arkansas River | 2007 | 5 | WOODS | Central Great Plains | Western Plains | Upper Arkansas | 835.65 | 36.9435 | -98.7739 | 46.641 | 621010 | WWAC |
| OKPB01-391 | Verdigris River | 2006 | 7 | ROGERS | Central Irregular Plains | Forested Plains | Grand Neosho | 6485.49 | 36.2337 | -95.7227 | 41.959 | 121500 | WWAC |
| OKPB01-395 | Dugout Creek | 2007 | 1 | OSAGE | Flint Hills | Forested Plains | Upper Arkansas | 8.59 | 36.8452 | -96.5764 | 153.914 | 621200 | WWAC |
| OKPB01-399 | Duck Pond Creek | 2006 | 3 | BEAVER | Southwestern Tablelands | Western Plains | Upper North Canadian | 83.12 | 36.7011 | -100.3118 | 84.343 | 720500 | WWAC |
| OKPB01-404 | Chouteau Creek | 2006 | 2 | MAYES | Central Irregular Plains | Forested Plains | Grand Neosho | 42.38 | 36.2071 | -95.3676 | 90.911 | 121600 | WWAC |
| OKPB01-405 | Bitter Creek | 2007 | 4 | KAY | Central Great Plains | Western Plains | Upper Arkansas | 80.85 | 36.9211 | -97.2646 | 76.957 | 621100 | WWAC |
| OKPB01-424 | Scipio Creek | 2007 | 4 | PITTSBURG | Arkansas Valley | Temperate Forests | Lower Canadian | 33.18 | 35.0975 | -95.9297 | 58.845 | 220600 | WWAC |
| OKPB01-429 | Unnamed Creek (Lariat Creek) | 2006 | 1 | BLAINE | Central Great Plains | Western Plains | Upper Canadian | 6.93 | 35.6274 | -98.4294 | 103.211 | 520620 | WWAC |
| OKPB01-431 | Clear Creek | 2006 | 4 | ELLIS | Southwestern Tablelands | Western Plains | Upper North Canadian | 39.60 | 36.5487 | -99.9417 | 54.822 | 720500 | WWAC |
| OKPB01-453 | Canadian River | 2006 | 7 | DEWEY | Central Great Plains | Western Plains | Upper Canadian | 3694.55 | 36.0037 | -99.2974 | 39.696 | 520620 | WWAC |
| OKPB01-469 | North Canadian River | 2006 | 7 | WOODWARD | Central Great Plains | Western Plains | Upper North Canadian | 11705.62 | 36.4617 | -99.4388 | 42.171 | 720500 | WWAC |
| OKPB01-495 | Beaver River | 2006 | 7 | BEAVER | Southwestern Tablelands | Western Plains | Upper North Canadian | 8006.11 | 36.814 | -100.4762 | 42.171 | 720500 | WWAC |
| OKPB01-504 | Bull Creek | 2007 | 3 | PITTSBURG | Arkansas Valley | Temperate Forests | Lower Canadian | 25.03 | 34.8597 | -95.8285 | 90.532 | 220600 | WWAC |
| OKPB01-519 | Bird Creek | 2006 | 5 | ROGERS | Central Irregular Plains | Forested Plains | Grand Neosho | 1131.11 | 36.2169 | -95.768 | 33.059 | 121300 | WWAC |
| OKPB01-527 | Beaver River | 2006 | 7 | BEAVER | Southwestern Tablelands | Western Plains | Upper North Canadian | 8574.92 | 36.7683 | -100.1072 | 42.171 | 720500 | WWAC |
| OKPB01-548 | Windy Creek | 2006 | 1 | OTTAWA | Central Irregular Plains | Forested Plains | Grand Neosho | 7.33 | 36.8755 | -94.9496 | 109.094 | 121600 | WWAC |
| OKPB01-552 | Mill Creek | 2007 | 4 | MCINTOSH | Arkansas Valley | Temperate Forests | Lower Canadian | 31.49 | 35.2082 | -95.9038 | 58.845 | 220600 | WWAC |
| OKPB01-567 | Bull Creek | 2006 | 3 | OSAGE | Cross Timbers | Forested Plains | Grand Neosho | 12.94 | 36.4693 | -96.1052 | 83.919 | 121300 | WWAC |

| Station ID | Waterbody Name | Yr Eval | S.O. | COUNTY | Ecoregion | Ecoregion Combined | Planning_Basin | Drainage Area (m2) | Lat_Field | Long_Field | final.wgt | Mgmt Segment | Aquatic Tier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OKPB01-581 | Canadian River | 2006 | 7 | DEWEY | Central Great Plains | Western Plains | Upper Canadian | 3903.82 | 35.9693 | -99.0263 | 39.696 | 520620 | WWAC |
| OKPB01-583 | Adams Creek | 2006 | 1 | WAGONER | Central Irregular Plains | Forested Plains | Grand Neosho | 14.67 | 36.0683 | -95.7128 | 109.094 | 121500 | WWAC |
| OKPB01-616 | Canadian River | 2007 | 7 | HUGHES | Arkansas Valley | Temperate Forests | Lower Canadian | 7753.06 | 35.0692 | -96.0653 | 45.265 | 220600 | WWAC |
| OKPB01-619 | Sand Creek | 2006 | 2 | OSAGE | Flint Hills | Forested Plains | Grand Neosho | 51.87 | 36.7589 | -96.3143 | 90.911 | 121400 | WWAC |

**Table 16. Appendix B—Water Quality Data for All Sites.**

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 377939 | OKPB01-003 | 07/05/2005 | 16:30 | 0.050 | 0.650 | 0.050 | 0.050 | 0.750 | 0.150 | 0.016 | 0.053 | 6.10 | 8.25 | | 33.97 | 2470.0 | 469.0 | 1970.0 | 601.0 |
| 378141 | OKPB01-005 | 07/11/2005 | 14:30 | 0.050 | 0.400 | 0.050 | 0.050 | 0.500 | 0.150 | 0.025 | 0.067 | 7.20 | 7.83 | 32.0 | 29.11 | 247.4 | 10.0 | 170.0 | 21.8 |
| 376904 | OKPB01-008 | 06/20/2005 | 15:55 | 0.050 | 0.150 | 0.050 | 0.050 | 0.250 | 0.150 | 0.039 | 0.060 | 5.70 | 7.25 | | 26.08 | 676.0 | 42.0 | 413.0 | 19.4 |
| 378659 | OKPB01-009 | 07/19/2005 | 10:45 | 0.050 | 0.790 | 0.050 | 0.050 | 0.890 | 0.150 | 0.088 | 0.173 | 2.52 | 7.71 | | 26.73 | 529.0 | 14.6 | 357.0 | 20.7 |
| 378306 | OKPB01-010 | 07/12/2005 | 12:00 | 0.930 | 2.250 | 1.840 | 0.150 | 4.240 | 2.920 | 0.045 | 0.452 | 7.12 | 7.93 | 55.0 | 32.36 | 2065.0 | 982.0 | 2510.0 | 552.0 |
| 378535 | OKPB01-011 | 07/18/2005 | 10:46 | 0.140 | 1.280 | 0.720 | 0.050 | 2.050 | 0.910 | 0.103 | 0.199 | 4.74 | 8.06 | | 25.60 | 1535.0 | 261.0 | 999.0 | 178.0 |
| 377938 | OKPB01-013 | 07/25/2005 | 13:00 | 0.070 | 0.940 | 0.490 | 0.050 | 1.480 | 0.610 | 0.036 | 0.137 | 8.37 | 8.67 | 10.0 | 23.62 | 2090.0 | 366.0 | 1600.0 | 499.0 |
| 379181 | OKPB01-013 | 07/05/2005 | 10:30 | 0.050 | 1.460 | 0.310 | 0.050 | 1.820 | 0.410 | 0.006 | 0.036 | 8.80 | 8.50 | | 29.54 | 9079.0 | 2000.0 | 5930.0 | 1200.0 |
| 379180 | OKPB01-015 | 07/25/2005 | 15:06 | 0.290 | 2.450 | 0.050 | 0.050 | 2.550 | 0.390 | 0.103 | 0.189 | 8.88 | 8.07 | 55.0 | 30.35 | 13254.0 | 2200.0 | 10800.0 | 4500.0 |
| 378536 | OKPB01-017 | 07/18/2005 | 13:31 | 0.050 | 0.920 | 0.810 | 0.050 | 1.780 | 0.910 | 0.429 | 0.496 | 10.68 | 8.34 | 20.0 | 29.94 | 1029.0 | 181.0 | 675.0 | 90.2 |
| 377407 | OKPB01-019 | 07/11/2005 | 10:30 | 0.050 | 0.550 | 0.060 | 0.050 | 0.660 | 0.160 | 0.020 | 0.054 | 4.06 | 7.42 | 17.0 | 28.37 | 1043.0 | 277.0 | 690.0 | 10.0 |
| 378140 | OKPB01-019 | 06/28/2005 | 16:25 | 0.050 | 0.440 | 0.080 | 0.050 | 0.570 | 0.180 | 0.029 | 0.058 | 9.00 | 7.25 | 16.0 | 26.72 | 674.4 | 160.0 | 412.0 | 24.5 |
| 378757 | OKPB01-021 | 07/20/2005 | 10:31 | 0.050 | 1.830 | 0.810 | 0.050 | 2.690 | 0.910 | 0.013 | 0.082 | 7.21 | 8.12 | 14.0 | 26.92 | 946.4 | 0.0 | 670.0 | 0.0 |
| 378305 | OKPB01-022 | 07/12/2005 | 15:00 | 1.180 | 2.720 | 0.140 | 0.400 | 3.260 | 1.720 | 0.132 | 0.565 | 1.33 | 7.21 | 55.0 | 29.22 | 335.4 | 33.2 | 300.0 | 93.8 |
| 377406 | OKPB01-024 | 06/28/2005 | 18:00 | 0.070 | 0.060 | 0.530 | 0.050 | 0.640 | 0.650 | 0.030 | 0.041 | 9.90 | 7.25 | 5.0 | 28.25 | 192.0 | 10.0 | 135.0 | 10.0 |
| 377046 | OKPB01-026 | 06/22/2005 | 17:31 | 0.050 | 0.050 | 0.080 | 0.050 | 0.180 | 0.180 | 0.009 | 0.019 | 4.10 | 5.91 | 14.3 | 21.60 | 45.3 | 10.0 | 46.0 | 11.8 |
| 377225 | OKPB01-026 | 06/27/2005 | 16:33 | 0.050 | 0.050 | 0.060 | 0.050 | 0.160 | 0.160 | 0.009 | 0.020 | | | 5.0 | 23.00 | | 10.0 | 43.0 | 12.4 |
| 400503 | OKPB01-027 | 09/20/2006 | 13:00 | 0.120 | 2.520 | 0.340 | 0.050 | 2.910 | 0.510 | 0.056 | 0.520 | 13.51 | 7.98 | 25.0 | 21.93 | 3164.0 | 480.0 | 1970.0 | 797.0 |
| 405721 | OKPB01- | 07/05/2006 | 11:45 | 0.050 | 0.840 | 1.880 | 0.080 | 2.800 | 2.010 | 0.005 | 0.060 | 12.29 | 7.75 | 316.0 | 28.57 | 5200.0 | 920.0 | 3290.0 | 1320.0 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 027 | | | | | | | | | | | | | | | | | | |
| 377425 | OKPB01-028 | 06/29/2005 | 10:00 | 0.070 | 0.510 | 0.050 | 0.050 | 0.610 | 0.170 | 0.053 | 0.095 | 6.84 | 8.08 | 31.2 | 27.20 | 719.0 | 88.8 | 395.0 | 23.8 |
| 400627 | OKPB01-029 | 07/10/2006 | 14:30 | 0.050 | 0.580 | 0.050 | 0.050 | 0.680 | 0.150 | 0.299 | 0.352 | 6.26 | 8.31 | 12.0 | 30.34 | 1031.0 | 172.0 | 778.0 | 155.0 |
| 401943 | OKPB01-031 | 08/02/2006 | 13:45 | 0.050 | 1.420 | 0.050 | 0.050 | 1.520 | 0.150 | 0.037 | 0.176 | 6.12 | 8.13 | 46.0 | 31.11 | 922.8 | 79.9 | 483.0 | 17.2 |
| 401507 | OKPB01-032 | 07/25/2006 | 10:45 | 0.050 | 0.580 | 0.050 | 0.050 | 0.680 | 0.150 | 0.066 | 0.119 | 5.50 | 8.05 | 13.0 | 30.21 | 414.0 | 10.3 | 500.0 | 40.5 |
| 401194 | OKPB01-033 | 07/19/2000 | 09:45 | 0.070 | 0.880 | 0.050 | 0.050 | 0.980 | 0.170 | 0.009 | 0.129 | 6.67 | 8.16 | 213.0 | 30.15 | 341.2 | 74.1 | 242.0 | 10.0 |
| 376983 | OKPB01-034 | 06/21/2005 | 12:30 | 0.050 | 0.070 | 0.050 | 0.050 | 0.170 | 0.150 | 0.005 | 0.012 | 6.71 | 6.99 | 1.3 | 25.70 | 135.0 | 10.0 | 77.0 | 11.5 |
| 401884 | OKPB01-035 | 08/01/2006 | 10:30 | 0.050 | 4.870 | 0.050 | 0.050 | 4.970 | 0.150 | 0.113 | 0.329 | 4.25 | 8.01 | 19.0 | 25.72 | 104960.0 | 43400.0 | 63000.0 | 6810.0 |
| 400990 | OKPB01-036 | 07/17/2006 | 19:30 | 0.050 | 0.360 | 0.050 | 0.050 | 0.460 | 0.150 | 0.008 | 0.036 | 5.33 | 7.38 | 4.0 | 34.50 | 95.8 | 10.0 | 74.0 | 11.0 |
| 376980 | OKPB01-038 | 06/21/2005 | 18:30 | 0.050 | 0.230 | 0.050 | 0.050 | 0.330 | 0.150 | 0.008 | 0.038 | 9.10 | 7.00 | 5.0 | 30.45 | 30.0 | 10.0 | 80.0 | 10.0 |
| 400626 | OKPB01-043 | 07/10/2006 | 11:30 | 0.050 | 0.650 | 0.050 | 0.050 | 0.750 | 0.150 | 0.119 | 0.186 | 6.86 | 8.28 | 35.0 | 26.65 | 577.3 | 44.3 | 366.0 | 72.4 |
| 381694 | OKPB01-044 | 08/23/2005 | 14:45 | 0.050 | 0.800 | 0.050 | 0.050 | 0.900 | 0.150 | 0.007 | 0.074 | 3.06 | 6.36 | 5.0 | 30.05 | 70.4 | 10.0 | 61.0 | 10.0 |
| 376906 | OKPB01-046 | 06/20/2005 | 12:46 | 0.050 | 0.050 | 0.160 | 0.050 | 0.260 | 0.260 | 0.010 | 0.019 | 7.58 | 6.15 | 11.9 | 26.30 | 31.2 | 10.0 | 40.0 | 10.0 |
| 401600 | OKPB01-050 | 07/26/2006 | 12:45 | 0.050 | 0.490 | 0.050 | 0.050 | 0.590 | 0.150 | 0.011 | 0.051 | 4.44 | 7.64 | 17.0 | 27.88 | 341.9 | 10.0 | 207.0 | 10.6 |
| 400718 | OKPB01-051 | 07/11/2006 | 09:30 | 0.050 | 0.940 | 1.010 | 0.050 | 2.000 | 1.110 | 0.008 | 0.019 | 5.76 | 7.81 | 9.0 | 23.55 | 3084.0 | 51.1 | 3150.0 | 1960.0 |
| 400989 | OKPB01-052 | 07/17/2006 | 13:30 | 0.050 | 0.670 | 0.080 | 0.050 | 0.800 | 0.180 | 0.026 | 0.113 | 3.61 | 7.04 | 58.0 | 30.08 | 70.5 | 10.0 | 92.0 | 26.5 |
| 404506 | OKPB01-054 | 09/06/2006 | 15:45 | 0.090 | 1.240 | 0.050 | 0.050 | 1.340 | 0.190 | 0.025 | 0.104 | 3.36 | 7.21 | 160.0 | 23.68 | 276.0 | 10.0 | 86.0 | 27.1 |
| 377370 | OKPB01-056 | 06/28/2005 | 16:35 | 0.050 | 0.920 | 0.050 | 0.050 | 1.020 | 0.150 | 0.011 | 0.085 | 13.52 | 7.57 | 7.0 | 30.90 | 201.0 | 10.9 | 127.0 | 10.0 |
| 427911 | OKPB01-059 | 10/03/2007 | 15:00 | 0.170 | 1.270 | 0.240 | 0.100 | 1.610 | 0.510 | 0.199 | 0.364 | 6.34 | 8.37 | 154.0 | 23.89 | 363.0 | 53.4 | 276.0 | 48.4 |
| 419687 | OKPB01-060 | 06/12/2007 | 13:30 | 0.050 | 0.460 | 0.050 | 0.050 | 0.560 | 0.150 | 0.017 | 0.025 | 7.65 | 7.90 | 7.6 | 34.90 | 3781.0 | 1220.0 | 2210.0 | 36.0 |
| 428679 | OKPB01-064 | 10/16/2007 | 14:00 | 0.180 | 1.280 | 1.600 | 0.130 | 3.010 | 1.910 | 0.271 | 0.385 | 7.55 | 7.96 | 40.8 | 17.96 | 421.0 | 45.5 | 217.0 | 22.1 |
| 422988 | OKPB01- | 08/06/2007 | 10:00 | 0.050 | 0.490 | 0.050 | 0.050 | 0.590 | 0.150 | 0.009 | 0.039 | 4.59 | 7.34 | 5.3 | 28.60 | 801.0 | 10.0 | 554.0 | 296.0 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 072 | | | | | | | | | | | | | | | | | | |
| 423522 | OKPB01-073 | 08/14/2007 | 13:00 | 0.050 | 1.820 | 1.400 | 0.090 | 3.310 | 1.540 | 0.009 | 0.051 | 9.15 | 8.00 | 16.0 | 25.45 | 1382.0 | 222.0 | 771.0 | 128.0 |
| 423008 | OKPB01-076 | 08/06/2007 | 12:31 | 0.100 | 0.430 | 0.110 | 0.050 | 0.590 | 0.260 | 0.005 | 0.000 | 5.38 | 6.53 | 11.0 | 28.10 | 1626.0 | 10.0 | 1310.0 | 912.0 |
| 376977 | OKPB01-078 | 06/21/2005 | 11:30 | 0.050 | 0.170 | 0.050 | 0.050 | 0.270 | 0.150 | 0.007 | 0.025 | 7.00 | 7.00 | 5.0 | 28.62 | 0.0 | 10.0 | 45.0 | 10.0 |
| 419805 | OKPB01-081 | 06/13/2007 | 10:00 | 0.050 | 0.280 | 0.050 | 0.050 | 0.380 | 0.150 | 0.011 | 0.036 | 8.47 | 8.11 | 27.0 | 23.86 | 502.0 | 37.7 | 310.0 | 14.2 |
| 424913 | OKPB01-081 | 09/04/2007 | 11:00 | 0.070 | 0.160 | 0.050 | 0.050 | 0.260 | 0.170 | 0.010 | 0.023 | 2.98 | 7.86 | 26.0 | 22.29 | 539.0 | 33.6 | 287.0 | 18.0 |
| 376907 | OKPB01-084 | 06/20/2005 | 16:30 | 0.050 | 0.050 | 0.050 | 0.050 | 0.150 | 0.150 | 0.007 | 0.020 | 6.84 | 6.26 | 8.3 | 25.90 | 50.5 | 10.0 | 45.0 | 10.0 |
| 424988 | OKPB01-085 | 09/05/2007 | 10:31 | 0.050 | 0.410 | 0.050 | 0.050 | 0.510 | 0.150 | 0.031 | 0.064 | 12.90 | 8.40 | 5.5 | 25.45 | 945.0 | 147.0 | 588.0 | 60.4 |
| 422061 | OKPB01-092 | 07/25/2007 | 12:15 | 0.050 | 0.140 | 0.050 | 0.050 | 0.240 | 0.150 | 0.005 | 0.005 | 9.11 | 7.46 | 2.4 | 23.44 | 26.0 | 10.0 | 24.0 | 10.0 |
| 377044 | OKPB01-098 | 06/22/2005 | 10:01 | 0.050 | 1.030 | 0.050 | 0.050 | 1.130 | 0.150 | 0.025 | 0.200 | 0.43 | 6.86 | 14.2 | 22.20 | 184.6 | 10.0 | 124.0 | 27.9 |
| 423524 | OKPB01-099 | 08/14/2007 | 19:00 | 0.050 | 0.610 | 0.050 | 0.050 | 0.710 | 0.150 | 0.005 | 0.020 | 11.13 | 7.96 | 3.0 | 34.70 | 18146.0 | 5550.0 | 10200.0 | 1470.0 |
| 377368 | OKPB01-118 | 06/28/2005 | 11:39 | 0.070 | 0.350 | 0.050 | 0.050 | 0.450 | 0.170 | 0.012 | 0.033 | 4.67 | 7.49 | 5.2 | 24.60 | 956.0 | 170.0 | 566.0 | 18.4 |
| 381841 | OKPB01-130 | 08/24/2005 | 16:30 | 0.050 | 0.360 | 0.050 | 0.050 | 0.460 | 0.150 | 0.026 | 0.071 | | | | | | 10.0 | 212.0 | 10.0 |
| 377047 | OKPB01-134 | 06/22/2005 | 15:00 | 0.050 | 0.340 | 0.050 | 0.050 | 0.440 | 0.150 | 0.008 | 0.041 | 8.10 | 7.00 | 5.0 | 30.00 | 66.0 | 10.0 | 57.0 | 17.2 |
| 377045 | OKPB01-136 | 06/22/2005 | 13:31 | 0.080 | 0.520 | 0.160 | 0.050 | 0.730 | 0.290 | 0.012 | 0.043 | 4.36 | 7.38 | 15.1 | 22.80 | 153.5 | 10.0 | 105.0 | 16.0 |
| 376984 | OKPB01-138 | 06/21/2005 | 15:00 | 0.050 | 0.130 | 0.060 | 0.050 | 0.240 | 0.160 | 0.006 | 0.012 | 4.92 | 6.69 | 4.0 | 25.50 | 43.6 | 10.0 | 39.0 | 10.0 |
| 376981 | OKPB01-144 | 06/21/2005 | 07:30 | 0.050 | 0.050 | 0.050 | 0.050 | 0.150 | 0.150 | 0.005 | 0.012 | 9.24 | 6.98 | 5.1 | 21.60 | 27.5 | 10.0 | 81.0 | 10.0 |
| 377223 | OKPB01-144 | 06/27/2005 | 11:00 | 0.050 | 0.080 | 0.050 | 0.050 | 0.180 | 0.150 | 0.005 | 0.014 | 3.11 | 5.45 | 8.2 | 22.00 | 41.1 | 10.0 | 25.0 | 10.0 |
| 376978 | OKPB01-148 | 06/21/2005 | 15:00 | 0.050 | 0.090 | 0.050 | 0.050 | 0.190 | 0.150 | 0.006 | 0.016 | 9.00 | 7.25 | 2.8 | 28.05 | 20.0 | 10.0 | 32.0 | 10.0 |
| 377369 | OKPB01-154 | 06/28/2005 | 14:31 | 0.050 | 0.250 | 0.050 | 0.050 | 0.350 | 0.150 | 0.037 | 0.051 | 5.88 | 8.16 | 8.1 | 31.40 | 456.0 | 10.0 | 249.0 | 11.9 |
| 376903 | OKPB01-156 | 06/20/2005 | 12:40 | 0.080 | 0.710 | 0.050 | 0.050 | 0.810 | 0.180 | 0.026 | 0.092 | 2.20 | 7.00 | | 22.42 | 263.0 | 17.4 | 187.0 | 54.0 |
| 377426 | OKPB01- | 06/29/2005 | 15:01 | 0.050 | 0.390 | 0.120 | 0.050 | 0.560 | 0.220 | 0.089 | 0.123 | 5.33 | 7.17 | 50.6 | 27.90 | 630.0 | 44.5 | 343.0 | 16.5 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 170 | | | | | | | | | | | | | | | | | | |
| 376982 | OKPB01-196 | 06/21/2005 | 10:00 | 0.050 | 0.180 | 0.050 | 0.050 | 0.280 | 0.150 | 0.007 | 0.028 | 10.92 | 8.63 | 3.8 | 30.30 | 48.0 | 10.0 | 41.0 | 10.0 |
| 376905 | OKPB01-210 | 06/20/2005 | 10:09 | 0.050 | 0.050 | 0.050 | 0.050 | 0.150 | 0.150 | 0.010 | 0.023 | 4.85 | 5.46 | 14.9 | 22.50 | 38.3 | 10.0 | 48.0 | 13.2 |
| 419686 | OKPB01-212 | 06/12/2007 | 09:01 | 0.050 | 0.860 | 0.050 | 0.050 | 0.960 | 0.150 | 0.043 | 0.094 | 4.55 | 8.18 | 71.0 | 22.90 | 2411.0 | 61.2 | 1610.0 | 705.0 |
| 400229 | OKPB01-213 | 06/28/2006 | 10:00 | 0.050 | 0.520 | 0.050 | 0.050 | 0.620 | 0.150 | 0.012 | 0.070 | 8.41 | 8.02 | 26.3 | 24.00 | 1222.0 | 181.0 | 728.0 | 156.0 |
| 378424 | OKPB01-216 | 07/13/2005 | 15:16 | 0.210 | 1.300 | 0.700 | 0.380 | 2.380 | 1.290 | 0.042 | 0.134 | 7.59 | 7.58 | 54.7 | 28.80 | 482.0 | 70.1 | 291.0 | 45.2 |
| 400994 | OKPB01-220 | 07/17/2006 | 13:00 | 0.050 | 0.610 | 0.050 | 0.050 | 0.710 | 0.150 | 0.022 | 0.078 | 6.40 | 7.61 | 27.5 | 30.80 | 300.9 | 12.5 | 171.0 | 13.9 |
| 400122 | OKPB01-223 | 06/27/2006 | 10:00 | 0.220 | 0.790 | 0.050 | 0.050 | 0.890 | 0.320 | 0.013 | 0.075 | 4.43 | 7.14 | 18.6 | 23.60 | 324.3 | 12.4 | 232.0 | 65.9 |
| 378324 | OKPB01-224 | 07/12/2005 | 14:30 | 0.050 | 0.270 | 0.080 | 0.050 | 0.400 | 0.180 | 0.005 | 0.012 | 8.60 | 8.14 | 1.3 | 27.90 | 109.8 | 10.0 | 62.0 | 10.0 |
| 419231 | OKPB01-227 | 6/4/2007 | 0905 | 0.160 | 1.660 | 1.360 | 0.100 | 3.120 | 1.620 | 0.088 | 0.121 | 10.61 | 8.60 | 2.3 | 21.29 | 513.0 | 145.0 | 665.0 | 213.0 |
| 423520 | OKPB01-229 | 08/14/2007 | 10:16 | 0.050 | 0.540 | 0.050 | 0.050 | 0.640 | 0.150 | 0.019 | 0.039 | 16.02 | 8.19 | 3.0 | 22.61 | 7138.0 | 1550.0 | 3970.0 | 608.0 |
| 419688 | OKPB01-232 | 06/12/2007 | 16:00 | 0.050 | 0.270 | 0.050 | 0.050 | 0.370 | 0.150 | 0.010 | 0.022 | 6.75 | 7.82 | 4.9 | 23.29 | 1358.0 | 390.0 | 1030.0 | 42.3 |
| 423077 | OKPB01-235 | 08/15/2007 | 15:15 | 0.050 | 0.390 | 0.050 | 0.050 | 0.490 | 0.150 | 0.035 | 0.045 | 8.31 | 7.59 | 2.5 | 30.20 | 732.0 | 24.4 | 428.0 | 46.9 |
| 423631 | OKPB01-235 | 08/07/2007 | 15:00 | 0.050 | 0.330 | 0.050 | 0.050 | 0.430 | 0.150 | 0.026 | 0.046 | 7.32 | 7.80 | 3.4 | 31.70 | 742.0 | 29.4 | 439.0 | 54.0 |
| 399032 | OKPB01-236 | 06/13/2006 | 15:31 | 0.050 | 0.540 | 0.050 | 0.050 | 0.640 | 0.150 | 0.009 | 0.038 | 9.31 | 7.92 | 6.1 | 28.10 | 418.4 | 41.1 | 240.0 | 18.8 |
| 419834 | OKPB01-239 | 06/13/2007 | 10:00 | 0.050 | 0.330 | 0.100 | 0.050 | 0.480 | 0.200 | 0.036 | 0.058 | 7.53 | 7.94 | 1.5 | 23.60 | 4542.0 | 1270.0 | 2440.0 | 201.0 |
| 399029 | OKPB01-247 | 06/13/2006 | 10:15 | 0.370 | 1.440 | 0.050 | 0.050 | 1.540 | 0.470 | 0.047 | 0.199 | 1.79 | 7.51 | 8.7 | 22.40 | 562.0 | 24.4 | 316.0 | 10.0 |
| 419497 | OKPB01-251 | 08/08/2007 | 09:41 | 0.110 | 1.030 | 1.080 | 0.050 | 2.160 | 1.240 | 0.265 | 0.322 | 5.96 | 7.61 | 9.8 | 25.30 | 2484.0 | 262.0 | 1700.0 | 780.0 |
| 423146 | OKPB01-251 | 08/15/2007 | 10:00 | 0.050 | 0.750 | 1.110 | 0.050 | 1.910 | 1.210 | 0.069 | 0.097 | 6.28 | 7.43 | 24.0 | 25.30 | 3028.0 | 326.0 | 2130.0 | 952.0 |
| 423630 | OKPB01-251 | 06/06/2007 | 10:00 | 0.090 | 0.790 | 1.120 | 0.050 | 1.960 | 1.260 | 0.078 | 0.112 | 6.84 | 7.80 | 50.1 | 27.20 | 2928.0 | 385.0 | 2090.0 | 848.0 |
| 423148 | OKPB01-255 | 08/08/2007 | 14:30 | 0.050 | 0.890 | 0.050 | 0.050 | 0.990 | 0.150 | 0.009 | 0.037 | 6.50 | 7.81 | 11.2 | 28.20 | 403.8 | 10.0 | 223.0 | 24.4 |
| 377224 | OKPB01- | 06/27/2005 | 13:31 | 0.050 | 0.210 | 0.050 | 0.050 | 0.310 | 0.150 | 0.014 | 0.044 | 2.40 | 5.75 | 8.7 | 24.00 | 67.7 | 10.0 | 49.0 | 10.0 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 256 | | | | | | | | | | | | | | | | | | |
| 399143 | OKPB01-260 | 06/14/2006 | 09:31 | 0.050 | 0.410 | 0.050 | 0.050 | 0.510 | 0.150 | 0.020 | 0.038 | 7.94 | 7.83 | 1.7 | 21.30 | 3939.0 | 10.0 | 4300.0 | 2390.0 |
| 378422 | OKPB01-266 | 07/13/2005 | 10:31 | 0.050 | 0.450 | 0.050 | 0.050 | 0.550 | 0.150 | 0.005 | 0.030 | 3.65 | 7.40 | 3.4 | 28.20 | 410.0 | 10.0 | 200.0 | 16.2 |
| 428678 | OKPB01-267 | 10/15/2007 | 17:00 | 0.050 | 0.320 | 0.230 | 0.050 | 0.600 | 0.330 | 0.075 | 0.082 | 10.65 | 8.31 | 3.5 | 18.94 | 766.0 | 113.0 | 398.0 | 56.7 |
| 419409 | OKPB01-282 | 06/06/2007 | | 0.050 | 0.360 | 0.740 | 0.050 | 1.150 | 0.840 | 0.059 | 0.073 | 10.52 | 7.96 | 9.0 | 20.60 | 597.0 | 18.3 | 409.0 | 31.2 |
| 423075 | OKPB01-283 | 08/07/2007 | 10:00 | 0.050 | 1.190 | 3.380 | 0.090 | 4.660 | 3.520 | 0.401 | 0.487 | 6.62 | 7.77 | 19.7 | 26.10 | 1911.0 | 288.0 | 1150.0 | 258.0 |
| 398400 | OKPB01-284 | 06/05/2006 | 12:30 | 0.690 | 2.710 | 0.190 | 0.230 | 3.130 | 1.110 | 0.033 | 0.250 | 5.15 | 7.37 | 77.8 | 24.40 | 398.9 | 14.7 | 242.0 | 74.0 |
| 399144 | OKPB01-292 | 06/14/2006 | 12:31 | 0.870 | 3.710 | 0.070 | 0.190 | 3.970 | 1.130 | 0.040 | 0.236 | 1.92 | 6.85 | 93.3 | 30.10 | 314.8 | 142.0 | 489.0 | 87.9 |
| 423920 | OKPB01-293 | 08/21/2007 | 11:15 | 0.050 | 1.360 | 0.500 | 0.050 | 1.910 | 0.600 | 0.058 | 0.191 | 4.74 | 7.92 | 70.1 | 26.00 | 1939.0 | 89.0 | 1470.0 | 822.0 |
| 378423 | OKPB01-298 | 07/13/2005 | 12:01 | 2.640 | 4.380 | 0.130 | 0.130 | 4.640 | 2.900 | 0.235 | 0.344 | 2.42 | 7.25 | 10.8 | 25.90 | 401.0 | 19.4 | 245.0 | 29.6 |
| 423410 | OKPB01-299 | 08/13/2007 | 11:30 | 0.050 | 0.480 | 0.050 | 0.050 | 0.580 | 0.150 | 0.012 | 0.037 | 3.94 | 7.21 | 8.3 | 27.00 | 539.0 | 15.1 | 304.0 | 21.4 |
| 378323 | OKPB01-302 | 07/12/2005 | 10:31 | 0.050 | 0.350 | 0.050 | 0.050 | 0.450 | 0.150 | 0.005 | 0.043 | 4.34 | 6.34 | 5.4 | 26.50 | 41.2 | 10.0 | 34.0 | 10.0 |
| 400124 | OKPB01-311 | 06/27/2006 | 13:45 | 0.320 | 0.880 | 0.050 | 0.050 | 0.980 | 0.420 | 0.016 | 0.088 | 9.36 | 8.16 | 23.1 | 24.50 | 347.7 | 10.0 | 207.0 | 47.8 |
| 398742 | OKPB01-317 | 06/07/2006 | 10:46 | 0.050 | 0.330 | 0.110 | 0.050 | 0.490 | 0.210 | 0.016 | 0.024 | 6.79 | 7.71 | 4.2 | 22.40 | 1900.0 | 29.8 | 1620.0 | 225.0 |
| 427729 | OKPB01-323 | 10/01/2007 | 14:30 | 0.050 | 2.140 | 1.170 | 0.050 | 3.360 | 1.270 | 0.289 | 0.555 | 14.90 | 8.72 | 17.0 | 23.23 | 173.0 | 271.0 | 1020.0 | 200.0 |
| 404083 | OKPB01-327 | 08/29/2006 | 12:30 | 0.110 | 1.040 | 1.020 | 0.080 | 2.140 | 1.210 | 0.215 | 0.294 | 5.71 | 7.67 | 29.0 | 28.33 | 332.2 | 29.6 | 209.0 | 49.9 |
| 399113 | OKPB01-328 | 06/14/2006 | 10:45 | 0.050 | 0.420 | 0.060 | 0.050 | 0.530 | 0.160 | 0.007 | 0.036 | 6.36 | 7.62 | 10.0 | 28.09 | 126.1 | 10.0 | 49.0 | 10.0 |
| 400115 | OKPB01-330 | 06/27/2006 | 09:00 | 0.190 | 0.440 | 0.050 | 0.050 | 0.540 | 0.290 | 0.043 | 0.102 | 2.65 | 7.67 | 18.0 | 27.51 | 552.0 | 40.7 | 308.0 | 21.0 |
| 398405 | OKPB01-335 | 06/05/2006 | 12:31 | 0.050 | 0.700 | 0.050 | 0.050 | 0.800 | 0.150 | 0.011 | 0.070 | 6.80 | 7.36 | 6.8 | 29.34 | 3303.0 | 815.0 | 1990.0 | 366.0 |
| 398989 | OKPB01-336 | 06/13/2006 | 09:15 | 0.050 | 0.230 | 0.370 | 0.050 | 0.650 | 0.470 | 0.010 | 0.032 | 6.70 | 7.79 | 4.0 | 23.22 | 291.7 | 14.1 | 220.0 | 16.4 |
| 398987 | OKPB01-342 | 06/12/2006 | 19:00 | 0.050 | 0.430 | 0.050 | 0.050 | 0.530 | 0.150 | 0.006 | 0.042 | 5.30 | 7.19 | 6.4 | 30.74 | 124.9 | 10.0 | 61.0 | 10.0 |
| 423489 | OKPB01- | 08/14/2007 | 14:45 | 0.050 | 0.870 | 0.130 | 0.050 | 1.050 | 0.230 | 0.054 | 0.093 | 8.54 | 7.59 | 18.6 | 29.80 | 2884.0 | 992.0 | 2910.0 | 1020.0 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 343 | | | | | | | | | | | | | | | | | | |
| 426010 | OKPB01-344 | 09/17/2007 | 14:30 | 0.050 | 0.790 | 0.160 | 0.050 | 1.000 | 0.260 | 0.038 | 0.087 | 6.63 | 7.88 | 69.0 | 31.60 | 201.0 | 12.5 | 170.0 | 40.8 |
| 423076 | OKPB01-347 | 08/07/2007 | 12:50 | 0.050 | 0.550 | 0.050 | 0.050 | 0.650 | 0.150 | 0.035 | 0.097 | 11.55 | 8.03 | 2.8 | 32.00 | 3897.0 | 1190.0 | 2130.0 | 82.2 |
| 399031 | OKPB01-348 | 06/13/2006 | 13:50 | 0.050 | 0.610 | 0.050 | 0.050 | 0.710 | 0.150 | 0.012 | 0.051 | 7.64 | 7.65 | 19.4 | 28.10 | 484.0 | 30.1 | 281.0 | 23.4 |
| 423147 | OKPB01-355 | 08/08/2007 | 12:00 | 0.050 | 0.490 | 0.500 | 0.050 | 1.040 | 0.600 | 0.111 | 0.125 | 7.34 | 7.83 | 12.1 | 27.20 | 1096.0 | 61.7 | 776.0 | 273.0 |
| 423921 | OKPB01-357 | 08/21/2007 | 13:30 | 0.050 | 0.700 | 0.050 | 0.050 | 0.800 | 0.150 | 0.006 | 0.047 | 7.70 | 7.77 | 42.6 | 26.60 | 3232.0 | 97.9 | 2950.0 | 845.0 |
| 426397 | OKPB01-360 | 09/19/2007 | 16:00 | 0.050 | 0.780 | 0.070 | 0.050 | 0.900 | 0.170 | 0.042 | 0.096 | 7.40 | 8.10 | 72.3 | 25.18 | 362.0 | 22.4 | 234.0 | 13.8 |
| 423487 | OKPB01-363 | 08/14/2007 | 10:00 | 0.070 | 1.480 | 0.200 | 0.060 | 1.740 | 0.330 | 0.160 | 0.279 | 6.35 | 7.88 | 104.0 | 29.30 | 553.0 | 88.3 | 308.0 | 35.2 |
| 401079 | OKPB01-369 | 07/18/2006 | 11:00 | 0.050 | 2.580 | 4.280 | 0.340 | 7.200 | 4.670 | 0.677 | 0.950 | 10.38 | 9.18 | 16.0 | 36.73 | 719.4 | 71.0 | 443.0 | 91.4 |
| 402552 | OKPB01-369 | 08/09/2006 | 13:30 | 0.050 | 3.330 | 3.560 | 0.920 | 7.810 | 4.530 | 1.070 | 1.260 | 9.97 | 9.21 | 14.0 | 27.41 | 578.9 | 86.3 | 543.0 | 130.0 |
| 401164 | OKPB01-372 | 07/18/2006 | 15:00 | 0.050 | 0.130 | 1.240 | 0.050 | 1.420 | 1.340 | 0.038 | 0.048 | 8.81 | 7.19 | 0.9 | 23.90 | 302.8 | 10.0 | 171.0 | 10.0 |
| 401901 | OKPB01-372 | 08/01/2006 | 14:00 | 0.050 | 0.130 | 0.930 | 0.050 | 1.110 | 1.030 | 0.033 | 0.048 | 4.30 | 7.45 | 1.9 | 24.30 | 319.1 | 10.0 | 169.0 | 10.0 |
| 419233 | OKPB01-376 | 06/04/2007 | | 0.080 | 0.980 | 0.170 | 0.050 | 1.200 | 0.300 | 0.061 | 0.104 | 5.46 | 7.17 | 33.3 | 25.50 | 1475.0 | 10.0 | 344.0 | 51.3 |
| 423769 | OKPB01-389 | 08/20/2007 | 14:00 | 0.050 | 0.290 | 0.050 | 0.050 | 0.390 | 0.150 | 0.005 | 0.016 | 7.29 | 7.64 | 3.7 | 35.40 | 2615.0 | 486.0 | 2200.0 | 1180.0 |
| 404084 | OKPB01-391 | 08/29/2006 | 14:40 | 0.220 | 0.910 | 0.510 | 0.070 | 1.490 | 0.800 | 0.111 | 0.167 | 5.45 | 7.73 | 15.0 | 29.86 | 349.6 | 23.9 | 219.0 | 55.7 |
| 422987 | OKPB01-395 | 08/06/2007 | 14:30 | 0.050 | 0.720 | 0.050 | 0.050 | 0.820 | 0.150 | 0.007 | 0.040 | 8.63 | 7.71 | 18.2 | 35.80 | 245.4 | 10.0 | 167.0 | 15.7 |
| 399981 | OKPB01-399 | 06/26/2006 | 10:00 | 0.210 | 0.990 | 0.050 | 0.050 | 1.090 | 0.310 | 0.017 | 0.096 | 6.12 | 7.40 | 9.7 | 23.40 | 1017.0 | 212.0 | 556.0 | 37.9 |
| 398399 | OKPB01-404 | 06/05/2006 | 10:00 | 0.150 | 1.920 | 0.050 | 0.050 | 2.020 | 0.250 | 0.016 | 0.173 | 2.38 | 6.70 | 1.9 | 23.20 | 0.2 | 10.0 | 168.0 | 30.5 |
| 423488 | OKPB01-405 | 08/14/2007 | 13:00 | 0.070 | 0.750 | 0.430 | 0.050 | 1.230 | 0.550 | 0.044 | 0.073 | 6.70 | 7.36 | 76.0 | 26.30 | 3707.0 | 656.0 | 2620.0 | 1130.0 |
| 419234 | OKPB01-424 | 6/4/2007 | | 0.050 | 0.460 | 0.050 | 0.050 | 0.560 | 0.150 | 0.010 | 0.018 | 6.50 | 7.12 | 16.6 | 27.10 | 133.8 | 10.0 | 89.0 | 21.4 |
| 398514 | OKPB01-429 | 06/06/2006 | 10:41 | 0.110 | 0.700 | 0.090 | 0.050 | 0.840 | 0.250 | 0.259 | 0.316 | 7.03 | 7.63 | 7.6 | 23.90 | 692.0 | 13.9 | 386.0 | 13.5 |
| 399982 | OKPB01- | 06/26/2006 | 13:15 | 0.210 | 1.160 | 0.050 | 0.050 | 1.260 | 0.310 | 0.000 | 0.093 | 4.64 | 8.10 | 7.5 | 25.50 | 408.9 | 14.6 | 239.0 | 23.7 |

| Sample ID | Station ID | Sample Date | Sample Time | $NH_3$ (mg/L) | TKN (mg/L) | $NO_3$ (mg/L) | NO2 (mg/L) | TN (mg/L) | AN (mg/L) | P-Ortho (mg/L) | P-Total (mg/L) | DO (mg/L) | pH (std units) | Turb. (NTU) | Water Temp. (°C) | Cond. (us/cm) | Cl (mg/L) | TDS (mg/L) | Su (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 431 | | | | | | | | | | | | | | | | | | |
| 398743 | OKPB01-453 | 06/07/2006 | 13:46 | 0.050 | 0.390 | 0.050 | 0.050 | 0.490 | 0.150 | 0.007 | 0.015 | 7.46 | 8.17 | 1.6 | 33.20 | 2686.0 | 640.0 | 1660.0 | 188.0 |
| 400230 | OKPB01-469 | 06/28/2006 | 12:15 | 0.050 | 0.480 | 0.050 | 0.050 | 0.580 | 0.150 | 0.006 | 0.022 | 9.06 | 8.17 | 2.6 | 28.60 | 1861.0 | 268.0 | 1200.0 | 405.0 |
| 398740 | OKPB01-495 | 06/07/2006 | 09:01 | 0.050 | 2.810 | 0.050 | 0.050 | 2.910 | 0.150 | 0.012 | 0.206 | 1.25 | 7.53 | 18.0 | 23.53 | 10310.0 | 2590.0 | 6270.0 | 240.0 |
| 422417 | OKPB01-504 | 07/30/2007 | 11:45 | 0.050 | 0.590 | 0.110 | 0.100 | 0.800 | 0.260 | 0.005 | 0.035 | 5.28 | 7.32 | 7.5 | 28.13 | 266.0 | 15.1 | 151.0 | 31.4 |
| 400993 | OKPB01-519 | 07/17/2006 | 10:15 | 0.050 | 1.080 | 1.730 | 0.050 | 2.860 | 1.830 | 0.353 | 0.446 | 5.77 | 7.44 | 47.3 | 31.50 | 374.4 | 34.8 | 203.0 | 31.6 |
| 398406 | OKPB01-527 | 06/05/2006 | 14:01 | 0.050 | 0.990 | 0.050 | 0.050 | 1.090 | 0.150 | 0.009 | 0.110 | 3.83 | 7.36 | 9.5 | 29.07 | 1776.0 | 309.0 | 1060.0 | 195.0 |
| 399145 | OKPB01-548 | 06/14/2006 | 15:01 | 0.050 | 1.600 | 0.050 | 0.050 | 1.700 | 0.150 | 0.020 | 0.138 | 10.00 | 6.60 | 26.5 | 32.00 | 291.3 | 10.0 | 175.0 | 29.3 |
| 422668 | OKPB01-552 | 08/01/2007 | 11:20 | 0.050 | 0.720 | 0.060 | 0.050 | 0.830 | 0.160 | 0.010 | 0.065 | 2.69 | 7.23 | 20.0 | 25.98 | 276.0 | 11.0 | 175.0 | 20.4 |
| 398771 | OKPB01-567 | 06/07/2006 | 14:31 | 0.050 | 0.720 | 0.050 | 0.050 | 0.820 | 0.150 | 0.005 | 0.030 | 7.13 | 6.96 | 5.0 | 29.50 | 226.1 | 18.4 | 131.0 | 18.7 |
| 398515 | OKPB01-581 | 06/06/2006 | 13:51 | 0.050 | 0.630 | 0.050 | 0.050 | 0.730 | 0.150 | 0.005 | 0.024 | 6.28 | 8.29 | 3.5 | 34.10 | 2785.0 | 565.0 | 1790.0 | 265.0 |
| 398401 | OKPB01-583 | 06/05/2006 | 14:55 | 0.050 | 0.340 | 0.080 | 0.050 | 0.470 | 0.180 | 0.009 | 0.030 | 7.14 | 7.60 | 7.3 | 25.20 | 1161.0 | 39.1 | 819.0 | 413.0 |
| 400123 | OKPB01-583 | 06/27/2006 | 11:30 | 0.050 | 0.260 | 0.050 | 0.050 | 0.360 | 0.150 | 0.018 | 0.036 | 5.70 | 7.52 | 10.2 | 22.50 | 1344.0 | 30.9 | 1040.0 | 545.0 |
| 426396 | OKPB01-616 | 09/18/2007 | 19:00 | 0.050 | 1.030 | 0.050 | 0.050 | 1.130 | 0.150 | 0.048 | 0.173 | 9.71 | 8.22 | 67.4 | 26.18 | 721.0 | 66.7 | 470.0 | 145.0 |
| 398770 | OKPB01-619 | 06/07/2006 | 10:45 | 0.050 | 0.430 | 0.050 | 0.050 | 0.530 | 0.150 | 0.005 | 0.025 | 10.76 | 8.30 | 2.7 | 27.50 | 309.6 | 10.0 | 185.0 | 15.8 |

**Table 17. Appendix C—Habitat Data for All Sites.**

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| OKPB01-003 | 78.5 | 99% | NC | 0% | 91% | impaired | Unimpaired |
| OKPB01-005 | 96.5 | 10% | 5% | 40% | 61% | impaired | Unimpaired |
| OKPB01-008 | 90.2 | 36% | 1% | 16% | 87% | impaired | Impaired |
| OKPB01-009 | 53.2 | 85% | NC | 28% | 87% | impaired | impaired |
| OKPB01-010 | 86.6 | 100% | 100% | 16% | 87% | impaired | impaired |
| OKPB01-011 | 85.1 | 61% | 20% | 8% | 70% | impaired | impaired |
| OKPB01-013 | 64.2 | 98% | NC | 0% | 87% | impaired | impaired |
| OKPB01-013 | 65.7 | 97% | NC | 8% | 87% | impaired | impaired |
| OKPB01-015 | 44.5 | 100% | NC | 0% | 87% | impaired | impaired |
| OKPB01-019 | 88.7 | 16% | 9% | 28% | 87% | impaired | impaired |
| OKPB01-021 | 78.2 | 100% | NC | 4% | 87% | impaired | impaired |
| OKPB01-022 | 74.2 | 99% | NC | 48% | 87% | impaired | impaired |
| OKPB01-024 | 90.0 | 29% | 10% | 28% | 48% | impaired | unimpaired |
| OKPB01-027 | 48.3 | 85% | 89% | 0% | 87% | impaired | impaired |
| OKPB01-027 | 85.1 | 100% | 100% | 0% | 0% | impaired | impaired |
| OKPB01-028 | 104.2 | 88% | 96% | 36% | 0% | impaired | impaired |
| OKPB01-029 | 88.7 | 16% | NC | 28% | 87% | impaired | unimpaired |
| OKPB01-031 | 63.7 | 86% | NC | 12% | 87% | impaired | impaired |
| OKPB01-032 | 67.3 | 54% | 100% | 0% | 87% | impaired | impaired |
| OKPB01- | 77.4 | 97% | 88% | 12% | 87% | impaired | impaired |

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| 033 | | | | | | | |
| OKPB01-034 | 100.2 | 6% | 3% | 16% | 26% | impaired | impaired |
| OKPB01-034 | 92.2 | 6% | NC | 12% | 26% | impaired | impaired |
| OKPB01-035 | 45.9 | 65% | NC | 0% | 87% | impaired | impaired |
| OKPB01-036 | 80.9 | 26% | 8% | 20% | 65% | impaired | impaired |
| OKPB01-038 | 83.5 | 3% | 5% | 44% | 57% | impaired | impaired |
| OKPB01-043 | 83.5 | 41% | 97% | 40% | 87% | impaired | impaired |
| OKPB01-044 | 81.9 | 27% | 5% | 32% | 48% | impaired | impaired |
| OKPB01-046 | 97.8 | 2% | 9% | 0% | 0% | impaired | impaired |
| OKPB01-050 | 73.3 | 33% | NC | 80% | | impaired | unimpaired |
| OKPB01-051 | 57.9 | 62% | 25% | 0% | 87% | impaired | impaired |
| OKPB01-052 | 77.6 | 26% | 10% | 28% | 87% | impaired | impaired |
| OKPB01-054 | 86.2 | 52% | NC | 64% | 87% | impaired | impaired |
| OKPB01-056 | 67.0 | 62% | 0% | 4% | 13% | impaired | impaired |
| OKPB01-059 | 75.2 | 90% | NC | 0% | 48% | impaired | impaired |
| OKPB01-060 | 61.7 | 96% | 62% | 4% | 87% | impaired | impaired |
| OKPB01-064 | 77.7 | 97% | 100% | 8% | 4% | impaired | impaired |
| OKPB01-072 | 95.3 | 22% | 40% | 60% | 26% | impaired | unimpaired |
| OKPB01-073 | 84.7 | 87% | 100% | 4% | 87% | impaired | impaired |
| OKPB01-076 | 99.1 | 77% | 50% | 68% | 61% | impaired | impaired |
| OKPB01-078 | 83.6 | 5% | 0% | 32% | 65% | impaired | impaired |
| OKPB01-081 | 53.3 | 83% | 61% | 0% | 87% | impaired | impaired |
| OKPB01-081 | 60.5 | 60% | 93% | 0% | 48% | impaired | impaired |
| OKPB01-085 | 87.9 | 95% | NC | 20% | 48% | impaired | impaired |

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| OKPB01-092 | 99.8 | 10% | 5% | 12% | 87% | impaired | impaired |
| OKPB01-098 | 100.6 | 68% | NC | 72% | 0% | impaired | unimpaired |
| OKPB01-099 | 82.9 | 83% | 100% | 0% | 87% | impaired | impaired |
| OKPB01-118 | 86.3 | 82% | NC | 12% | 48% | impaired | impaired |
| OKPB01-118 | 90.2 | 81% | NC | 20% | 48% | impaired | impaired |
| OKPB01-130 | 95.7 | 82% | 100% | 64% | 87% | impaired | impaired |
| OKPB01-134 | 92.9 | 13% | 9% | 32% | 87% | impaired | impaired |
| OKPB01-136 | 108.3 | 93% | 0% | 52% | 0% | impaired | unimpaired |
| OKPB01-138 | 87.4 | 10% | 0% | 0% | 13% | impaired | unimpaired |
| OKPB01-144 | 79.0 | 0% | NC | 8% | 0% | unimpaired | unimpaired |
| OKPB01-148 | 114.1 | 13% | 5% | 60% | 22% | impaired | impaired |
| OKPB01-154 | 92.9 | 94% | 17% | 80% | 0% | impaired | impaired |
| OKPB01-156 | 84.1 | 34% | 0% | 48% | 87% | impaired | impaired |
| OKPB01-170 | 109.0 | 70% | NC | 76% | 0% | impaired | unimpaired |
| OKPB01-196 | 101.7 | 3% | 5% | 32% | 0% | impaired | unimpaired |
| OKPB01-210 | 108.2 | 2% | 5% | 12% | 0% | impaired | impaired |
| OKPB01-212 | 69.1 | 100% | NC | 80% | 0% | impaired | unimpaired |
| OKPB01-213 | 79.9 | 93% | NC | 0% | 87% | impaired | unimpaired |
| OKPB01-216 | 97.0 | 50% | 23% | 60% | 0% | impaired | impaired |
| OKPB01-220 | 99.6 | 26% | NC | 40% | 9% | unimpaired | unimpaired |
| OKPB01-223 | 100.4 | 67% | NC | 56% | 4% | impaired | unimpaired |
| OKPB01-224 | 88.0 | 0% | NC | 0% | 0% | impaired | unimpaired |
| OKPB01-227 | 66.1 | 0% | 0% | 0% | 9% | impaired | unimpaired |
| OKPB01- | 71.2 | 98% | NC | 0% | 87% | impaired | unimpaired |

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| 229 | | | | | | | |
| OKPB01-232 | 84.3 | 99% | NC | 48% | 57% | impaired | impaired |
| OKPB01-235 | 69.8 | 73% | NC | 12% | 39% | impaired | impaired |
| OKPB01-235 | 85.5 | 73% | NC | 20% | 43% | impaired | impaired |
| OKPB01-236 | 89.3 | 24% | 0% | 36% | 57% | impaired | impaired |
| OKPB01-239 | 95.4 | 100% | NC | 0% | 0% | impaired | impaired |
| OKPB01-247 | 75.0 | 80% | NC | 64% | 22% | impaired | unimpaired |
| OKPB01-251 | 96.6 | 84% | NC | 20% | 35% | impaired | impaired |
| OKPB01-251 | 94.8 | 84% | NC | 16% | 22% | impaired | unimpaired |
| OKPB01-256 | 99.9 | 7% | 10% | 24% | 0% | impaired | impaired |
| OKPB01-260 | 96.2 | 94% | NC | 28% | 0% | impaired | unimpaired |
| OKPB01-266 | 81.8 | 48% | 0% | 28% | 87% | impaired | impaired |
| OKPB01-267 | 75.5 | 88% | NC | 0% | 87% | impaired | impaired |
| OKPB01-282 | 91.4 | 98% | NC | 32% | 61% | impaired | impaired |
| OKPB01-283 | 90.7 | 85% | NC | 16% | 35% | impaired | unimpaired |
| OKPB01-284 | 69.3 | 77% | NC | 0% | 35% | impaired | impaired |
| OKPB01-292 | 64.5 | 74% | NC | 24% | 22% | impaired | unimpaired |
| OKPB01-293 | 114.4 | 72% | NC | 56% | 17% | unimpaired | unimpaired |
| OKPB01-298 | 86.2 | 46% | 43% | 36% | 74% | impaired | impaired |
| OKPB01-299 | 95.4 | 41% | NC | 80% | 0% | impaired | unimpaired |
| OKPB01-302 | 93.7 | 6% | 0% | 0% | 0% | impaired | unimpaired |
| OKPB01-311 | 83.4 | 34% | NC | 4% | 22% | impaired | unimpaired |
| OKPB01-317 | 86.6 | 84% | NC | 8% | 13% | impaired | unimpaired |
| OKPB01-323 | 69.7 | 91% | 70% | 36% | 87% | impaired | impaired |

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| OKPB01-327 | 56.3 | 100% | NC | 80% | 87% | impaired | impaired |
| OKPB01-328 | 77.5 | 1% | 7% | 64% | 87% | impaired | unimpaired |
| OKPB01-330 | 74.0 | 90% | NC | 80% | 87% | impaired | impaired |
| OKPB01-335 | 63.0 | 72% | NC | 0% | 87% | impaired | impaired |
| OKPB01-336 | 80.8 | 90% | 100% | 4% | 87% | impaired | impaired |
| OKPB01-342 | 97.0 | 25% | 15% | 64% | 87% | impaired | unimpaired |
| OKPB01-343 | 111.2 | 88% | NC | 64% | 39% | impaired | unimpaired |
| OKPB01-344 | 88.7 | 66% | 20% | 76% | 61% | impaired | impaired |
| OKPB01-347 | 90.3 | 54% | NC | 0% | 70% | impaired | impaired |
| OKPB01-348 | 63.0 | 31% | 0% | 12% | 39% | impaired | impaired |
| OKPB01-355 | 96.7 | 99% | NC | 0% | 22% | impaired | impaired |
| OKPB01-357 | 94.2 | 89% | NC | 48% | 26% | impaired | unimpaired |
| OKPB01-360 | 90.6 | 100% | NC | 0% | 17% | impaired | impaired |
| OKPB01-363 | 89.9 | 78% | NC | 32% | 74% | impaired | impaired |
| OKPB01-369 | 70.7 | 75% | NC | 0% | 87% | impaired | impaired |
| OKPB01-369 | 68.9 | 98% | NC | 0% | 87% | impaired | impaired |
| OKPB01-372 | 92.4 | 3% | 13% | 32% | 61% | unimpaired | unimpaired |
| OKPB01-372 | 98.0 | 4% | 13% | 40% | 61% | unimpaired | unimpaired |
| OKPB01-376 | 97.7 | 48% | 15% | 60% | 57% | impaired | impaired |
| OKPB01-389 | 72.4 | 98% | NC | 0% | 87% | impaired | impaired |
| OKPB01-391 | 73.0 | 100% | NC | 80% | 87% | impaired | impaired |
| OKPB01-395 | 51.9 | 0% | NC | 0% | 0% | impaired | unimpaired |
| OKPB01-399 | 88.0 | 98% | NC | 20% | 0% | impaired | unimpaired |
| OKPB01- | 74.2 | 53% | NC | 20% | 39% | impaired | impaired |

| SITE_ID | Final Habitat Score | % Loose Bed Material | % Embeddedness | % Deep Pools | % Point Bars | Sed USAP- 1 Parameter | Sed USAP- 2 Parameter |
|---|---|---|---|---|---|---|---|
| 404 | | | | | | | |
| OKPB01-405 | 100.7 | 82% | NC | 40% | 30% | impaired | unimpaired |
| OKPB01-429 | 58.5 | 100% | NC | 0% | 78% | impaired | impaired |
| OKPB01-429 | 67.0 | 99% | NC | 4% | 43% | impaired | impaired |
| OKPB01-431 | 80.9 | 100% | NC | 8% | 9% | impaired | impaired |
| OKPB01-453 | 68.8 | 96% | NC | 12% | 87% | impaired | impaired |
| OKPB01-469 | 70.1 | 93% | NC | 0% | 87% | impaired | unimpaired |
| OKPB01-495 | 53.5 | 74% | NC | 0% | 87% | impaired | impaired |
| OKPB01-504 | 87.9 | 63% | 100% | 44% | 87% | impaired | impaired |
| OKPB01-519 | 97.3 | 25% | 0% | 76% | 4% | unimpaired | unimpaired |
| OKPB01-527 | 73.4 | 63% | NC | 16% | 87% | impaired | impaired |
| OKPB01-548 | 64.7 | 83% | NC | 16% | 4% | impaired | unimpaired |
| OKPB01-552 | 98.3 | 98% | NC | 40% | 87% | impaired | impaired |
| OKPB01-567 | 93.1 | 11% | 0% | 40% | 0% | unimpaired | unimpaired |
| OKPB01-581 | 59.2 | 95% | 0% | 4% | 87% | impaired | impaired |
| OKPB01-583 | 90.8 | 25% | 25% | 44% | 52% | impaired | impaired |
| OKPB01-616 | 63.9 | 100% | NC | 0% | 87% | impaired | impaired |
| OKPB01-619 | 71.5 | 27% | NC | 16% | 0% | impaired | impaired |

**Table 18. Appendix C—Fish and Macroinvertebrate Scores and Classifications for All Sites.**

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| OKPB01-003 | 18 | Undetermined | 84 | Good | Good | 112 | Non-impaired | Good |
| OKPB01-005 | 33 | No Biocriteria | 85 | Good | Good | 113 | Non-impaired | Good |
| OKPB01-008 | 35 | Supporting | 92 | Excellent | Good | 92 | Non-impaired | Good |
| OKPB01-009 | 26 | Supporting | 92 | Excellent | Good | 81 | Non-impaired | Good |
| OKPB01-010 | 25 | Undetermined | No ref | No Reference | Good | 88 | Non-impaired | Good |
| OKPB01-011 | 27 | Supporting | 92 | Excellent | Good | 113 | Non-impaired | Good |
| OKPB01-013 | 23 | Supporting | 100 | Excellent | Good | 106 | Non-impaired | Good |
| OKPB01-015 | 23 | Supporting | 74 | Fair | Good | 58 | Slightly Impaired | Poor |
| OKPB01-017 | 20 | Undetermined | 92 | Excellent | Good | 124 | Non-impaired | Good |
| OKPB01-019 | 31 | Supporting | 78 | Good | Good | 74 | Slightly Impaired | Poor |
| OKPB01-021 | 20 | Undetermined | 63 | Fair | Poor | 92 | Non-impaired | Good |
| OKPB01-022 | 20 | Undetermined | 57 | Poor | Poor | 140 | Non-impaired | Good |
| OKPB01-024 | 39 | Supporting | 100 | Excellent | Good | 118 | Non-impaired | Good |
| OKPB01-026 | No Collection | No Score | No Collection | No Score | No Score | 108 | Non-impaired | Good |
| OKPB01-027 | 21 | Undetermined | 61 | Poor | Poor | 75 | Slightly Impaired | Poor |
| OKPB01-028 | 33 | No Biocriteria | 92 | Excellent | Good | 112 | Non-impaired | Good |
| OKPB01-029 | 23 | Supporting | 91 | Excellent | Good | 69 | Slightly Impaired | Poor |
| OKPB01-031 | 26 | Supporting | 70 | Fair | Good | 73 | Slightly Impaired | Poor |
| OKPB01- | 24 | Undetermined | 52 | Poor | Poor | 42 | Moderately Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| 032 | | | | | | | | |
| OKPB01-033 | 26 | Supporting | 70 | Fair | Good | 88 | Non-impaired | Good |
| OKPB01-034 | 45 | Supporting | 126 | Excellent | Good | 123 | Non-impaired | Good |
| OKPB01-035 | 12 | Not Supporting | 26 | Very Poor | Poor | 25 | Moderately Impaired | Poor |
| OKPB01-036 | 37 | Supporting | 78 | Good | Good | 100 | Non-impaired | Good |
| OKPB01-038 | 35 | Supporting | 85 | Good | Good | 84 | Non-impaired | Good |
| OKPB01-043 | 27 | Supporting | 100 | Excellent | Good | 112 | Non-impaired | Good |
| OKPB01-044 | 41 | Supporting | 100 | Excellent | Good | 103 | Non-impaired | Good |
| OKPB01-046 | 25 | Undetermined | 63 | Fair | Poor | 85 | Non-impaired | Good |
| OKPB01-050 | 33 | No Biocriteria | 85 | Good | Good | 63 | Slightly Impaired | Poor |
| OKPB01-051 | 25 | Supporting | 91 | Excellent | Good | 124 | Non-impaired | Good |
| OKPB01-052 | 39 | Supporting | 79 | Good | Good | 108 | Non-impaired | Good |
| OKPB01-054 | 27 | Undetermined | 74 | Fair | Good | 77 | Slightly Impaired | Good |
| OKPB01-056 | 27 | Supporting | 60 | Poor | Poor | 54 | Slightly Impaired | Poor |
| OKPB01-059 | 24 | Undetermined | 65 | Fair | Poor | No Collection | No Score | No Score |
| OKPB01-060 | 24 | Undetermined | 76 | Fair | Good | 93 | Non-impaired | Good |
| OKPB01-064 | 27 | Supporting | 74 | Fair | Good | No Collection | No Score | No Score |
| OKPB01-072 | 33 | Supporting | 76 | Fair | Good | 100 | Non-impaired | Good |
| OKPB01-073 | 29 | No Biocriteria | 92 | Excellent | Good | 108 | Non-impaired | Good |
| OKPB01-076 | 31 | Supporting | 68 | Fair | Good | 55 | Slightly Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| OKPB01-078 | 37 | Supporting | 100 | Excellent | Good | 118 | Non-impaired | Good |
| OKPB01-081 | 25 | Undetermined | 68 | Fair | Poor | 87 | Non-impaired | Good |
| OKPB01-084 | No Collection | No Score | No Collection | No Score | No Score | No Collection | No Score | No Score |
| OKPB01-085 | 26 | Supporting | 74 | Fair | Good | 62 | Slightly Impaired | Poor |
| OKPB01-092 | 33 | Undetermined | 100 | Excellent | Good | 100 | Non-impaired | Good |
| OKPB01-098 | 27 | No Biocriteria | 60 | Poor | Poor | 50 | Moderately Impaired | Poor |
| OKPB01-099 | 21 | Undetermined | 78 | Good | Good | 58 | Slightly Impaired | Poor |
| OKPB01-118 | 35 | No Biocriteria | 92 | Excellent | Good | 69 | Slightly Impaired | Poor |
| OKPB01-130 | 31 | No Biocriteria | 84 | Good | Good | 112 | Non-impaired | Good |
| OKPB01-134 | 27 | Undetermined | 78 | Good | Good | 117 | Non-impaired | Good |
| OKPB01-136 | 27 | No Biocriteria | 74 | Fair | Good | 85 | Non-impaired | Good |
| OKPB01-138 | 33 | Undetermined | 93 | Excellent | Good | 96 | Non-impaired | Good |
| OKPB01-144 | 33 | Undetermined | 115 | Excellent | Good | 112 | Non-impaired | Good |
| OKPB01-148 | 29 | Undetermined | 78 | Good | Good | 122 | Non-impaired | Good |
| OKPB01-154 | 31 | Supporting | 109 | Excellent | Good | 115 | Non-impaired | Good |
| OKPB01-156 | 35 | Supporting | 78 | Good | Good | 54 | Slightly Impaired | Poor |
| OKPB01-170 | 29 | Supporting | 91 | Excellent | Good | 85 | Non-impaired | Good |
| OKPB01-196 | 39 | Supporting | 100 | Excellent | Good | 123 | Non-impaired | Good |
| OKPB01-210 | 37 | Supporting | 107 | Excellent | Good | 85 | Non-impaired | Good |
| OKPB01- | 18 | No Biocriteria | 57 | Poor | Poor | 62 | Slightly Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| 212 | | | | | | | | |
| OKPB01-213 | 24 | No Biocriteria | 76 | Fair | Good | 123 | Non-impaired | Good |
| OKPB01-216 | 39 | Supporting | 79 | Good | Good | 100 | Non-impaired | Good |
| OKPB01-220 | 32 | Supporting | 70 | Fair | Good | 85 | Non-impaired | Good |
| OKPB01-223 | 35 | Supporting | 83 | Good | Good | 54 | Slightly Impaired | Poor |
| OKPB01-224 | 33 | Undetermined | 85 | Good | Good | 100 | Non-impaired | Good |
| OKPB01-227 | No Fish Obs | Not Supporting | 0 | Very Poor | Poor | 33 | Moderately Impaired | Poor |
| OKPB01-229 | 19 | Undetermined | 56 | Poor | Poor | 50 | Moderately Impaired | Poor |
| OKPB01-232 | 24 | Undetermined | 60 | Poor | Poor | 82 | Non-impaired | Good |
| OKPB01-235 | 22 | Supporting | 70 | Fair | Good | 108 | Non-impaired | Good |
| OKPB01-236 | 33 | Supporting | 70 | Fair | Good | 92 | Non-impaired | Good |
| OKPB01-239 | 22 | No Biocriteria | 76 | Fair | Good | 108 | Non-impaired | Good |
| OKPB01-247 | 25 | Undetermined | 70 | Fair | Good | 67 | Slightly Impaired | Poor |
| OKPB01-251 | 26 | Supporting | 100 | Excellent | Good | 68 | Slightly Impaired | Poor |
| OKPB01-255 | 20 | Undetermined | 48 | Poor | Poor | 100 | Non-impaired | Good |
| OKPB01-256 | 37 | Supporting | 93 | Excellent | Good | 54 | Slightly Impaired | Poor |
| OKPB01-260 | 21 | Not Supporting | 63 | Fair | Poor | 92 | Non-impaired | Good |
| OKPB01-266 | 27 | No Biocriteria | 76 | Fair | Good | 50 | Moderately Impaired | Poor |
| OKPB01-267 | 31 | Supporting | 92 | Excellent | Good | No Collection | No Score | No Score |
| OKPB01-282 | 26 | Supporting | 65 | Fair | Good | 62 | Slightly Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| OKPB01-283 | 24 | Supporting | 92 | Excellent | Good | 97 | Non-impaired | Good |
| OKPB01-284 | 16 | Not Supporting | 33 | Very Poor | Poor | 46 | Moderately Impaired | Poor |
| OKPB01-292 | 35 | Supporting | 78 | Good | Good | 54 | Slightly Impaired | Poor |
| OKPB01-293 | 20 | Undetermined | 92 | Excellent | Good | 60 | Slightly Impaired | Poor |
| OKPB01-298 | 33 | Supporting | 100 | Excellent | Good | 69 | Slightly Impaired | Poor |
| OKPB01-299 | 29 | Supporting | 100 | Excellent | Good | 92 | Non-impaired | Good |
| OKPB01-302 | 35 | Supporting | 92 | Excellent | Good | 123 | Non-impaired | Good |
| OKPB01-311 | 20 | Not Supporting | 63 | Fair | Poor | 46 | Moderately Impaired | Poor |
| OKPB01-317 | 14 | Not Supporting | 41 | Very Poor | Poor | 75 | Slightly Impaired | Poor |
| OKPB01-323 | 24 | Supporting | 100 | Excellent | Good | No Collection | No Score | No Score |
| OKPB01-327 | 28 | Undetermined | 76 | Fair | Good | 60 | Slightly Impaired | Poor |
| OKPB01-328 | 33 | Undetermined | 85 | Good | Good | 108 | Non-impaired | Good |
| OKPB01-330 | 22 | No Biocriteria | 44 | Poor | Poor | 54 | Slightly Impaired | Poor |
| OKPB01-335 | 14 | No Biocriteria | 28 | Very Poor | Poor | 83 | Non-impaired | Good |
| OKPB01-336 | 33 | No Biocriteria | 84 | Good | Good | 77 | Slightly Impaired | Good |
| OKPB01-342 | 31 | Undetermined | 70 | Fair | Good | 104 | Non-impaired | Good |
| OKPB01-343 | 26 | Supporting | 91 | Excellent | Good | 62 | Slightly Impaired | Poor |
| OKPB01-344 | 35 | Supporting | 79 |  | Good | No Collection | No Score | No Score |
| OKPB01-347 | 25 | Supporting | 84 | Good | Good | 108 | Non-impaired | Good |
| OKPB01- | 37 | Supporting | 85 | Good | Good | 23 | Moderately Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| 348 | | | | | | | | |
| OKPB01-355 | 26 | Supporting | 100 | Excellent | Good | 123 | Non-impaired | Good |
| OKPB01-357 | 18 | Undetermined | 48 | Poor | Poor | 100 | Non-impaired | Good |
| OKPB01-360 | 24 | Undetermined | 91 | Excellent | Good | No Collection | No Score | No Score |
| OKPB01-363 | 29 | Supporting | 91 | Excellent | Good | 123 | Non-impaired | Good |
| OKPB01-369 | 21 | Undetermined | 82 | Good | Good | 48 | Moderately Impaired | Poor |
| OKPB01-372 | 42 | Supporting | 94 | Excellent | Good | 115 | Non-impaired | Good |
| OKPB01-376 | 33 | Undetermined | 66 | Fair | Poor | 123 | Non-impaired | Good |
| OKPB01-389 | 16 | Not Supporting | 84 | Good | Good | 92 | Non-impaired | Good |
| OKPB01-391 | 24 | Undetermined | 76 | Fair | Good | 56 | Slightly Impaired | Poor |
| OKPB01-395 | No Fish Obs | Not Supporting | 0 | Very Poor | Poor | 77 | Slightly Impaired | Good |
| OKPB01-399 | 22 | No Biocriteria | 60 | Poor | Poor | 77 | Slightly Impaired | Good |
| OKPB01-404 | 30 | Supporting | 70 | Fair | Good | 46 | Moderately Impaired | Poor |
| OKPB01-405 | 26 | Supporting | 91 | Excellent | Good | 92 | Non-impaired | Good |
| OKPB01-424 | No Collection | No Score | No Collection | No Score | No Score | 46 | Moderately Impaired | Poor |
| OKPB01-429 | 23 | Supporting | 74 | Fair | Good | 92 | Non-impaired | Good |
| OKPB01-431 | 20 | No Biocriteria | 52 | Poor | Poor | 46 | Moderately Impaired | Poor |
| OKPB01-453 | 27 | Supporting | 85 | Good | Good | 77 | Slightly Impaired | Good |
| OKPB01-469 | 18 | Undetermined | 84 | Good | Good | 108 | Non-impaired | Good |
| OKPB01-495 | 18 | No Biocriteria | 65 | Fair | Poor | 46 | Moderately Impaired | Poor |

| Station ID | OKFIBI Score | OKFIBI Support Stat. | OCCIBI % of Ref. | OCCIBI Integ. Class. | FIBI Binomial | BIBI_._of_Reference | BIBI Binomial | BIBI Binomial |
|---|---|---|---|---|---|---|---|---|
| OKPB01-504 | 35 | Supporting | 86 | Good | Good | 82 | Non-impaired | Good |
| OKPB01-519 | 35 | Supporting | 76 | Fair | Good | 62 | Slightly Impaired | Poor |
| OKPB01-527 | 16 | No Biocriteria | 68 | Fair | Poor | 46 | Moderately Impaired | Poor |
| OKPB01-548 | 24 | Undetermined | 63 | Fair | Poor | 54 | Slightly Impaired | Poor |
| OKPB01-552 | 29 | Undetermined | 78 | Good | Good | 69 | Slightly Impaired | Poor |
| OKPB01-567 | 29 | Supporting | 56 | Poor | Poor | 23 | Moderately Impaired | Poor |
| OKPB01-581 | 29 | Supporting | 85 | Good | Good | 69 | Slightly Impaired | Poor |
| OKPB01-583 | 35 | Supporting | 85 | Good | Good | 77 | Slightly Impaired | Good |
| OKPB01-616 | 20 | Not Supporting | 83 | Good | Poor | No Collection | No Score | No Score |
| OKPB01-619 | 35 | No Biocriteria | 85 | Good | Good | 117 | Non-impaired | Good |

**Table 19. Appendix C—Benthic and Sestonic Algal Data for All Sites.**

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 378143 | OKPB01-003 | 07/05/2005 | 31.81 | | 380465 | OKPB01-003 | 07/05/2005 | 24.200 |
| 378977 | OKPB01-005 | 07/11/2005 | 38.04 | | 380467 | OKPB01-005 | 07/11/2005 | 7.500 |
| 377813 | OKPB01-008 | 06/20/2005 | 3.66 | | 378335 | OKPB01-008 | 06/20/2005 | 0.840 |
| 379183 | OKPB01-009 | 07/19/2005 | 4.93 | | 380478 | OKPB01-009 | 07/19/2005 | 2.820 |
| 378985 | OKPB01-010 | 07/12/2005 | 3.24 | | 380470 | OKPB01-010 | 07/12/2005 | 45.900 |
| 378979 | OKPB01-011 | 07/18/2005 | 25.36 | | 380484 | OKPB01-011 | 07/18/2005 | 7.140 |
| 379185 | OKPB01-013 | 07/26/2005 | 9.70 | | 380464 | OKPB01-013 | 07/20/2005 | 7.400 |
| 379184 | OKPB01-015 | 07/25/2005 | 9.08 | | 380480 | OKPB01-015 | 07/25/2005 | 33.800 |
| 378980 | OKPB01-017 | 07/18/2005 | 10.12 | | 380483 | OKPB01-017 | 07/18/2005 | 9.250 |
| 378978 | OKPB01-019 | 07/11/2005 | 3.58 | | 380463 | OKPB01-019 | 06/28/2005 | 4.170 |
| 379182 | OKPB01-021 | 07/20/2005 | 7.21 | | 380482 | OKPB01-021 | 07/20/2005 | 47.600 |
| 378986 | OKPB01-022 | 07/12/2005 | 2.20 | | 380471 | OKPB01-022 | 07/12/2005 | 18.700 |
| 377814 | OKPB01-024 | 06/28/2005 | 8.07 | | 378351 | OKPB01-024 | 06/28/2005 | 1.070 |
| 377815 | OKPB01-026 | 06/22/2005 | 9.02 | | 378349 | OKPB01-026 | 06/27/2005 | 0.600 |
| 408579 | OKPB01-027 | 09/20/2006 | 126.28 | | 408575 | OKPB01-027 | 09/20/2006 | 55.800 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 402791 | OKPB01-029 | 07/10/2006 | 123.48 | | 402816 | OKPB01-029 | 07/10/2006 | 3.250 |
| 408577 | OKPB01-031 | 08/02/2006 | 96.66 | | 408574 | OKPB01-031 | 08/02/2006 | 61.400 |
| 402800 | OKPB01-032 | 07/25/2006 | 84.61 | | 402828 | OKPB01-032 | 07/25/2006 | 10.300 |
| 402798 | OKPB01-033 | 07/19/2006 | 40.12 | | 402825 | OKPB01-033 | 07/19/2006 | 6.720 |
| | OKPB01-034 | 06/21/2005 | NS | | 378332 | OKPB01-034 | 06/21/2005 | 525.000 |
| 402803 | OKPB01-035 | 8/1/2006 | 98.12 | | 407538 | OKPB01-035 | 8/1/2006 | 69.900 |
| 402794 | OKPB01-036 | 07/17/2006 | 64.86 | | 402824 | OKPB01-036 | 07/17/2006 | 1.370 |
| 378330 | OKPB01-038 | 7/21/2005 | 54.67 | | 378343 | OKPB01-038 | 06/21/2005 | 2.140 |
| 402790 | OKPB01-043 | 07/10/2006 | 104.77 | | 402815 | OKPB01-043 | 07/10/2006 | 16.000 |
| 384855 | OKPB01-044 | 10/18/2005 | 2.91 | | 384857 | OKPB01-044 | 8/23/2005 | 0.900 |
| 377817 | OKPB01-046 | 06/20/2005 | 7.05 | | 378329 | OKPB01-046 | 06/20/2005 | 0.100 |
| 402826 | OKPB01-050 | 07/26/2006 | 31.60 | | 402826 | OKPB01-050 | 07/26/2006 | 8.740 |
| 402789 | OKPB01-051 | 07/11/2006 | 41.58 | | 402814 | OKPB01-051 | 07/11/2006 | 2.910 |
| 402796 | OKPB01-052 | 07/17/2006 | 59.24 | | 408576 | OKPB01-052 | 07/17/2006 | 5.140 |
| 408578 | OKPB01-054 | 09/06/2006 | 74.42 | | 408573 | OKPB01-054 | 09/06/2006 | 16.800 |
| 377818 | OKPB01-056 | 06/28/2005 | 39.23 | | 378346 | OKPB01-056 | 06/28/2005 | 12.800 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 433235 | OKPB01-059 | 10/03/2007 | 3.99 | | 431563 | OKPB01-059 | 10/03/2007 | 5.680 |
| 425929 | OKPB01-060 | 06/13/2007 | 13.55 | | 425273 | OKPB01-060 | 06/12/2007 | 4.700 |
| 433233 | OKPB01-064 | 10/16/2007 | 4.97 | | 431557 | OKPB01-064 | 10/16/2007 | 16.900 |
| 425956 | OKPB01-072 | 8/6/2007 | 6.26 | | 425294 | OKPB01-072 | 08/14/2007 | 4.260 |
| 425940 | OKPB01-073 | 08/14/2007 | 66.10 | | 425279 | OKPB01-073 | 06/12/2007 | 38.790 |
| 425936 | OKPB01-076 | 08/06/2007 | 16.01 | | 429262 | OKPB01-076 | 08/06/2007 | 4.000 |
| 377820 | OKPB01-078 | 06/21/2005 | 10.21 | | 378339 | OKPB01-078 | 06/21/2005 | 1.840 |
| 425928 | OKPB01-081 | 06/13/2007 | 14.58 | | 425274 | OKPB01-081 | 06/12/2007 | 1.550 |
| 377821 | OKPB01-084 | 06/21/2005 | 5.16 | | 378328 | OKPB01-084 | 06/20/2005 | 1.990 |
| 425930 | OKPB01-085 | 09/05/2007 | 13.05 | | 429261 | OKPB01-085 | 09/05/2007 | 11.800 |
| 425932 | OKPB01-092 | 07/25/2007 | 12.62 | | 425277 | OKPB01-092 | 06/12/2007 | 0.360 |
| 377822 | OKPB01-098 | 06/22/2005 | 3.70 | | 380459 | OKPB01-098 | 06/22/2005 | 8.500 |
| 425938 | OKPB01-099 | 08/14/2007 | 17.90 | | 425281 | OKPB01-099 | 08/14/2007 | 5.300 |
| 377823 | OKPB01-118 | 06/28/2005 | 12.56 | | 378347 | OKPB01-118 | 06/28/2005 | 2.620 |
| 384859 | OKPB01-130 | 8/24/2005 | 60.70 | | 384860 | OKPB01-130 | 8/24/2005 | 15.300 |
| 377824 | OKPB01-134 | 06/22/2005 | 17.34 | | 380460 | OKPB01-134 | 06/22/2005 | 0.800 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 377826 | OKPB01-136 | 06/22/2005 | 1.48 | | 380458 | OKPB01-136 | 06/22/2005 | 0.360 |
| 377827 | OKPB01-138 | 06/21/2005 | 6.34 | | 380456 | OKPB01-138 | 06/21/2005 | 0.750 |
| 377828 | OKPB01-144 | 06/21/2005 | 28.06 | | 380461 | OKPB01-144 | 06/27/2005 | 0.520 |
| 378334 | OKPB01-148 | 06/21/2005 | 92.71 | | 378341 | OKPB01-148 | 06/21/2005 | 5.050 |
| | OKPB01-154 | | NS | | 378344 | OKPB01-154 | 06/28/2005 | 4.700 |
| 377830 | OKPB01-156 | 06/20/2005 | 22.03 | | 378337 | OKPB01-156 | 06/20/2005 | 12.300 |
| 377831 | OKPB01-170 | 06/29/2005 | 33.26 | | 378345 | OKPB01-170 | 06/29/2005 | 7.070 |
| 377832 | OKPB01-196 | 06/21/2005 | 12.74 | | 378340 | OKPB01-196 | 06/21/2005 | 0.910 |
| 377833 | OKPB01-210 | 06/20/2005 | 3.95 | | 378336 | OKPB01-210 | 06/20/2005 | 1.010 |
| 425958 | OKPB01-212 | 08/14/2007 | 4.68 | | 425291 | OKPB01-212 | 08/14/2007 | 9.790 |
| 402781 | OKPB01-213 | 6/28/2006 | 205.17 | | 402812 | OKPB01-213 | 6/28/2006 | 7.610 |
| 378984 | OKPB01-216 | 07/13/2005 | 16.78 | | 380479 | OKPB01-216 | 07/13/2005 | 2.300 |
| 402793 | OKPB01-220 | 07/17/2006 | 37.83 | | 402819 | OKPB01-220 | 07/17/2006 | 24.200 |
| 402787 | OKPB01-223 | 06/27/2006 | 28.27 | | 402808 | OKPB01-223 | 06/27/2006 | 10.500 |
| 378989 | OKPB01-224 | 07/12/2005 | 4.99 | | 380473 | OKPB01-224 | 07/12/2005 | 0.980 |
| 425925 | OKPB01-227 | 06/04/2007 | NS | | 425272 | OKPB01-227 | 06/04/2007 | 10.180 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 425935 | OKPB01-229 | 08/14/2007 | 9.89 | | 425283 | OKPB01-229 | 08/14/2007 | 9.320 |
| 425927 | OKPB01-232 | 06/12/2007 | 10.17 | | 425275 | OKPB01-232 | 06/12/2007 | 2.770 |
| 425955 | OKPB01-235 | 08/07/2007 | 10.52 | | 425284 | OKPB01-235 | 08/14/2007 | 3.760 |
| 399748 | OKPB01-236 | 06/13/2006 | 58.00 | | 399730 | OKPB01-236 | 06/13/2006 | 12.000 |
| 425957 | OKPB01-239 | 06/04/2007 | 22.45 | | 425301 | OKPB01-239 | 06/04/2007 | 2.000 |
| 399749 | OKPB01-247 | 06/13/2006 | 11.14 | | 399724 | OKPB01-247 | 06/13/2006 | 20.410 |
| 425945 | OKPB01-251 | 08/15/2007 | 59.45 | | 425285 | OKPB01-251 | 08/15/2007 | 4.900 |
| 425950 | OKPB01-255 | 08/08/2007 | NS | | 425304 | OKPB01-255 | 08/08/2007 | 12.250 |
| 377834 | OKPB01-256 | 06/27/2005 | 3.24 | | 378348 | OKPB01-256 | 06/27/2005 | 0.210 |
| 399755 | OKPB01-260 | 06/14/2006 | 107.89 | | 399723 | OKPB01-260 | 06/14/2006 | 2.240 |
| 378982 | OKPB01-266 | 07/13/2005 | 3.70 | | 380475 | OKPB01-266 | 07/13/2005 | 5.000 |
| 433236 | OKPB01-267 | 10/15/2007 | 40.12 | | 431558 | OKPB01-267 | 10/15/2007 | 4.480 |
| 425959 | OKPB01-282 | 08/08/2007 | 1.03 | | 425298 | OKPB01-282 | 08/08/2007 | 2.670 |
| 425953 | OKPB01-283 | 08/07/2007 | 83.15 | | 425297 | OKPB01-283 | 08/08/2007 | 20.390 |
| 399738 | OKPB01-284 | 06/05/2006 | 8.61 | | 399717 | OKPB01-284 | 06/05/2006 | 81.300 |
| 399754 | OKPB01-292 | 06/14/2006 | 32.22 | | 399733 | OKPB01-292 | 06/14/2006 | 48.440 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 425941 | OKPB01-293 | 08/21/2007 | 13.16 | | 425288 | OKPB01-293 | 08/21/2007 | 57.300 |
| 378981 | OKPB01-298 | 07/13/2005 | 19.23 | | 380476 | OKPB01-298 | 07/13/2005 | 2.110 |
| 425949 | OKPB01-299 | 08/13/2007 | 8.48 | | 425292 | OKPB01-299 | 08/14/2007 | 7.940 |
| 378988 | OKPB01-302 | 07/12/2005 | 6.88 | | 380472 | OKPB01-302 | 07/12/2005 | 4.220 |
| 402785 | OKPB01-311 | 06/27/2006 | 17.00 | | 402806 | OKPB01-311 | 06/27/2006 | 15.500 |
| 399740 | OKPB01-317 | 06/07/2006 | 65.27 | | 399714 | OKPB01-317 | 06/07/2006 | 0.480 |
| 433234 | OKPB01-323 | 10/01/2007 | 161.73 | | 431559 | OKPB01-323 | 10/01/2007 | 195.000 |
| 407533 | OKPB01-327 | 08/29/2006 | NS | | 407534 | OKPB01-327 | 08/29/2006 | 14.700 |
| 399758 | OKPB01-328 | 06/14/2006 | 70.78 | | 399727 | OKPB01-328 | 06/14/2006 | 1.910 |
| 402782 | OKPB01-330 | 06/27/2006 | 17.05 | | 402811 | OKPB01-330 | 06/27/2006 | 6.650 |
| 399745 | OKPB01-335 | 06/05/2006 | 1153.71 | | 399719 | OKPB01-335 | 06/05/2006 | 3.330 |
| 399751 | OKPB01-336 | 06/13/2006 | 35.55 | | 399732 | OKPB01-336 | 06/13/2006 | 0.290 |
| 399753 | OKPB01-342 | 06/12/2006 | 30.97 | | 399734 | OKPB01-342 | 06/12/2006 | 9.040 |
| 425947 | OKPB01-343 | 08/14/2007 | 37.83 | | 425293 | OKPB01-343 | 08/14/2007 | 11.720 |
| 425926 | OKPB01-344 | 08/20/2007 | 6.53 | | 431560 | OKPB01-344 | 09/17/2007 | 12.500 |
| 425954 | OKPB01-347 | 08/07/2007 | 16.26 | | 425295 | OKPB01-347 | 08/14/2007 | 2.590 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 399747 | OKPB01-348 | 06/13/2006 | 33.68 | | 399729 | OKPB01-348 | 06/13/2006 | 7.690 |
| 425952 | OKPB01-355 | 08/08/2007 | 63.61 | | 425303 | OKPB01-355 | 06/04/2007 | 1.580 |
| 425942 | OKPB01-357 | 08/21/2007 | 6.19 | | 425287 | OKPB01-357 | 08/21/2007 | 5.040 |
| 433237 | OKPB01-360 | 09/19/2007 | 5.76 | | 431561 | OKPB01-360 | 09/19/2007 | 25.000 |
| 425946 | OKPB01-363 | 08/14/2007 | 7.32 | | 425290 | OKPB01-363 | 08/14/2007 | 43.230 |
| 402799 | OKPB01-369 | 07/18/2006 | 161.31 | | 407536 | OKPB01-369 | 08/09/2006 | 33.700 |
| 402804 | OKPB01-372 | 08/01/2006 | 122.54 | | 402821 | OKPB01-372 | 07/18/2006 | 0.470 |
| 425960 | OKPB01-376 | 06/04/2007 | 0.02 | | 425300 | OKPB01-376 | 06/04/2007 | 1.410 |
| 425943 | OKPB01-389 | 08/20/2007 | 33.88 | | 425286 | OKPB01-389 | 08/20/2007 | 2.730 |
| No Sample | OKPB01-391 | 08/29/2007 | 0.00 | | 407535 | OKPB01-391 | 08/29/2007 | 14.100 |
| 425924 | OKPB01-395 | 08/06/2007 | 16.90 | | 429285 | OKPB01-395 | 08/06/2007 | 1.340 |
| 402783 | OKPB01-399 | 06/26/2006 | 47.60 | | 402810 | OKPB01-399 | 06/26/2006 | 36.700 |
| 399737 | OKPB01-404 | 06/05/2006 | 18.65 | | 399716 | OKPB01-404 | 06/05/2006 | 104.360 |
| 425948 | OKPB01-405 | 08/14/2007 | 117.87 | | 425289 | OKPB01-405 | 08/14/2007 | 7.870 |
| 425961 | OKPB01-424 | 6/4/2007 | 1.69 | | 425299 | OKPB01-424 | 06/04/2007 | 2.590 |
| 399743 | OKPB01-429 | 06/06/2006 | 91.67 | | 399715 | OKPB01-429 | 06/06/2006 | 4.400 |

| Sample ID | Station ID | Sample Date | Benthic Chlorophyll-a (mg/m2) | | Sample ID | Station ID | Sample Date | Sestonic Chlorophyl A (mg/m3) |
|---|---|---|---|---|---|---|---|---|
| 402784 | OKPB01-431 | 06/26/2006 | 111.42 | | 402809 | OKPB01-431 | 06/26/2006 | 16.500 |
| 399741 | OKPB01-453 | 06/07/2006 | 70.89 | | 399721 | OKPB01-453 | 06/07/2006 | 3.270 |
| 402780 | OKPB01-469 | 06/28/2006 | 153.41 | | 402813 | OKPB01-469 | 06/28/2006 | 1.440 |
| 399746 | OKPB01-495 | 06/07/2006 | 118.70 | | 399720 | OKPB01-495 | 06/07/2006 | 38.190 |
| 425933 | OKPB01-504 | 07/30/2007 | NS | | 425276 | OKPB01-504 | 06/12/2007 | 0.820 |
| 402732 | OKPB01-519 | 7/17/2006 | 135.54 | | 402818 | OKPB01-519 | 7/17/2006 | 12.700 |
| 399744 | OKPB01-527 | 06/05/2006 | 131.79 | | 399722 | OKPB01-527 | 06/05/2006 | 5.210 |
| 399756 | OKPB01-548 | 06/14/2006 | 120.36 | | 399725 | OKPB01-548 | 06/14/2006 | 41.010 |
| 425934 | OKPB01-552 | 08/01/2007 | 16.71 | | 425278 | OKPB01-552 | 06/12/2007 | 4.520 |
| 399757 | OKPB01-567 | 06/07/2006 | 135.33 | | 399736 | OKPB01-567 | 06/07/2006 | 4.700 |
| 399742 | OKPB01-581 | 06/06/2006 | 30.97 | | 399713 | OKPB01-581 | 06/06/2006 | 9.240 |
| 399739 | OKPB01-583 | 06/05/2006 | 17.69 | | 399718 | OKPB01-583 | 06/05/2006 | 5.620 |
| 433238 | OKPB01-616 | 09/18/2007 | 52.38 | | 431562 | OKPB01-616 | 09/18/2007 | 40.300 |
| 399760 | OKPB01-619 | 06/07/2006 | 41.99 | | 399735 | OKPB01-619 | 06/07/2006 | 1.370 |

Table 20. Appendix C—Microbiological Data for All Sites.

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 377939 | OKPB01-003 | 07/05/2005 | 118.0 | 430.0 | 108.0 |
| 378141 | OKPB01-005 | 07/11/2005 | 74.0 | 60.0 | 10.0 |
| 376904 | OKPB01-008 | 06/20/2005 | 63.0 | 110.0 | 108.0 |
| 378659 | OKPB01-009 | 07/19/2005 | 98.0 | 640.0 | 10.0 |
| 378306 | OKPB01-010 | 07/12/2005 | 10.0 | 50.0 | 31.0 |
| 378535 | OKPB01-011 | 07/18/2005 | 63.0 | 240.0 | 288.0 |
| 377938 | OKPB01-013 | 07/05/2005 | 382.0 | 1800.0 | 313.0 |
| ND | OKPB01-015 | | ND | ND | ND |
| 378536 | OKPB01-017 | 07/18/2005 | 9.0 | 100.0 | 41.0 |
| 377407 | OKPB01-019 | 06/28/2005 | 20.0 | 10.0 | 20.0 |
| 378757 | OKPB01-021 | 07/20/2005 | 74.0 | 730.0 | 41.0 |
| 378305 | OKPB01-022 | 07/12/2005 | 359.0 | 2770.0 | 309.0 |
| 377406 | OKPB01-024 | 06/28/2005 | 9.0 | 10.0 | 9.0 |
| 377046 | OKPB01-026 | 06/22/2005 | 63.0 | 20.0 | 31.0 |
| 693272 | OKPB01-027 | 7/5/2006 | 314.0 | 12400.0 | 496.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 377425 | OKPB01-028 | 06/29/2005 | 20.0 | 140.0 | 41.0 |
| 400627 | OKPB01-029 | 07/10/2006 | 20.0 | 270.0 | 203.0 |
| 401943 | OKPB01-031 | 08/02/2006 | 20.0 | 90.0 | 31.0 |
| A01397 | OKPB01-032 | 07/25/2006 | 10.0 | 10.0 | 10.0 |
| 401194 | OKPB01-033 | 07/19/2000 | 74.0 | 60.0 | 63.0 |
| 376983 | OKPB01-034 | 06/21/2005 | 9.0 | 9.0 | 9.0 |
| A01237 | OKPB01-035 | 08/01/2006 | 298.0 | 10.0 | 63.0 |
| 400990 | OKPB01-036 | 07/17/2006 | 9.0 | 9.0 | 9.0 |
| 376980 | OKPB01-038 | 06/21/2005 | 10.0 | 60.0 | 10.0 |
| 693704 | OKPB01-043 | 7/10/2006 | 10.0 | 50.0 | 41.0 |
| 381694 | OKPB01-044 | 08/23/2005 | 9.0 | 70.0 | 9.0 |
| 376906 | OKPB01-046 | 06/20/2005 | 9.0 | 10.0 | 209.0 |
| A01404 | OKPB01-050 | 07/26/2006 | 20.0 | 50.0 | 41.0 |
| 400718 | OKPB01-051 | 07/11/2006 | 145.0 | 290.0 | 246.0 |
| 400989 | OKPB01-052 | 07/17/2006 | 63.0 | 140.0 | |
| A01685 | OKPB01-054 | 09/06/2006 | 20.0 | 180.0 | 97.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 377370 | OKPB01-056 | 06/28/2005 | 10.0 | 10.0 | 9.0 |
| 723809 | OKPB01-059 | 10/3/2007 | 24192.0 | 8664.0 | 10462.0 |
| 419687 | OKPB01-060 | 06/12/2007 | 355.0 | 500.0 | 52.0 |
| 724691 | OKPB01-064 | 10/15/2007 | 201.0 | 170.0 | 62.0 |
| 422988 | OKPB01-072 | 08/06/2007 | 31.0 | 50.0 | 108.0 |
| 719810 | OKPB01-073 | 8/14/2007 | 10.0 | 160.0 | 20.0 |
| 423008 | OKPB01-076 | 08/06/2007 | 10.0 | 150.0 | 10.0 |
| 376977 | OKPB01-078 | 06/21/2005 | 10.0 | 20.0 | 9.0 |
| 419805 | OKPB01-081 | 06/13/2007 | 10 | 810.0 | 324.0 |
| 376907 | OKPB01-084 | 06/20/2005 | 10.0 | 9.0 | 31.0 |
| 721298 | OKPB01-085 | 9/5/2007 | 30.0 | 90.0 | 10.0 |
| 422061 | OKPB01-092 | 07/25/2007 | 9.0 | 9.0 | 9.0 |
| 377044 | OKPB01-098 | 06/22/2005 | 10.0 | 20.0 | 10.0 |
| 719811 | OKPB01-099 | 8/14/2007 | 86.0 | 10.0 | 20.0 |
| 377368 | OKPB01-118 | 06/28/2005 | 74.0 | 70.0 | 74.0 |
| 381841 | OKPB01-130 | 08/24/2005 | 9.0 | 500.0 | 9.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 377047 | OKPB01-134 | 06/22/2005 | 10.0 | 9.0 | 20.0 |
| 377045 | OKPB01-136 | 06/22/2005 | 135.0 | 70.0 | 121.0 |
| 376984 | OKPB01-138 | 06/21/2005 | 20.0 | 30.0 | 9.0 |
| 376981 | OKPB01-144 | 06/21/2005 | 410.0 | 30.0 | 62.0 |
| 376978 | OKPB01-148 | 06/21/2005 | 9.0 | 9.0 | 9.0 |
| 377369 | OKPB01-154 | 06/28/2005 | 85.0 | 160.0 | 31.0 |
| 376903 | OKPB01-156 | 06/20/2005 | 97.0 | 260.0 | 41.0 |
| 377426 | OKPB01-170 | 06/29/2005 | 107.0 | 70.0 | 20.0 |
| 376982 | OKPB01-196 | 06/21/2005 | 63.0 | 40.0 | 30.0 |
| 376905 | OKPB01-210 | 06/20/2005 | 20.0 | 30.0 | 10.0 |
| 419686 | OKPB01-212 | 06/12/2007 | 9.0 | 10.0 | 20.0 |
| 400229 | OKPB01-213 | 06/28/2006 | 278.0 | 720.0 | 31.0 |
| 378424 | OKPB01-216 | 07/13/2005 | 9.0 | 110.0 | 10.0 |
| 400994 | OKPB01-220 | 07/17/2006 | 20.0 | 50.0 | 98.0 |
| 692851 | OKPB01-223 | 6/27/2006 | 109.0 | 100.0 | 74.0 |
| 378324 | OKPB01-224 | 07/12/2005 | 247.0 | 240.0 | 275.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 714265 | OKPB01-227 | 6/4/2007 | 441.0 | 770.0 | 62.0 |
| 719808 | OKPB01-229 | 8/14/2007 | 84.0 | 100.0 | 41.0 |
| 419688 | OKPB01-232 | 06/12/2007 | 31.0 | 20.0 | 10.0 |
| 423077 | OKPB01-235 | 08/07/2007 | 31.0 | 10.0 | 10.0 |
| 399032 | OKPB01-236 | 06/13/2006 | 20.0 | 40.0 | 10.0 |
| 419834 | OKPB01-239 | 06/13/2007 | 9.0 | 20.0 | 31.0 |
| 399029 | OKPB01-247 | 06/13/2006 | 9.0 | 9.0 | 10.0 |
| 419497 | OKPB01-251 | 06/06/2007 | 354.0 | 520.0 | 143.0 |
| 423148 | OKPB01-255 | 08/08/2007 | 41.0 | 9.0 | 9.0 |
| 377224 | OKPB01-256 | 06/27/2005 | 31.0 | 20.0 | 135.0 |
| 691990 | OKPB01-260 | 6/14/06 | 63.0 | 110.0 | 275.0 |
| 378422 | OKPB01-266 | 07/13/2005 | 262.0 | 390.0 | 41.0 |
| 720228 | OKPB01-267 | 8/21/2007 | 717.0 | 1020.0 | 703.0 |
| 714562 | OKPB01-282 | 6/5/2007 | 645.0 | 580.0 | 471.0 |
| 423075 | OKPB01-283 | 08/07/2007 | 160.0 | 310.0 | 41.0 |
| 398400 | OKPB01-284 | 06/05/2006 | 31.0 | 50.0 | 98.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 691991 | OKPB01-292 | 6/14/2006 | 86.0 | 260.0 | 52.0 |
| 720228 | OKPB01-293 | 8/21/2007 | 717.0 | 1020.0 | 703.0 |
| 378423 | OKPB01-298 | 07/13/2005 | 2143.0 | 5400.0 | 278.0 |
| 423410 | OKPB01-299 | 08/13/2007 | 408.0 | 470.0 | 10.0 |
| 378323 | OKPB01-302 | 07/12/2005 | 10.0 | 20.0 | 9.0 |
| 692853 | OKPB01-311 | 6/27/2006 | 20.0 | 40.0 | 63.0 |
| 398742 | OKPB01-317 | 06/07/2006 | 789.0 | 420.0 | 1067.0 |
| ND | OKPB01-323 | | ND | ND | ND |
| 404083 | OKPB01-327 | 08/29/2006 | 74.0 | 150.0 | 41.0 |
| 399113 | OKPB01-328 | 06/14/2006 | 20.0 | 9.0 | 9.0 |
| 692840 | OKPB01-330 | 6/27/2006 | 52.0 | 90.0 | 31.0 |
| 398405 | OKPB01-335 | 06/05/2006 | 364.0 | 310.0 | 1178.0 |
| 398989 | OKPB01-336 | 06/13/2006 | 265.0 | 230.0 | 135.0 |
| 398987 | OKPB01-342 | 06/12/2006 | 9.0 | 20.0 | 84.0 |
| ND | OKPB01-343 | | ND | ND | ND |
| 722392 | OKPB01-344 | 9/18/2007 | 74.0 | 60.0 | 20.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 423076 | OKPB01-347 | 08/07/2007 | 9.0 | 50.0 | 9.0 |
| 399031 | OKPB01-348 | 06/13/2006 | 9.0 | 9.0 | 9.0 |
| 423147 | OKPB01-355 | 08/08/2007 | 41.0 | 130.0 | 86.0 |
| 720229 | OKPB01-357 | 8/21/2007 | 86.0 | 190.0 | 51.0 |
| 722611 | OKPB01-360 | 9/19/2007 | 62.0 | 70.0 | 31.0 |
| 719805 | OKPB01-363 | 8/14/2007 | 96.0 | 370.0 | 171.0 |
| 402552 | OKPB01-369 | 08/09/2006 | 175.0 | 1300.0 | 122.0 |
| 401901 | OKPB01-372 | 08/01/2006 | 10.0 | 10.0 | 40.0 |
| 714417 | OKPB01-376 | 6/4/2007 | 98.0 | 220.0 | 20.0 |
| 720191 | OKPB01-389 | 8/20/2007 | 52.0 | 80.0 | 10.0 |
| 404084 | OKPB01-391 | 08/29/2006 | 233.0 | 470.0 | 52.0 |
| 422987 | OKPB01-395 | 08/06/2007 | 20.0 | 100.0 | 9.0 |
| 692718 | OKPB01-399 | 6/26/2006 | 10.0 | 240.0 | 228.0 |
| 398399 | OKPB01-404 | 06/05/2006 | 309.0 | 280.0 | 122.0 |
| 719806 | OKPB01-405 | 8/14/2007 | 52.0 | 130.0 | 52.0 |
| 714418 | OKPB01-424 | 6/4/2007 | 187.0 | 240.0 | 10.0 |

| Sample ID | Station ID | Sample Date | Eschericia Coli (cfu/mL) | Fecal Coliform (cfu/mL) | Enterococci (cfu/mL) |
|---|---|---|---|---|---|
| 398514 | OKPB01-429 | 06/06/2006 | 706.0 | 2300.0 | 121.0 |
| 692719 | OKPB01-431 | 6/26/2006 | 84.0 | 70.0 | 97.0 |
| 398743 | OKPB01-453 | 06/07/2006 | 591.0 | 380.0 | 1153.0 |
| 692972 | OKPB01-469 | 6/28/06 | 10.0 | 60.0 | 10.0 |
| 398740 | OKPB01-495 | 06/07/2006 | 31.0 | 90.0 | 134.0 |
| 422417 | OKPB01-504 | 07/30/2007 | 10.0 | 30.0 | 9.0 |
| 400993 | OKPB01-519 | 07/17/2006 | 9.0 | 180.0 | 51.0 |
| 398406 | OKPB01-527 | 06/05/2006 | 74.0 | 240.0 | 52.0 |
| 691992 | OKPB01-548 | 6/14/2006 | 20.0 | 10.0 | 10.0 |
| 422668 | OKPB01-552 | 08/01/2007 | 262.0 | 220.0 | 74.0 |
| 398771 | OKPB01-567 | 06/07/2006 | 9.0 | 10.0 | 86.0 |
| 398515 | OKPB01-581 | 06/06/2006 | 41.0 | 80.0 | 63.0 |
| 398401 | OKPB01-583 | 06/05/2006 | 318.0 | 340.0 | 20.0 |
| ND | OKPB01-616 | | ND | ND | ND |
| 398770 | OKPB01-619 | 06/07/2006 | 9.0 | 9.0 | 9.0 |