Methodology for the Development

of the

2008 Section 303(d) List in Missouri

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program

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Missouri
Department of
Natural Resources

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I. Citation and Requirements

A. Citation of Section of Clean Water Act

This document is required by revisions of rules under the Federal Clean Water Act (CWA), Section 303(d), 40 CFR 130.7, and the timetable for presenting the finished document to United States Environmental Protection Agency (EPA) and the public is given in part 130.10. Section 303(d) requires states to list certain impaired waters, and the rules require that states describe how this list will be constructed. Missouri fulfills reporting requirements under Section 303(d), 305(b) and 313 of the CWA by the submission to EPA of an integrated report at the time the 303(d) is approved by the Missouri Clean Water Commission. In years when no integrated report is submitted, the department submits a copy of its statewide water quality assessment database to EPA.

B. U.S. Environmental Protection Agency (EPA) Guidance

In July 2003, EPA issued new guidance entitled "Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the CWA". This guidance gives further recommendations about listing of 303(d) and other waters. In July 2005, EPA published an amended version entitled "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the CWA." In October 2006, EPA issued a memorandum entitled "Information Concerning 2008 CWA Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions." This memorandum serves as EPA's guidance for the 2008 reporting cycle.

The entity responsible for administration of the Federal CWA in Missouri is the Department of Natural Resources (the department). EPA regulations require that the department describe the methodology used to develop the state's 303(d) List. This draft document should be made available to the public by the department for at least a 60-day public review and comment period. The department should provide EPA with a document summarizing all comments received and department responses to significant comments. EPA's guidance recommends that the department provide: (1) a description of the methodology used to develop the Section 303(d) List; (2) a description of the data and information used to identify (impaired and threatened) waters, including a description of the existing and readily available data and information used; and (3) a rationale for any decision for not using any existing and readily available data and information. The guidance also notes that "prior to submission of its Integrated Report, each state should provide the public with the opportunity to review and comment on the methodology." The guidelines further recommend that the methodology document include information on how interstate or international disagreements concerning the list are resolved.

<u>Placement of Waters within the Five Categories in the 2006 EPA Assessment, Listing and Reporting Guidance</u>

The guidance issued by EPA in 2005 recommends that all waters of the state be placed in one of five categories.

Category 1

All designated beneficial uses are fully maintained. Data or other information supporting full beneficial use attainment for all designated beneficial uses must be consistent with the state's listing methodology document (LMD). The department will place a water in Category 1 if the following conditions are met:

- The water has physical and chemical data (at a minimum, water temperature, pH, dissolved oxygen and ammonia for streams, and total nitrogen, total phosphorus and secchi depth for lakes) and biological water quality data (at a minimum, *E. coli* or fecal coliform bacteria) that indicates attainment with water quality standards.
- The level of mercury in fish fillets or fish eggs used for human consumption does not exceed fish tissue guidelines of 0.3 mg/kg or less. Where at least three samples are available for higher trophic level species (bass, sauger, walleye and northern pike), only those samples will be used. When there are less than three samples from these species, data from all fish species will be used.
- The water is not rated as "threatened".

Category 2

One or more designated beneficial uses are fully attained but at least one designated beneficial use has inadequate data or information to make a use attainment decision consistent with the state LMD. The department will place a water in Category 2 at least one of the following conditions are met:

- There is inadequate data for water temperature, pH, dissolved oxygen or ammonia in streams to assess attainment with water quality standards or inadequate total nitrogen, total phosphorus or secchi data in lakes.
- There is inadequate *E. coli* or fecal coliform bacteria data to assess attainment with the whole body contact recreational use.
- There is insufficient fish fillet tissue or fish egg data available for mercury to assess attainment with the fish consumption use.

Category 2 waters will be placed in one of two sub-categories.

Category 2A: Waters will be placed in this category if available data, using best professional judgement, indicates compliance with numeric water quality criteria of Table A or B in Missouri's Water Quality Standards (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment.

Category 2B: Waters will be placed in this category if the available data, using best professional judgement, indicates noncompliance with numeric water quality criteria of Table A or B in Missouri's Water Quality Standards, or other quantitative thresholds for determining use attainment, and this data is insufficient to support a statistical test or to qualify as representative data. Category 2B waters will be given high priority for additional water quality monitoring.

Category 3

Water quality data are not adequate to assess any of the designated beneficial uses consistent with the LMD. The department will place a water in Category 3 if data are insufficient to support a statistical test or to qualify as representative data to assess any of the designated beneficial uses. Category 3 waters will be placed in one of two sub-categories.

Category 3A. Waters will be placed in this category if available data, using best professional judgement, indicates compliance with numeric water quality criteria of Table A or B in Missouri's Water Quality Standards (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment.

Category 3B. Waters will be placed in this category if the available data, using best professional judgement, indicates noncompliance with numeric water quality criteria of Table A or B in Missouri's Water Quality Standards or other quantitative thresholds for determining use attainment. Category 3B waters will be given high priority for additional water quality monitoring.

Category 4

State water quality standards (WQS) or other criteria, as per the requirements of Table 1 of this document, are not attained, but a Total Maximum Daily Load (TMDL) study is not required. Category 4 waters will be placed in one of three sub-categories.

Category 4A. EPA has approved a TMDL study that addresses the impairment. The department will place a water in Category 4A if both the following conditions are met:

- Any portion of the water is rated as being in non-attainment with state WQS or other criteria as explained in Table 1 of this document due to one or more discrete pollutants or discrete properties of the water[1], and
- EPA has approved a TMDL for all pollutants causing that non-attainment.

Category 4B. Water pollution controls required by a local, state or federal authority, are expected to correct the impairment in a reasonable period of time. The department will place a water in Category 4B if both of the following conditions are met:

- Any portion of the water is rated as being in non-attainment with state WQS or other criteria as explained in Table 1 of this document due to one or more discrete pollutants or discrete properties of water, and
- A water quality based permit that addresses the pollutant(s) causing the designated use impairment has been issued and compliance with the permit limits will eliminate the impairment; or other pollution control requirements have been made that are expected to

[1] A discrete pollutant or a discrete property of water is defined here as a specific chemical or other attribute of the water (such as temperature, dissolved oxygen or pH) that causes beneficial use impairment and that can be measured quantitatively.

adequately address the pollutant(s) causing the impairment. This may include implemented voluntary watershed control plans as noted in EPA's guidance document.

Category 4C. Any portion of the water is rated as being in non-attainment with state WQS or other criteria as explained in Table 1 of this document, and a discrete pollutant(s) or other discrete property of the water does not cause the impairment. Discrete pollutants may include specific chemical elements (e.g., lead, zinc), chemical compounds (e.g., ammonia, dieldrin, atrazine) or one of the following quantifiable physical, biological or bacteriological conditions: water temperature, percent of gas saturation, amount of dissolved oxygen, pH, deposited sediment, toxicity or counts of fecal coliform or *E. coli* bacteria.

Category 5

At least one discrete pollutant has caused non-attainment with state WQS or other criteria as explained in Table 1 of this document, and the water does not meet the qualifications for listing as either Category 4A or 4B. Category 5 waters are those that are candidates for the state's 303(d) List[2].

If a designated use is not supported and the segment is impaired or threatened, the fact that a specific pollutant is not known does not provide a basis for excluding a segment from Category 5. These segments must be listed as Category 5 unless the state can demonstrate that no discrete pollutant or pollutants causes or contributes to the impairment. Pollutants causing the impairment will be identified before a TMDL study is written. The TMDL must be written within the time period allowed for TMDL development in EPA guidelines.

Threatened Waters

When a water that would otherwise be in Category 1, 2 or 3 has a time trend analysis for one or more discrete water quality pollutants that indicates the water is currently maintaining all beneficial uses but will not continue to meet these uses before the next listing cycle, it will be considered a "threatened water." A threatened water will be treated as an impaired water and placed in the appropriate category (4A, 4B or 5).

[2] The proposed state 303(d) List is determined by the Missouri Clean Water Commission and the final list is determined by the U.S. Environmental Protection Agency.

II. The Methodology Document

A. Procedures and Methods Used to Collect Water Quality Data

DNR Monitoring

The major purposes of the department's water quality monitoring program are:

- to characterize background or reference water quality conditions;
- to better understand daily, flow event and seasonal water quality variations and their underlying processes;
- to characterize aquatic biological communities;
- to assess time trends in water quality;
- to characterize local and regional impacts of point and nonpoint source discharges on water quality;
- to check for compliance with WQS or wastewater permit limits;
- to support development of strategies, including TMDLs, to return impaired waters to compliance with WQS. All of these objectives are statewide in scope.

Coordination with Other Monitoring Efforts in Missouri

To maximize efficiency, the department routinely coordinates its monitoring activities to avoid overlap with other agencies and to provide and receive interagency input on monitoring study design. Data from other sources is used for meeting the same objectives as department sponsored monitoring. The agencies most often involved are the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers, EPA, the Missouri Department of Conservation (MDC), and the Missouri Department of Health and Senior Services (MDHSS). The department also tracks the monitoring efforts of the National Park Service, the U.S. Forest Service, several of the state's larger cities, the states of Oklahoma, Arkansas, Kansas, Iowa and Illinois, and graduate level research conducted at universities within Missouri. For those wastewater discharges where the department has required instream water quality monitoring, the department may also use monitoring data acquired by wastewater dischargers as a condition of discharge permits issued by the department. In 1995, the department also began using data collected by volunteers that have passed Quality Assurance/Quality Control (QA/QC) tests.

Existing Monitoring Networks and Programs

The following list is a description of the kinds of water quality monitoring activities presently occurring in Missouri.

1. Fixed Station Network

    A. Objective: To better characterize background or reference water quality conditions, to better understand daily, flow event and seasonal water quality variations and their underlying processes, to assess time trends and to check for compliance with WQS.

B. Design Methodology: Sites were chosen based on one of the following criteria:

- Site is believed to have water quality representative of many neighboring streams of similar size due to similarity in watershed geology, hydrology and land use, and the absence of any impact from a significant point or discrete nonpoint water pollution source.
- Site is downstream of a significant point source or discrete nonpoint source area.

C. Number of Sites, Sampling Methods, Sampling Frequency, and Parameters:

- Department/USGS cooperative network: 60 sites statewide, horizontally and vertically integrated grab sampled, six to 12 times per year. Samples are analyzed for major ions, nutrients, temperature, pH, dissolved oxygen, specific conductance and flow on all visits, two to four times annually for suspended solids and heavy metals, and for pesticides six times annually at six sites.
- Department raw water sampling of public drinking water reservoirs: nine drinking water reservoirs are sampled **4** four times per year for some commonly used agricultural herbicides.
- Department/UMC lake monitoring network. This program has monitored about 185 lakes. About 40 lakes are monitored each year. Each lake is usually sampled four times during the summer and about 12 are monitored spring through fall for nutrients, chlorophyll, turbidity and suspended solids.
- Department routine monitoring of finished public drinking water supplies for bacteria and trace contaminants.
- Routine bacterial monitoring (typically weekly during the summer) of swimming beaches at Missouri state parks during the recreational season by the department's Division of State Parks.
- Monitoring of sediment quality by the department at approximately 10 discretionary sites annually. All sites are monitored for several heavy metals and organic contaminants. A pore water sample is analyzed for ammonia, and a Microtox toxicity test is performed on the sediment.

2. Special Water Quality Studies

A. Objective: Special water quality studies are used to characterize the water quality impacts from a specific pollutant source area.

B. Design Methodology: These studies are designed to determine the contaminants of concern based on previous water quality studies, effluent sampling and/or Missouri State Operating Permit (MSOP) applications. These studies employ multiple sampling stations downstream and upstream (if appropriate). If contaminants of concern have significant seasonal or daily variation, season of the year and time of day variation must be accounted for in the sampling design.

C. Number of Sites, Sampling Methods, Sampling Frequency and Parameters: The department conducts or contracts for 10 to15 special studies annually. Each study has multiple sampling sites. Number of sites, sampling frequency and parameters all vary greatly depending on the study. Intensive studies would also require multiple samples per site over a relatively short time frame.

3. Toxics Monitoring Program

The fixed station network and many of the department's intensive studies monitor for toxic chemicals. In addition, major municipal and industrial dischargers must monitor for toxicity in their effluents as a condition of their MSOP.

4. Biological Monitoring Program

A. Objectives: The objectives of this program are to develop numeric criteria describing "reference" aquatic macroinvertebrate and fish communities in Missouri's streams, to implement these criteria within state WQS and to continue a statewide fish and aquatic invertebrate monitoring program.

B. Design Methodology: Development of biocriteria for invertebrates and fish involves identification of reference streams in each of Missouri's 17 ecological drainage units. It also includes intensive sampling of invertebrate and fish communities to quantify temporal and spatial variation in reference streams within ecoregions and variation between ecoregions, and the sampling of chemically and physically impaired streams to test sensitivity of various community metrics to differences in stream quality.

C. Number of Sites, Sampling Methods, Sampling Frequency and Parameters:
The department has conducted biological sampling of aquatic invertebrates for many years. Since 1991, this program has consisted of standardized monitoring of approximately 55 sites twice annually. MDC presently has a statewide fish and aquatic invertebrate monitoring program, the Resource Assessment and Monitoring (RAM) program, designed to assess and monitor the health of Missouri's stream resources. This program samples a minimum of 450 random and 30 reference sites every five years.

5. Fish Tissue Monitoring Program

A. Objective: Fish tissue monitoring can address two separate objectives. These are: (1) the assessment of ecological health or the health of aquatic biota (usually accomplished by monitoring whole fish samples); and (2) the assessment of human health risk based on the level of contamination of fish fillets or fish eggs.

B. Design Methodology: Fish tissue monitoring sites were chosen based on one of the following criteria:

- site is believed to have water and sediment quality representative of many neighboring streams or lakes of similar size due to similarity in geology, hydrology and land use, and the absence of any known impact from a significant point source or

discrete nonpoint water pollution source.

- site is downstream of a significant point source or discrete nonpoint source area.
- site has shown fish tissue contamination in the past.

C. Number of Sites, Sampling Methods, Sampling Frequency and Parameters:

The department and EPA have a cooperative fish tissue monitoring program that collects whole fish composite samples[3] at approximately 12 fixed sites. Each site is sampled once every two years. The preferred species for these sites are either carp or redhorse sucker.

The department, EPA and the Missouri Department of Conservation also sample 40 to 50 discretionary sites annually for two fish fillet composite samples. One sample is of a top carnivore such as largemouth bass, smallmouth bass, walleye or sauger. The other sample is for a species of a lower trophic level such as catfish, carp or sucker. This program occasionally samples fish eggs for certain fish species at selected locations. Both of these monitoring programs analyze for several chlorinated hydrocarbon insecticides, PCBs, lead, cadmium, mercury and fat content.

6. Volunteer Monitoring Program

Two major volunteer monitoring programs are now generating water quality data in Missouri. The first is the Lakes of Missouri Volunteer Program (LVMP). This cooperative program consists of persons from the department, UMC and volunteers that monitor approximately 50 lakes, including Lake Taneycomo, Table Rock Lake and several lakes in the Kansas City area. Data from this program is used by the university as part of a long-term study on the limnology of midwestern reservoirs.

The second program involves volunteers who monitor water quality of streams throughout Missouri. The Volunteer Water Quality Monitoring (VWQM) Program is a subprogram of the Missouri Stream Team Program, a cooperative project sponsored by the department, MDC and the Conservation Federation of Missouri. By the end of 2006, almost 3,800 citizen volunteers had attended at least one training workshop. After the introductory class, many proceed on to at least one more class of higher level training: Levels 1, 2, 3 and 4. Each level of training is a prerequisite for the next higher level, as is appropriate data submission. Data generated by Levels 2, 3,4 and the new Cooperative Site Investigation Program volunteers represent increasingly higher quality assurance. Of those completing an introductory course, about 40 percent proceed to Levels 1 and 2. Eighty-two volunteers have reached Level 3 and six volunteers Level 4. The CSI program uses trained volunteers to collect samples and transport them to laboratories approved by the department. Volunteers and department staff work together to develop a monitoring plan. Currently there are 11 volunteers qualified to work in the CSI program.

[3] A composite sample is one in which several individual fish are combined to produce one sample.

Laboratory Analytical Support

Laboratories used:

- DNR/USGS Cooperative Fixed Station Network: USGS Lab, Denver, Colorado
- DNR Public Drinking Water Reservoir Network: DNR Environmental Services Program (ESP)
- Intensive Surveys: varies, many are done by DNR, ESP
- Toxicity Testing of Effluents: many commercial laboratories
- Biological Criteria for Aquatic Invertebrates: DNR, ESP and UMC
- Fish Tissue: EPA Region VII Laboratory, Kansas City, Kansas and miscellaneous contract laboratories (MDC)
- MSOP: self-monitoring or commercial laboratories
- DNR Public Drinking Water Monitoring: DNR and commercial laboratories
- Other water quality studies: many commercial laboratories

B. Identification of All Existing and Readily Available Water Quality Data Sources

The following data sources are used by the department to aid in the compilation of the state's 305(b) Report. Where quality assurance programs are deemed acceptable, these sources would also be used to develop the state's Section 303(d) List. These sources presently include but are not limited to:

1. Fixed station water quality and sediment data collected and analyzed by department personnel in the department's Environmental Services Program.
2. Fixed station water quality data collected by the USGS under contractual agreements with the department.
3. Fixed station water quality data collected by the USGS under contractual agreements to agencies or organizations other than the department.
4. Fixed station water quality, sediment quality and aquatic biological information collected by the USGS under their National Stream Quality Accounting Network (NASQAN) and the National Water Quality Assessment (NAWQA) monitoring programs.
5. Fixed station raw water quality data collected by the Kansas City Water Services Department, the St. Louis City Water Company, Missouri American Water Company (formerly St. Louis County Water Company), Springfield City Utilities and Springfield Department of Public Works.
6. Fixed station water quality data collected by the U.S. Army Corps of Engineers. The Kansas City, St. Louis and Little Rock Corps districts have monitoring programs for Corps-operated reservoirs in Missouri.
7. Fixed station water quality data collected by the Arkansas Department of Environmental Quality, the Kansas Department of Health and Environment, ~~and~~ the Iowa DNR, and the

Illinois EPA.

8. Fixed station water quality monitoring by corporations**.**

9. Annual fish tissue monitoring programs by EPA/DNR Regional Ambient Fish Tissue Monitoring Program (RAFTMP) and MDC.

10. Special water quality surveys conducted by the department. Most of these surveys are focused on the water quality impacts of specific point source wastewater discharges. Some surveys are of well-delimited nonpoint sources such as abandoned mined lands. These surveys often include physical habitat evaluation and monitoring of aquatic invertebrates as well as water chemistry monitoring.

11. Special water quality surveys conducted by USGS, including but not limited to:

    a) geology, hydrology and water quality of various hazardous waste sites,

    b) geology, hydrology and water quality of various abandoned mining areas,

    c) hydrology and water quality of urban nonpoint source runoff in St. Louis, Kansas City and Springfield, Missouri, and

    d) bacterial and nutrient contamination of streams in southern Missouri.

12. Special water quality studies by other agencies such as MDC, the U.S. Public Health Service, and MDHSS.

13. Monitoring of fish occurrence and distribution by MDC.

14. Fish Kill and Water Pollution Investigations Reports published by MDC.

15. Selected graduate research projects pertaining to water quality and/or aquatic biology.

16. Water quality, sediment and aquatic biological data collected by the department, EPA or their contractors at hazardous waste sites in Missouri.

17. Self-monitoring of receiving streams by cities, sewer districts and industries, or contractors on their behalf, for those discharges that require this kind of monitoring. This monitoring includes chemical and sometimes toxicity monitoring of some of the larger wastewater discharges, particularly those that discharge to smaller streams and have the greatest potential to affect instream water quality.

18. Compliance monitoring of receiving waters by the department and EPA. This can include chemical and toxicity monitoring.

19. Bacterial monitoring of streams and lakes by county health departments, community lake associations and other organizations using acceptable analytical methods.

20. Other monitoring activities done under a quality assurance project plan approved by the department.

21. Fixed station water quality and aquatic invertebrate monitoring by volunteers who have successfully completed the VWQM Program Level 2 workshop. Data collected by volunteers who have successfully completed a training Level 2 workshop is considered to be Data Code One. Data generated from volunteer training levels 2,3 and 4 are considered "screening" level data, and can be useful in providing an indication of a water quality

problem. For this reason, the data is eligible for use in distinguishing between waters in Categories 2A and 2B or 3A and 3B. Most of this data is not used to place waters in main categories (1,2, 3,4,5) because analytical procedures do not use EPA or Standard Methods approved methods. Data from volunteers who have not yet completed a Level 2 training workshop do not have sufficient quality assurance to be used for any assessment purposes. Data generated by volunteers while participating in the department's CSI program (Section II C1) or other volunteer data that otherwise meets the quality assurance outlined in Section II C2 can be used in the Section 303(d) assessment process.

The following data sources (22-25) cannot be used rate a water as impaired (Category 4A, 4B, 4C or 5. However, these data sources may be used to direct additional monitoring that would allow a water quality assessment for Section 303(d) listing purposes

22. Fish Management Basin Plans published by MDC.
23. Fish Consumption Advisories published annually by MDHSS. Note: the department may use data from source No.9 to list individual waters as impaired due to contaminated fish tissue.
24. Self-monitoring of wastewater by cities, sewer districts and industries, or contractors on their behalf, that have significant wastewater discharges. This monitoring includes chemical and sometimes toxicity monitoring of some of the larger wastewater discharges, particularly those that discharge to smaller streams and have the greatest potential to affect instream water quality.
25. Compliance monitoring of wastewater by the department and EPA. This can include chemical and toxicity monitoring.

The department will review all data of acceptable quality that is submitted to the department prior to the end of the first public notice of the draft 303(d) list. The department reserves the right to review and use data of acceptable quality submitted after this date if the data results in a change to the assessment status of the water.

C. Data Quality Considerations

1. DNR QA/QC Program

The department and EPA Region VII have completed a Total Quality Management Plan. All environmental data generated directly by the department, or through contracts funded by the department, or EPA require a Quality Assurance Project Plan (QAPP). The agency or organization responsible for collection and/or analysis of the environmental sampling must write and adhere to a QAPP approved through the department's Total Quality Management Plan. Any environmental data generated by a monitoring plan with a department approved QAPP is considered suitable for use in the 303(d) assessment process. This includes data generated by volunteers participating in the department's CSI program. Under this program, the department's Environmental Services Lab will audit selected non-profit (governmental and university) laboratories. Labs that pass this audit will be approved for the CSI program. Individual volunteers that collect samples and deliver them to an approved laboratory must first successfully complete department training in proper collection and handling of samples.

2. Other QA/QC Programs

Data generated in the absence of a department-approved QAPP may be used to determine the 303(d) status of a water if the department determines that the data is scientifically defensible after making a review of the quality assurance procedures used by the data generator. This review would include: (1) names of all persons involved in the monitoring program, their duties and a description of training and work related experience, (2) all written procedures, SOPs, or QAPPs pertaining to this monitoring effort, (3) a description of all field methods used, brand names and model numbers of any equipment and a description of calibration and maintenance procedures, and (4) a description of laboratory analytical methods. This review may also include an audit by the department Environmental Services Program.

3. Other Data Quality Considerations

3.1 Data Age. For assessing present conditions, more recent data is preferable. However, older data can be used to assess present conditions if the data remains representative of present conditions.
If the department uses data to make a 303(d) Listing decision that predates the date the list is developed by more than seven years, the department will provide a written justification for the use of such data.

A second consideration is the age of the data relative to significant events that may have an effect on water quality. Data collected prior to the initiation, closure or significant change in a wastewater discharge, or prior to a large spill event or the reclamation of a mining or hazardous waste site, for example, may not be representative of present conditions. Such data would not be used to assess present conditions even if it was less than seven years old. Such "pre-event" data can be used to determine changes in water quality before and after the event or to show water quality time trends.

3.2 Data Type, Amount and Information Content. EPA recommends establishing a series of data codes, and rating data quality by the kind and amount of data present at a particular location (EPA 1997[4]). The codes are single digit numbers from one to four, indicating the relative degree of assurance the user has in the value of a particular environmental data set. Data Code One indicates the least assurance or the least number of samples or analytes and Data Code Four the greatest. Based on EPA's guidance, the department uses the following rules to assign code numbers to data.

Data Code[5] One: All data not meeting the requirements of Data Code Two, Three or Four.

[4] *Guidelines for the Preparation of the Comprehensive State Water Quality Assessments (305b) and Electronic Updates*, 1997.
[5] Data Code One is equivalent to data water quality assurance Level One in 10 CSR 20-7.050 General Methodology for Development of Impaired Waters List, subsection (2)(C), Data Code Two is equivalent to Level 2, etc.

Data Code Two: Chemical data collected quarterly to bimonthly for at least three years or intensive studies that monitor several nearby sites repeatedly over short periods of time or at least three fish tissue samples per water body.

Data Code Three: Chemical data collected at least monthly for more than three years on a variety of water quality constituents including heavy metals and pesticides; or Quantitative biological monitoring of at least one aquatic assemblage (fish, invertebrates or algae) at multiple sites, or multiple samples at a single site when data from that site is supported by biological monitoring at an appropriate control site.

Data Code Four: Chemical data collected at least monthly for more than three years that provides data on a variety of water quality constituents including heavy metals and pesticides, and including chemical sampling of sediments and fish tissue; or Quantitative biological monitoring of at least two aquatic assemblages (fish, invertebrates or algae) at multiple sites.

In Missouri, the primary purpose of Data Code One data is to provide a rapid and inexpensive method of screening large numbers of waters for obvious water quality problems and to determine where more intensive monitoring is needed. In the preparation of the state's 305(b) Report, data from all four data quality levels are used. Most of the data is of Data Code One quality, and without Data Code One data, staff would not be able to assess a majority of the state's waters.

In general, when selecting water bodies for the Missouri 303(d) List, only Data Code Two or higher data are used, unless the problem can be accurately characterized by Data Code One data.[6] The reason is that Data Code Two data provides a higher level of assurance that a WQS is actually being exceeded and that a TMDL study is necessary. All water bodies placed in Category 2B or 3B receive high priority for additional monitoring so that data quality is upgraded to at least Data Code Two.

D. How Water Quality Data is Evaluated to Determine Whether or Not Waters are Impaired for 303(d) Listing Purposes

Physical, Chemical, Biological and Toxicity Data

Each reporting cycle, the department and stakeholders review and revise the guidelines for determining water quality impairment. These guidelines are shown in Table 1 of this document below. In addition, if time trend data indicates that presently unimpaired waters will become impaired prior to the next listing cycle, these "threatened waters" will be judged to be impaired. Where antidegradation provisions in Missouri's WQS apply, those provisions shall be upheld. The numeric criteria included in Table 1.1 have been adopted into the state water quality

[6] When a listing, amendment or delisting of a 303(d) water is made with only Data Code One data, a document will be prepared that includes a display of all data and a presentation of all statistical tests or other evaluative techniques that documents the scientific defensibility of the data. This requirement applies to all Data Code One data identified in Table 1 of this document.

standards, 10 CSR 20-7.031, and are used, as described in Table 1.1, to make use attainment decisions. For narrative criteria, the numeric thresholds included in Table 1.2 have not been adopted into state water quality standards. The department will use a weight of evidence analysis for all narrative criteria. For those analytes with numeric thresholds, the threshold values given in Table 1.2 will trigger a weight of evidence analysis to determine the existence or likelihood of a use impairment and the appropriateness of proposing a listing based on narrative criteria. When the weight of evidence analysis suggests, but does not provide strong, scientifically defensible evidence of impairment, the department will place the water body in question in Category 2B/3B. The department will produce a document showing all relevant data and the rationale for the use attainment decision. All such documents will be made available to the public at the time of the first public notice of the proposed 303(d) list. A final recommendation on the listing of a water based on narrative criteria will only be made after full consideration of all comments on the proposal.

TABLE 1.1 METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS, 10 CSR 20-7.031

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS
Overall use protection (all beneficial uses)	No data. Evaluated based on similar land use/ geology as stream with water quality data.[7]	Not applicable	Given same rating as monitored stream with same land use and geology.
Any beneficial uses	No data available or where only effluent data is available. Results of dilution calculations or water quality modeling. (see ALRR p.38)	Not applicable	Where models or other dilution calculations indicate noncompliance with allowable pollutant levels and frequencies noted in this table, waters may be added to Category 3B and considered high priority for water quality monitoring.
Protection of Aquatic Life	Water temperature, pH, total dissolved gases, oil and grease.	1-4	Full: No more than 10% of all samples exceed criterion.[8] Non-Attainment: Requirements for full attainment not met.
Protection of Aquatic Life	Dissolved oxygen.	1-4	Full: Criterion value not exceeded on more than 10% of days for which data is available.[8] Non-Attainment: Requirements for full attainment not met.
Protection of Aquatic Life	Toxic Chemicals	1-4	Full: No more than one acute toxic event in three years. No more than one exceedence of acute or chronic criterion in three years for all toxics Non-Attainment: Requirements for full attainment not met.[9]

[7] This data type is used only for wide-scale assessments of aquatic biota and aquatic habitat for 305(b) Report purposes. This data type is not used in the development of the 303(d) List.

[8] Some sampling periods are wholly or predominantly during the critical period of the year when criteria violations occur. Where the monitoring program presents good evidence of a demarcation between seasons where criteria exceedences occur and seasons when they do not, the 10% exceedence rate will be based on an annual estimate of the frequency of exceedence.

[9] The test result must be representative of water quality for the entire time period for which acute or chronic criteria apply. For ammonia the chronic exposure period is 30 days, for all other toxics 96 hours. The acute exposure period for all toxics is 24 hours. The department will review all appropriate data, including hydrographic data, to insure only representative data is used. Except on large rivers where storm water flows may persist at relatively unvarying levels for several days, grab samples collected during storm water flows will not be used for assessing chronic toxicity criteria.

TABLE 1.1 METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIATHAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS, 10 CSR 20-7.031 (continued).

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS
Fish Consumption	Chemicals (water)	1-4	Full: Water quality does not exceed WQS.[10] Non-Attainment: Requirements for full attainment not met.
Drinking Water Supply -Raw Water.[11]	Chemical (toxics)	1-4	Full: WQS not exceeded [10] Non-Attainment: Requirements for full attainment not met.
Drinking Water Supply- Raw Water	Chemical(sulfate,chloride, fluoride)	1-4	Full: WQS not exceeded .[10] Non-Attainment: Requirements for full attainment not met.
Drinking Water Supply-Finished Water	Chemical (toxics)	1-4	Full: No MCL* violations based on Safe Drinking Water Act data evaluation procedures. Non-Attainment: Requirements for full attainment not met. NOTE: Finished water data will not be used for analytes where water quality problems may be caused by the drinking water treatment process such as the formation of Trihalomethanes (THMs) or problems that may be caused by the distribution system (bacteria, lead, copper).
Whole-Body-Contact Recreation and Secondary Contact Recreation	Fecal Coliform or *E. coli* count	1-4	Full: WQS not exceeded as a geometric mean for samples collected during seasons and flow conditions for which bacteria criteria apply.[10] Non-Attainment: Requirements for full attainment not met.
Irrigation, Livestock and Wildlife Water	Chemical	1-4	Full: WQS not exceeded.[10] Non-Attainment: Requirements for full attainment not met.

*Maximum Contaminant Level

[10] See section on Statistical Considerations and Table B-1.
[11] Raw water is water from a stream, lake or ground water prior to treatment in a drinking water treatment plant.

TABLE 1.2 METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS
Overall use protection (all beneficial uses)	Narrative criteria for which quantifiable measurements can be made.	1-4	Full: Stream appearance typical of reference streams in this region of the state. Non-Attainment: The weight of evidence, based on the narrative criteria in 10 CSR 20-7.031(3), demonstrates the observed condition exceed a numeric threshold necessary for the attainment of a beneficial use For example: Color: Color as measured by the Platinum-Cobalt visual method (SM 2120 B) in a water is statistically significantly higher than a control water. Objectionable Bottom Deposits: The affected stream segment must be at least 100 yards in length, and for all areas within this affected segment that have a flow velocity less than 0.5 feet/second at the time the stream is evaluated, greater than 10% of the stream bottom is covered by sewage sludge, trash or other materials reaching the water due to anthropogenic sources. Note: Waters in mixing zones and unclassified waters which support aquatic life on an intermittent basis shall be subject to acute toxicity criteria for protection of aquatic life. Waters in the initial Zone of Dilution (ZID) shall not be subject to acute toxicity criteria.

TABLE 1.2 METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)
(continued)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS
Protection of Aquatic Life	Toxic Chemicals	1-4	Full: No more than one acute toxic event in three years. No more than one exceedence of acute or chronic criterion in three years for all toxics.[12] [13] Non-Attainment: Requirements for full attainment not met.
Protection of Aquatic Life	Biological	3-4	Full: Fauna very similar to regional reference streams. If DNR wadeable streams macroinvertebrate sampling and evaluation protocols are followed, for seven or fewer samples, at least 75% of the stream condition index scores must be 16 or greater. For greater than seven samples or for other sampling and evaluation protocols, results must be statistically similar to representative reference or control streams. Non-Attainment: If DNR wadeable streams macroinvertebrate sampling and evaluation protocols are followed, for seven or fewer samples, at least 75% of the stream condition index scores must be 14 or lower. For more than seven samples or for other sampling and evaluation protocols, results must be statistically dissimilar to control or representative reference streams.

[12] The test result must be representative of water quality for the entire time period for which acute or chronic criteria apply. For ammonia the chronic exposure period is 30 days, for all other toxics 96 hours. The acute exposure period for all toxics is 24 hours. The department will review all appropriate data, including hydrographic data, to insure only representative data is used. Except on large rivers where storm water flows may persist at relatively unvarying levels for several days, grab samples collected during storm water flows will not be used for assessing chronic toxicity criteria.

[13] In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations (PECs) proposed in "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems" by McDonald,D.D. et al. Arch. Environ. Contam. Toxicol. 39,20-31 (2000). These - PECs are as follows: 33 mg/kg As; 4.98 mg/kg Cd; 111 mg/kg Cr; 149 mg/kg Cu; 48.6 mg/kg Ni; 128 mg/kg Pb; 459 mg/kg Zn; 561 µg/kg naphthalene; 1170 µg/kg phenanthrene; 1520 µg/kg pyrene; 1050 µg/kg benzo(a)anthracene, 1290 µg/kg chrysene; 1450 µg/kg benzo(a)pyrene; 22,800 µg/kg total polyaromatic hydrocarbons; 676 µg/kg total PCBs. Chlordane 17.6 ug/kg; Sum DDE 31.3 ug/kg; Lindane (gamma-BHC) 4.99 ug/kg. Where multiple sediment contaminants exist, the PEC Quotient shall not exceed 0.5. See Appendix D for more information on the PEC Quotient.

TABLE 1.2 METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031) (continued)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS
Protection of Aquatic Life	Toxicity testing of streams or lakes using aquatic organisms	2	Full: No more than one test result of statistically significant deviation from controls in acute or chronic test in a three-year period.[10] Non-Attainment: Requirements for full attainment not met.
Fish Consumption	Chemicals (tissue)	1-2	Full: Fish tissue levels in fillets and eggs do not exceed guidelines.[14] Non-Attainment: Requirements for full attainment not met.

*Maximum Contaminant Level

Duration of Assessment Period

Except where the assessment period is specifically noted in Table 1, the time period for which data will be used in making the assessments noted in Table 1 will be determined by the data age considerations in Section IIC3.1 and data representativeness considerations in Table 1 footnote 8.

Other Types of Information

1. Observation and evaluation of waters for noncompliance with state narrative water quality criteria. Missouri's narrative water quality criteria, as described in 10 CSR 20-7.031 Section (3), may be used to evaluate waters when a quantitative value can be applied to the pollutant (see Table 1 page 15). These narrative criteria apply to both classified and unclassified waters and prohibit the following in waters of the state:

    a. unsightly, putrescent or harmful bottom deposits,

    b. oil, scum and floating debris,

    c. unsightly turbidity or odor,

    d. substances causing toxicity to human, animal or aquatic life,

    e. human health hazard due to incidental contact,

    f. acute toxicity to livestock or wildlife when used as a drinking water supply,

[14] Fish tissue threshold levels are; chlordane 0.1 mg/kg (Crellin, J.R. 1989, *"New Trigger Levels for Chlordane in Fish-Revised Memo"* Mo. Dept. of Health inter-office memorandum. June 16, 1989); mercury 0.3 mg/kg based on "Water Quality Criterion for Protection of Human Health: Methylmercury" EPA-823-R-01-001. Jan. 2001. http://www.epa.gov/waterscience/criteria/methylmercury/merctitl.pdf; PCBs 0.75 mg/kg, MDHSS Memorandum August 30, 2006 "*Development of PCB Risk-based Fish Consumption Limit Tables*"; and lead 0.3- mg/kg (World Health Organization 1972. *"Evaluation of Certain Food Additives and the Contaminants Mercury, Lead and Cadmium"*. WHO Technical Report Series No. 505, Sixteenth Report on the Joint FAO/WHO Expert Committee on Food Additives. Geneva 33 pp.

g. physical, chemical or hydrologic changes that impair the natural biological community, and

h. used tires, car bodies, appliances, demolition debris, used vehicles or equipment and any solid waste as defined by Missouri's Solid Waste Law.

2. Habitat assessment protocols for wadeable streams have been established and are made in conjunction with sampling of aquatic invertebrates and the analysis of aquatic invertebrates data. The department will not use habitat assessment data alone for assessment purposes.

E. Other 303(d) Listing Considerations

1. Adding to the Existing List or Expanding the Scope of Impairment to a Previously Listed Water

   The listed portion of an impaired water may be increased based on recent monitoring data following the guidelines in this document. One or more new pollutants may be added to the listing for a water already on the list based on recent monitoring data following these same guidelines. Waters not previously listed may be added to the list following the guidelines in this document.

2. Deleting from the Existing List or Decreasing the Scope of Impairment to a Previously Listed Water

   The listed portion of an impaired water may be decreased based on recent monitoring data following the guidelines in this document. One or more pollutants may be deleted from the listing for a water already on the list based on recent monitoring data following these same guidelines. Waters may be completely removed from the list for several reasons[15], the most common being (1) water has returned to compliance with water quality standards or (2) the water has an approved TMDL study.

3. Prioritization of Waters for TMDL Development

   Section 303(d) of the CWA and federal regulation 40 CFR 130.7(b)(4) require states to submit a priority ranking of waters still requiring TMDLs. The department will prioritize development of TMDLs based on several variables including:
   - severity of the water quality problem
   - amount of time necessary to acquire sufficient data to develop the TMDL
   - court orders, consent decrees or other formal agreements
   - budgetary constraints, and
   - amenability of the problem to treatment

   The department's TMDL schedule will represent its prioritization.

[15] see, "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the CWA". USEPA, Office of Water, Washington DC.

4. Resolution of Interstate/International Disagreements

   The department will review the draft 303(d) Lists of all other states with which it shares a border (Missouri River, Mississippi River, Des Moines River and the St. Francis River)or other interstate waters. Where the listing in another state is different than in Missouri, the department will request the data upon which the listing in the other state is based. This data will be reviewed following all data evaluation guidelines previously discussed in this document. The Missouri list may be changed pending the evaluation of this additional data.

Appendix A

Excerpt from *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act.* July 29, 2005. USEPA pp.39-41.

G. How should statistical approaches be used in attainment determinations?

The state's methodology should provide a rationale for any statistical interpretation of data for the purpose of making an assessment determination.

1. Description of statistical methods to be employed in various circumstances:

   The methodology should provide a clear explanation of which analytic tools the state uses and under which circumstances. EPA recommends that the methodology explain issues such as the selection of key sample statistics (arithmetic mean concentration, median concentration, or a percentile), null and alternative hypotheses, confidence intervals, and Type I and Type II error thresholds. The choice of a statistic tool should be based on the known or expected distribution of the concentration of a pollutant in the segment (e.g., normal or log normal) in both time and space.

   Past EPA guidance, 1997 305(b) and 2000 CALM, recommended making non-attainment decisions for "conventional pollutants" – Total Suspended Solids, pH, Biochemical Oxygen Demand, fecal coliform bacteria and oil and grease – when more than 10% of measurements exceed the water quality criterion (WQC). However, EPA guidance has not encouraged use of the 10% rule with other pollutants, including toxics. Use of this rule when addressing conventional pollutants, is appropriate if its application is consistent with the manner in which the applicable WQC are expressed. An example of a WQC for which an assessment based on the 10% rule would be appropriate is the EPA acute WQC for fecal coliform bacteria, applicable to protection of water contact recreational use. This 1976-issued WQC was expressed as, "...no more than ten percent of the samples exceeding 400 CFU per 100ml, during a 30-day period. This assessment methodology is clearly reflective of the WQC.

   On the other hand, use of the 10 percent rule for interpreting water quality data is usually not consistent with WQC expressed either as: (1) instantaneous maxima not to be surpassed at any time; or (2) average concentrations over specified times. In the case of "instantaneous maxima (or minima) never to occur" criteria use of the 10 percent rule typically leads to the belief that segment conditions are equal to or better than specified by the WQC, when they in fact are considerably worse. (That is, pollutant concentrations are above the criterion concentration a far greater proportion of the time than specified by the WQC). Conversely, use of this decision rule in concert with WQC expressed as average concentrations over specific times can lead to concluding that segment conditions are worse than WQC, when in fact, they are not.

If the state applies different decision rules for different types of pollutants (e.g., toxic, conventional, and non-conventional pollutants) and types of standards (e.g., acute versus chronic criteria for aquatic life or human health), the state should provide a reasonable rationale supporting the choice of a particular statistical approach to each of its different sets of pollutants and types of standards.

2. Elucidation of policy choices embedded in selection of particular statistical approaches and use of certain assumptions

   EPA strongly encourages states to highlight policy decisions implicit in the statistical analysis that they have chosen to employ in various circumstances. For example, if hypothesis testing is used, the state should make its decision-making rules transparent by explaining why it chose either "meeting WQS" or "not meeting WQS" as the null hypothesis (refutable presumption) as a general rule for all waters, a category of waters, or an individual segment. Starting with the assumption that a water is "healthy" when employing hypothesis testing means that a segment will be identified as impaired, and placed in Category 4 or 5, only if substantial amounts of credible evidence exist to refute the presumption. By contrast, making the null hypothesis "WQS not being met" shifts the burden of proof to those who believe the segment is, in fact, meeting WQS.

   Which "null hypothesis" a state selects could likely create contrasting incentives regarding support for additional ambient monitoring among different stakeholders. If the null hypothesis is "meeting standards", there was no previous data on the segment, and no additional existing and readily available data and information is collected, then the "null hypothesis" cannot be rejected, and the segment would not be placed in Category 4 or 5. In this situation, those concerned about possible adverse consequences of having a segment declared "impaired" might have little interest in collection of additional ambient data. Meanwhile, users of the segment would likely want to have the segment monitored, so they can be assured that it is indeed capable of supporting the uses of concern. On the other hand, if the null hypothesis is changed to "segment not meeting WQS": then those that would prefer that a particular segment not be labeled "impaired" would probably want more data collected, in hopes of proving that the null hypothesis is not true.

   Another key policy issue in hypothesis testing is what significance level to use in deciding whether to reject the null hypothesis. Picking a high level of significance for rejecting the null hypothesis means that great emphasis is being placed on avoiding a Type I error (rejecting the null hypothesis, when in fact, the null hypothesis is true). This means that if a 0.10 significance level is chosen, the state wants to keep the chance of making a Type I error at or below 10 percent. Hence, if the chosen null hypothesis is "segment meeting WQS", the state is trying to keep the chance of saying a segment is impaired, when in reality it is not, under 10 percent.

An additional policy issue is the Type II errors (not rejecting the null hypothesis, when it should have been). The probability of Type II errors depends on several factors. One key factor is the number of samples available. With a fixed number of samples, as the probability of Type I error decreases, the probability of a Type II error increases. States would ideally collect enough samples so the chances of making Type I and Type II errors are simultaneously small. Unfortunately, resources needed to collect those numbers of samples are quite often not available.

The final example of a policy issue that a state should describe is the rationale for concentrating limited resources to support data collection and statistical analysis in segments where there are documented water quality problems or where the combination of nonpoint source loadings and point source discharges would indicate a strong potential for a water quality problem to exist.

EPA recommends that, when picking the decision rules and statistical methods to be utilized when interpreting data and information, states attempt to minimize the chances of making either of the following two errors:

- Concluding the segment is impaired, when in fact it is not, and
- Deciding not to declare a segment impaired, when it is in fact impaired.

States should specify in their methodology what significance level they have chosen to use, in various circumstances. The methodology would best describe in "plain English" the likelihood of deciding to list a segment that in reality is not impaired (Type I error if the null hypothesis is "segment not impaired"). Also, EPA encourages states to estimate, in their assessment databases, the probability of making a Type II error (not putting on the 303(d) List a segment that in fact fails to meet WQS), when: (1) commonly-available numbers of grab samples are available, and (2) the degree of variance in pollutant concentrations are at commonly encountered levels. For example, if an assessment is being performed with a WQC expressed as a 30-day average concentration of a certain pollutant, it would be useful to estimate the probability of a Type II error when the number of available samples over a 30-day period is equal to the average number of samples for that pollutant in segments statewide, or in a given group of segments, assuming a degree of variance in levels of the pollutant often observed over typical 30-day periods.

Appendix B
Statistical Considerations

The most recent EPA guidance on the use of statistics in the 303(d) LMD is given in Appendix A. Within this guidance there are three major recommendations regarding statistics:

- Provide a description of which analytical tools the state uses under various circumstances,
- When conducting hypothesis testing, explain the various circumstances under which the burden of proof is placed on proving the water is impaired and when it is placed on proving the water is unimpaired, and
- Explain the level of statistical significance used under various circumstances.

Description of Analytical Tools

The table below describes the analytical tools the department proposes and asks stakeholders to comment on. In general, the information in the right-hand three columns is negotiable and should encompass the area of discussion with stakeholders.

Table B-1. Description of Analytical Tools

Beneficial Use	Analytes	Analytical Tool	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule [16]	Significance Level
Narrative Criteria	Color	Hypothesis Test Two Sample "t "Test	Null Hypothesis: There is no difference in color between test stream and control stream.	Reject Null Hypothesis if calculated "t" value exceeds tabular "t" value for test alpha=0.10	0.10
	Bottom Deposits	Hypothesis Test, One Sided Confidence Limit	Null Hypothesis: Solids of anthropogenic origin cover less than 10% of stream bottom where velocity is less than 0. 5 feet/second.	Reject Null Hypothesis if 60% Lower Confidence Limit (LCL) of mean percent fine sediment deposition in stream exceeds mean in control stream by more than 10%.	0.40

[16] Where hypothesis testing is used for media other than fish tissue, for data sets with five samples or fewer, a 75 percent confidence interval around the appropriate central tendencies will be used to determine use attainment status. Use attainment will be determined as follows: (1) If the criterion value is above this interval (all values within the interval are in conformance with the criterion), rate as unimpaired. (2) If the criterion value falls within this interval, rate as unimpaired and place in Category 2B or 3B. (3) If the criterion value is below this interval (all values within the interval are not in conformance with the criterion), rate as impaired. For fish tissue this procedure will be used with the following changes: (1) it will apply only to sample sizes of less than four and, (2) a 50% confidence interval will be used in place of the 75% confidence interval.

Aquatic Life	Biological Monitoring	Significant alteration of composition or reduction in diversity	7 or fewer samples using DNR Invert. protocol: rate as unimpaired if 75% of scores are 16 or more, rate as impaired if 75% of scores are 14 or less, else rate as inconclusive.	Not applicable	Not applicable
			8 or more samples using DNR Invert. protocol: % of samples that score 16 more is no less than 5 percent less than the percent for reference streams in that EDU.	Not applicable	Not applicable

Table B-1. Description of Analytical Tools (cont.)

Beneficial Use	Analytes	Analytical Tool	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule [15]	Significance Level
Aquatic Life			Other biological monitoring to be determined by type of data.		
	Toxic Chemicals	Not applicable	No more than one exceedence of acute or chronic criterion in 3 years.	Not applicable	Not applicable
Aquatic Life	temperature, pH, total diss. gases, oil and grease, diss. oxygen	40 or fewer samples: binomial probability	Null Hypothesis: no more than 10% of samples exceed the water quality criterion	Reject Null Hypothesis if there is less than an 10% probability that the true exceedence frequency is not greater than 10%.	0.10
		More than 40 samples: Estimated binomial Probability, 'z ' statistic			0.10
Fish Consumption	Toxic Chemicals in water	Hypothesis test 1-Sided Confidence limit	Null Hypothesis: Levels of contaminants in water exceed criterion.	Reject Null Hypothesis if the 60% UCL is less than the criterion value.	0.40
Fish Consumption	Toxic Chemicals in Tissue	Four or more samples: Hypothesis test 1-Sided Confidence Limit	Null Hypothesis: Levels in fillet samples or fish eggs exceed criterion.	Reject Null Hypothesis if the 60% UCL is less than the criterion value.	0.40
Drinking Water Supply (Raw)	Toxic Chemicals	Hypothesis test 1-Sided Confidence limit	Null Hypothesis: Levels of contaminants exceed criterion.	Reject Null Hypothesis if the 60% UCL is less than the criterion value.	0.40
Drinking Water Supply (Raw)	Non-toxic Chemicals	Hypothesis test 1-Sided Confidence limit	Null Hypothesis: Levels of contaminants do not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.40
Drinking Water Supply (Finished)	Toxic Chemicals, ~~Bacteria~~	Methods stipulated by Safe Drinking Water Act	Methods stipulated by Safe Drinking Water Act	Methods stipulated by Safe Drinking Water Act	Methods stipulated by Safe Drinking Water Act
Whole Body Contact and Secondary Contact Rec.	Bacteria	Hypothesis test 1-Sided Confidence limit	Null Hypothesis: Levels of contaminants exceed criterion.	Reject Null Hypothesis if the 60% UCL is less than the criterion value.	0.40
Irrigation & Livestock Water	Toxic Chemicals	Hypothesis test 1-Sided Confidence limit	Null Hypothesis: Level of contaminants does not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.40

Rationale for the Burden-of-Proof

Hypothesis testing is a common statistical practice. The procedure involves first stating a hypothesis you want to test, such as "the most frequently seen color on clothing at a St. Louis Cardinals game is red" and then the opposite or null hypothesis "red is not the most frequently seen color on clothing at a Cardinals game." Then a statistical test is applied to the data (a sample of the predominant color of clothing worn by 200 fans at a Cardinals game on July 12) and based on an analysis of that data, one of the two hypotheses is chosen as correct.

In hypothesis testing, the burden-of-proof is always on the alternate hypothesis. In other words, there must be very convincing data to make us conclude that the null hypothesis is not true and that

we must accept the alternate hypothesis. How convincing the data must be is stated as the "significance level" of the test. A significance level of 0.10 means that there must be at least a 90 percent probability that the alternate hypothesis is true before we can accept it and reject the null hypothesis.

When conducting hypothesis testing on water quality data, there are two general ways of stating the hypothesis. In the first case, the alternate hypothesis is that the water is impaired and the null hypothesis is that water quality is unimpaired. In the second general case, the alternate hypothesis is that the water is unimpaired and the null hypothesis is that the water is impaired. In the first case, the burden-of-proof requires convincing data that the water is impaired and in the second, convincing data that the water is unimpaired. Which of these two ways should be used?

The decision of how to state these hypotheses and assign the burden-of-proof should, in some way, relate to the consequences of making an incorrect decision based on a statistical test. When using a high level of significance like 0.05 or 0.01, the probability of accepting the alternate hypothesis when it was in fact, incorrect (Type I error) is very low. However, in this same test, the chance of accepting the null hypothesis when in fact, it was incorrect (Type II error) can be very high. If the data set is small, the Type II error could exceed 80 to 90 percent. Thus, particularly for small data sets, there can be a large discrepancy in error rates between Type I and Type II errors.

Thus, in assigning the burden-of-proof, we should assign the lower error rate to the error that has the most serious consequences. The approach proposed in Table B-1 is, where hypothesis testing is used, to assign the burden-of-proof on showing that the water is not impaired where human health criteria are involved, and for other criteria, assign the burden of proof on showing that the water is impaired. As an example:

> Atrazine data in Monroe City/Route J Lake from 1997 to 2004 has the following data attributes: mean = 2.997 µg/L, standard deviation = 2.41, number of samples = 87. We have three options for statistical analysis of this data. One, make a direct comparison of the sample mean to the criterion value. Two, use a hypothesis test that places the burden-of-proof on showing the water is impaired or three, using a hypothesis test that places the burden-of-proof on showing the water is unimpaired. Using the sample mean indicates the lake is just meeting the 3.000 µg/l criterion value for atrazine and should be judged unimpaired, but we cannot assign a level of confidence to this decision. Comparing the criterion value to a one-sided lower confidence limit of the mean places the burden-of-proof on showing the water is impaired, and comparing the criterion value to the one-sided upper confidence limit places the burden on proving the water is unimpaired.
>
> A test significance level of 0.4 equates to a 60 percent one-sided confidence limit. The formula for a 60 percent one-sided confidence limit is:
>
> upper confidence limit (UCL) = sample mean + ((0.253)(standard deviation)/square root of sample size)
> lower confidence limit (LCL)= sample mean - ((0.253)(standard deviation)/square root of sample size)
>
> For Monroe City Lake the 60% UCL is 3.062 µg/L and the LCL is 2.932 µg/L. Thus placing the burden-of-proof on showing the lake is impaired, we compare the LCL of 2.932 to the 3 µg/L criterion and conclude the lake is unimpaired by atrazine. The actual statistical statement is "there is a 60% probability that the true mean is greater than or equal to 2.932 µg/L". Placing the burden-of-proof on showing the lake is unimpaired, we compare the UCL of 3.062 to the 3.000 µg/L criterion and conclude the lake is impaired. The actual statistical statement is "there is a 60% probability that the true mean is less than or equal to 3.062 µg/L."

Neither of these two statements is very reassuring that the lake is really meeting the atrazine standard since the mean value is so close to the criterion value. If the sample data are applied to the frequency distribution of the "z" statistic, the result shows that the true mean has only a 50.4 percent chance of meeting the criterion. It seems unwise to judge a water to be in conformance with a human health criterion when there is only a 50.4 percent chance that this is true[17].

For non-human health related criteria that are to be evaluated by hypothesis tests the burden-of-proof will be placed on showing that the water is impaired. The rationale for this decision is that the often-significant social and or economic consequences that follow listing a water as impaired should not be imposed unless there is convincing evidence of impairment. Placing the burden-of-proof in this manner provides impetus to the department and other environmental agencies and organizations to focus monitoring efforts on these waters.

Level of Significance Used in Tests

The choice of significance levels is largely related to two concerns. The first, as with the wording of the test and null hypotheses, is concerned with matching error rates with the severity of the consequences of making a decision error. The second addresses the need to balance, to the degree practicable, Type I and Type II error rates. For most circumstances, the department is recommending a 0.40 significance. We are not recommending a more stringent significance level such as 0.10 because of the increase in Type II error rate when going to this higher significance level.

For relatively small databases, the disparity between Type I and Type II errors can be large. The table below shows error rates calculated using the binomial distribution for two very similar situations. Type I error rates are based on a stream with a 10 percent exceedence rate of a standard and Type II error rates for a stream with a 15 percent exceedence rate of a standard. Note that choosing a Type I error rate of 0.05 rather than 0.10 increases an already very large Type II error rate by about 10 percent. Also note that for a given Type I error rate, the Type II error rate declines as sample size increases.

Table B-2. Effects of Type I Error Rates and Sample Size on Type II Error Rates

No. of Samples	No. Meeting Standards	Type I Error Rate	Type II Error Rate	No. of Samples	No. Meeting Standards	Type I Error Rate	Type II Error Rate
6	5	.11	.78	4	3	.05	.89
11	9	.09	.78	9	7	.05	.86
18	15	.10	.72	15	12	.05	.82
25	21	.10	.68	21	17	.05	.80
				27	21	.05	.78

[17] Monroe City Route J Lake provides a good example of the value of an upper confidence limit. However, it should be noted that this data set is highly unusual in the similarity of the mean value (2.997) and the criterion value (3.000). In two other lakes in northeast Missouri with mean atrazine levels of 2.20 and 2.36, the UCL was less than the criterion value and use of the UCL, mean or LCL all lead to the conclusion that the water was unimpaired by atrazine. The message here is that we can use the UCL to judge impairment with the added confidence it provides that we are protecting human health, without greatly adding to the list of waters we judge to be impaired. This becomes increasingly true as sample size increases.

Use of the Binomial Probability Distribution for Interpretation of the Ten Percent Rule

There are two options for assessing data for compliance with the ten percent rule. One is to simply calculate the percent of time the criterion value is not met and to judge the water to be impaired if this value is greater than ten percent. The second method is to use some evaluative procedure that can review the data and provide a probability statement regarding the compliance with the ten percent rule. Since the latter option allows assessment decisions relative to specific test significance levels and the first option does not, the latter option is preferred. The procedure chosen is the binomial probability distribution, for smaller data sets, and the normal approximation to the binomial distribution, for larger data sets.

Other Statistical Considerations

Prior to calculation of confidence limits, the normality of the data set will be evaluated. If normality is improved by a data transformation, the confidence limits will be calculated on the transformed data.

Time of sample collection may be biased and interfere with an accurate measurement of frequency of exceedence of a criterion. Data sets composed mainly or entirely of storm water data or data collected only during a season when water quality problems are expected could result in a biased estimate of the true exceedence frequency. In these cases, the department may use methods to estimate the true annual frequency and display these calculations whenever they result in a change in the impairment status of a water.

For waters judged to be impaired based on biological data where data evaluation procedures are not specifically noted in Table 1, the statistical procedure used, test assumptions and results will be reported.

Appendix C
Examples of Statistical Procedures

Two Sample "t" Test for Color

Null Hypothesis: Amount of color is no greater in test stream than in a control stream. (As stated, this is a one-sided test, meaning that we are only interested in determining whether or not the color level in the test stream is greater than in a control stream.) If the null hypothesis had been "amount of color is different in the test and control streams" we would have been interested in determining if the amount of color was either less than or greater than the control stream, a two-sided test).

Significance Level (also known as the alpha level): 0.10

Data Set: Platinum-Cobalt color units data for the test stream and a control stream samples collected at each stream on same date.

Test Stream	70	45	35	45	60	60	80
Control Stream	50	40	20	40	30	40	75
Difference (T-C)	20	5	15	5	30	20	5

Statistics for the Difference: Mean = 14.28, standard deviation = 9.76, n = 7
Calculated "t" value = (square root of n)(mean)/standard deviation = 3.86
Tabular "t" value is taken from a table of the "t" distribution for 2 alpha (0.20) and n-1 degrees of freedom. Tabular "t" = 1.44.
Since calculated "t" value is greater than tabular t value, reject the null hypothesis and conclude that the test stream is impaired by color.

Statistical Procedure for Data Sets of Less than Four for Mercury in Fish Tissue

Data Set: data in ug/Kg 130, 230, 450. Mean = 270, Standard Deviation = 163.7
The 50% Confidence Interval (CI) = the sample mean plus or minus the quantity:
(0.676)(163.7)/square root 3 = 63.89. Thus the 50% CI is 206.11 – 333.89
Since the criterion value, 300 ug/Kg, falls within this 50% CI, this water is judged to be unimpaired by mercury in fish tissue but the waterbody is placed in Category 2B or 3B.

Statistical Procedure for Data Sets of Four or More for Mercury in Fish Tissue

Data Set: data in ug/Kg 130, 230, 450, 350, 220. Mean = 276, Std. Deviation = 124.82
The 60% Upper Confidence Limit (UCL) = the sample mean plus the quantity:
(0.253)(124.82)/square root 5 = 14.12. Thus the 60% UCL is 290.12 ug/Kg.
Since the UCL is less than the criterion value of 300 ug/Kg, this water is judged to be unimpaired by mercury in fish tissue.

Appendix D. The Meaning of the Sediment Quotient and How to Calculate It

While sediment criteria in the form of Probably Effect Concentrations[18] (PECs) are given for several individual contaminants, it is recognized that when multiple contaminants occur in sediment, toxicity may occur even though the level of each individual pollutant does not reach toxic levels. The method of estimating the synergistic effects of multiple pollutants in sediments given in McDonald et al [10] is the calculation of a PEC Quotient. This calculation is made by dividing the pollutant concentration in the sample by the PEC value for that pollutant. These values are summed and normalized by dividing that sum by the number of pollutants.

Example: A sediment sample contains the following results in mg/kg.

Arsenic 2.5, Cadmium 4.5, Copper 17, Lead 100, Zinc 260. The PEC values for these five pollutants in respective order are 33, 4.98, 149, 128, 459.

PEC Quotient = ((2.5/33)+(4.5/4.98)+(17/149)+(100/128)+(260/459)/5) = 0.488

Based on research by McDonald (2000) 83% of sediment samples with PEC quotients less than 0.5 were non-toxic while 85% of sediment samples with PEC quotients greater than 0.5 were toxic. Based on these findings a PEC quotient greater than 0.5 will be judged to be toxic**.**

[18] Level at which harmful effects on the aquatic community are likely to be observed.