STATE OF MISSOURI
Bob Holden, Governor • Stephen M. Mahfood, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.state.mo.us

October 27, 2003

Ms. Cheryl Crisler
U.S. Environmental Protection
Agency, Region VII
901 North Fifth Street
Kansas City, KS 66101

Re: TMDL for Shoal Creek

Dear Ms. Crisler:

Enclosed please find a copy of the total maximum daily load study (TMDL) for Shoal Creek near Monett in Barry County, Missouri. The TMDL was public noticed from August 29 through September 28, 2003. Public comments were received and the document was adjusted where appropriate. All public comments received and Missouri Department of Natural Resources' (MDNR) response letters are on file with MDNR. We now submit this document as a final TMDL for review and approval by the U.S. EPA pursuant to Section 303(d)(2) of the federal Clean Water Act.

The Shoal Creek TMDL was developed by the department's Water Pollution Control Program to address the fecal coliform contamination of this waterbody, as identified on the section 1998 303(d) list. The impairment arises from excessive amounts of manure entering the stream from several sources including cattle in the stream, horse and cattle pastures, poultry litter washing off the land and faulty rural septic systems. A watershed group of local stakeholders has been organized and will implement this TMDL. They are formulating plans to address the sources of impairment.

We appreciate EPA taking prompt action on this TMDL. If you have any questions, please contact Sharon Clifford or me at (573) 751-7428 or at Missouri Department of Natural Resources, Water Pollution Control Program, P. O. Box 176, Jefferson City, MO 65102-0176.

Sincerely,

WATER POLLUTION CONTROL PROGRAM

Jim Hull
Director

JH:apd

Enclosure

c: William Bryan, AGO

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Ms. Cheryl Crisler
U.S. Environmental Protection
Agency, Region VII
901 North Fifth Street
Kansas City, KS 66101

Re: Correction for the Shoal Creek TMDL

Dear Ms. Crisler:

Enclosed please find pages five, six, nine, ten, and 17 - 20 of the Total Maximum Daily Load study (TMDL) for Shoal Creek near Monett in Barry County, Missouri. Changes were at the request of the U.S. Environmental Protection Agency (EPA).

- On page six under the "Septic tanks" heading in the first paragraph, last sentence, the number 1,077 was corrected to 1,005.
- On page 10, first sentence, "(E. coli)" was corrected to "(*E. coli*)."
- On page 17, last paragraph, fifth sentence, the word "only" was replaced with the word "mainly."
- On page 19, last line, "e-coli" was corrected to "*E. coli.*"

These eight pages are submitted for approval by EPA pursuant to section 303(d)(2) of the federal Clean Water Act and are to replace the pages of these same numbers in our earlier submission.

We appreciate EPA's assistance in revising this TMDL and in taking prompt action on it. If you have any questions, please contact Sharon Clifford or me at (573) 751-7428 or at Missouri Department of Natural Resources, Water Pollution Control Program, P. O. Box 176, Jefferson City, MO 65102-0176.

Sincerely,

WATER POLLUTION CONTROL PROGRAM

Jim Hull
Director

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Enclosure

c: William Bryan, AGO

poultry litter production map was developed from this information. It is assumed that each house produces 120 to 125 tons of poultry litter per year and it is spread within 10 miles of the poultry house. Using this information and the number of pasture acres in each sub-basin, poultry litter application rates were determined for the watershed (Figure 1).

**Figure 1. Poultry litter application rates**

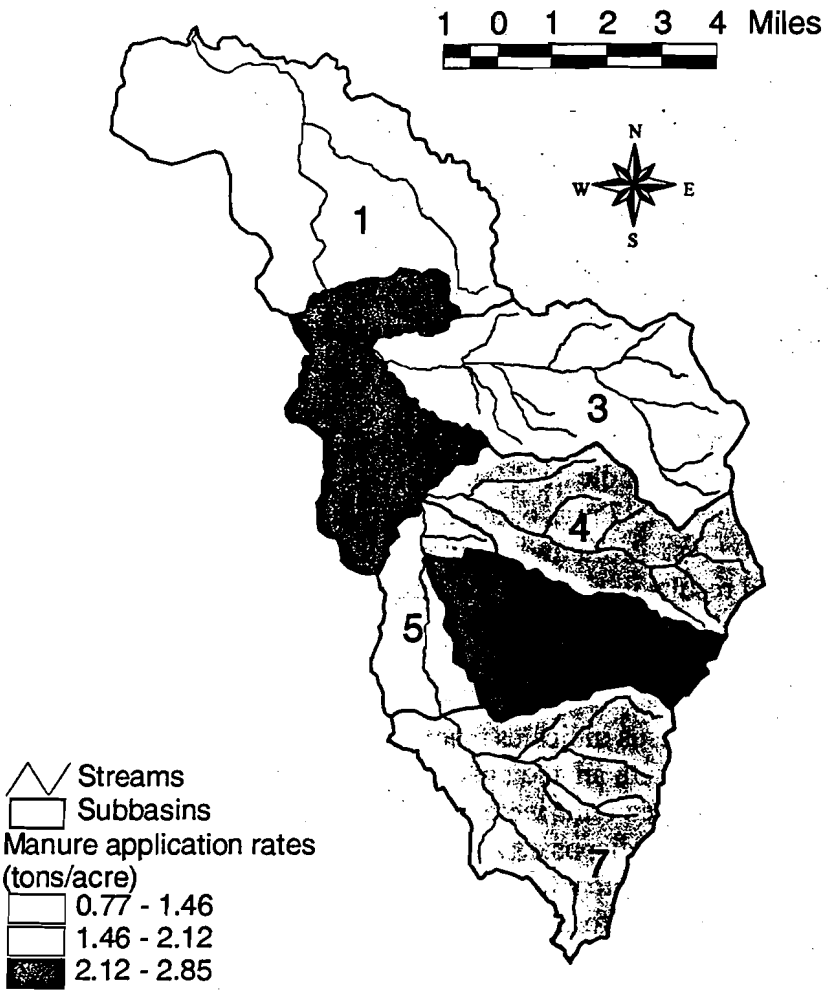


**Table 1. Land use in the Shoal Creek Watershed**

| | Subbasin number | | | | | | | Watershed |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Forest (%) | 16 | 12 | 8 | 8 | 14 | 8 | 10 | 11 % |
| Grassland (%) | 84 | 88 | 92 | 92 | 86 | 93 | 90 | 89 % |
| Area ($km^2$) | 53.3 | 23.6 | 40.3 | 30.4 | 15.9 | 25.3 | 36.1 | 224.9 $km^2$ |
| Area (acres) | 13175 | 5835 | 9954 | 7504 | 3936 | 6247 | 8912 | 55563 acres |

**Other domestic animals**
By a rough estimate, there are approximately 300 horses in the upper Shoal Creek watershed[4]. DNA analyses of the water samples collected at the Highway 97 Bridge identified horse fecal coliform in the creek. This can be explained by the fact that there is a horse pasture just above this sampling point. It is likely other horses in the watershed also contribute to the load, but there has not been any attempt to identify the origin of the patterns detected. DNA analysis also reveals that the percentage of horse fecal coliform is highest during late spring and summer. Thus, though horses are only a small part of the bacteria problem, they are considered a source of the pollutant.

Dogs are a potential source of bacteria. There are 66 licensed or registered puppy farms in Barry County, the highest concentration for any county in Missouri. The waste from dog farms consists of approximately 50 percent solids and 50 percent liquid. All waste has to be carried away from the facility to avoid health or odor problems in the operation. There are no regulations on the disposal of this waste and it is often spread in a nearby field. Although the amount of waste generated by these operations is small in comparison to other types of animal production, DNA analyses of water samples collected in Shoal Creek have shown dogs are a source of bacterial pollution.

Pigs may also be in the watershed, although no significant operation is known at this time. The agricultural Census indicates 39 pig farms in Barry County in 1997. Of these farms, 30 out of 39 had a total of 227 pigs or an average number of 6 to 7 pigs per farm. Six others had less than 100 pigs. Prorating the number of pig operations in Barry County to the Shoal Creek watershed results in six to seven small producers in the watershed. There is no information available on how the waste from these operations is managed.

**Septic tanks**
The Barry County Census indicates that there were 15,964 housing units in 2000, 13,398 of which were occupied with an average of 2.5 people. The 1990 census indicates that 67.4 percent of these occupied units were not connected to a public sewage system, i.e. they used a septic tank for sewage disposal. Assuming the same percentage for 2000, that would represent 9,030 units in Barry County. Assuming that the distribution of units that use on-site sewage disposal is uniform across Barry County, the number of individual septic systems in the upper Shoal Creek Watershed is estimated to be 1,005.

The rate of failure of these units can be estimated from their construction date, also determined from the 1990 Census data. Three categories of units were considered: before 1970, 1970-1984, and after 1984. The rates of failure were assumed to be 40 percent, 20 percent, and 5 percent, respectively. These rates have been used in Virginia for the development of a TMDL and were backed up by studies done in that area that found that 30 percent of all septic tanks were either failing or not functioning (Virginia DEQ, 2002). Using these rates and the number of septic systems in the watershed, we determined the number of failing systems (Table 2).

[4] Dan Philbrick, National Resource Conservation Service, personal communication.

- Cool Water Fishery
- Whole Body Contact Recreation (Swimming)
- Boating and Canoeing

**2.2 Use that is impaired:**
Whole Body Contact Recreation (Swimming)

**2.3 Standards that apply:**
Missouri's Water Quality Standards at 10 CSR 20-7.031(4)(C) state:

> "Protections of whole-body-contact recreation is limited to classified waters designated for that use. For periods when the stream or lake is not affected by stormwater runoff, the fecal coliform count shall not exceed two hundred colonies per one hundred milliliters (200 col/100 mL) during the recreational season in waters designated for whole-body-contact recreation or at any time in losing streams. The recreational season is from April 1 to October 31."

The stormwater exclusion in the standards is difficult to apply because there is no definition of what constitutes stormwater flow. In this TMDL, stormwater is addressed in the Load Frequency Curve (Figure 5). The curve is the 200 col/100 mL standard and different loads apply to different flows. The issue of the stormwater exclusion will be addressed in Missouri's next Standards revision.

**2.4 Anti-degradation Policy:**
Missouri's Water Quality Standards include the Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier I defines baseline conditions for all waters and requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen and ammonia) are met to protect uses.

Tier II requires that no degradation of high-quality waters occur unless limited lowering of quality is shown to be necessary for "economic and social development". A clear implementation policy for this tier has not been developed, although if sufficient data on high-quality waters are available, TMDLs could be based on maintaining existing conditions, rather than the minimal Tier I criteria.

Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires that no degradation under any conditions occurs. Management may prohibit discharge or certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

This TMDL will result in the protection of existing beneficial uses, which conforms to Missouri's Tier I anti-degradation policy.

**2.5 Target Determination:**
Currently the Missouri Department of Natural Resources is conducting a Water Quality Standards review. Regarding this review, EPA has a longstanding recommendation that the standard for the

indicator bacterium be changed from fecal coliform to *Escherichia coli* (*E. coli*) (EPA 2002). The department has data in both forms in this study. For the purpose of this TMDL, the existing fecal coliform standard will be used and, until the standard is changed, the numeric water quality target will be 200 col/100 mL.

## 3. CALCULATION OF LOAD CAPACITY

Load Capacity (LC) is defined as the greatest amount of a pollutant that a waterbody can receive without violating Missouri Water Quality Standards. The TMDL for this watershed is a continuous curve calculated from discrete loading capacities over a range of flow conditions. Specific loading capacities are calculated by taking the flowrate times the 200 col/100 mL Water Quality Standard times a conversion factor. This load is divided among the point sources (Waste Load Allocation or WLA) and nonpoint sources (Load Allocation or LA) with an allowance for an explicit Margin of Safety (MOS). The Margin of Safety ensures a conservative estimate of the pollutant load. It is calculated due to the inherent error that exists due to the high number of variables that exist in a dynamic stream system.

**LC = WLA + LA + MOS**

### 3.1 Model Set-up and Description:

The Soil and Water Assessment Tool (SWAT) was used to simulate fecal coliform loading (Arnold et al., 1998). The methodology relies on a mathematical computer simulation that calculates bacteria loads and concentrations. Both fecal coliform and *E. coli* were used in this study. The model takes into account climate, physical landscape features and land management factors. The purpose of using a model is to integrate the flow data and the water quality data in order to establish water quality baseline characteristics.

For modeling purposes, the watershed was divided into sub-basins and further sub-divided into nearly homogeneous units that has a distinct land use, soil type and management practice. The units are called hydrologic response units (HRU). For the Shoal Creek watershed, the sub-basins were selected on the basis of the natural tributaries to Shoal Creek and on the existing water sampling points. Figure 2 shows the sub-basins that were utilized. Once a baseline is established, the model evaluates the potential change in environmental impact if landowners in the watershed change their management practices.

## 5. LOAD ALLOCATION (NON-POINT SOURCE LOAD)

The Load Allocation (LA) includes all existing and future nonpoint sources plus the natural background conditions.

To compare the impact of different sources, model scenarios were run with each of the bacteria sources contributing to the load during the recreation season. These conclusions are based on the hypotheses regarding the number of on-site septic systems that may result in direct bacteria inputs, the number of cows that stand in the stream and the loading from pastures. Other scenarios were simulated to estimate the loadings from various sources:

- Cattle direct deposits only
- Nonpoint source direct inputs only (cattle + sanitary)
- Nonpoint source loadings from grazing cattle only
- Nonpoint source loadings from poultry litter only

The results indicate that direct nonpoint source inputs have the largest impact on the stream loads and bacteria concentrations 50 percent of the time. Bacteria loads carried by surface runoff are the dominant source of loading and bacteria 15 percent of the time. The loads delivered by surface runoff are equal to those directly contributed to the stream 35 percent of the time. Contributions from each source can be estimated during the three different types of flow conditions and are shown in Table 4.

During base flow, cattle are responsible for the majority of the bacteria. On-site systems make a smaller contribution. During periods of mixed base flow and stormwater runoff, cattle again are the major source of fecal coliform loading. Under these flow conditions, both direct deposits of manure and runoff from pastures add to the load. Poultry litter is a significant source of bacteria mainly during periods of high surface runoff. Poultry litter is spread in the spring when large storm events are likely to occur. The litter is spread at one time in large quantities. This increases the potential for large, one-time bacteria loadings if a rain event immediately follows the spread of the litter. However, the probability of a rain event occurring after the current single application is lower than would be expected if smaller amounts of litter were spread more frequently. The timing of the spreading of poultry litter is critical to prevent one-time, large bacterial loadings.

**Table 4. Averaged simulated contributions in percentages from each source to the fecal coliform loading in Shoal Creek.**

| Flow type | Base flow (>50% frequency) | Mixed base and storm flow (15-50% frequency) | Storm flow (< 15% frequency) | All flows (0 – 100 %) |
|---|---|---|---|---|
| Cattle in streams | 82.5% | 31.5% | 0.7% | 2.7% |
| Sanitary sewage | 16.8% | 5% | 0.1% | 0.4% |
| Grazing cattle | 0.7% | 63.1% | 28.5% | 29.4% |
| Poultry litter | 0% | 0.4% | 70.7% | 67.5% |

Due to the variations in loading from different sources over the range of flow conditions, determination of the load allocation is appropriated to the differing flow regimes. The Load

Allocation is equal to the Load Capacity (Total Maximum Daily Load) minus the Wasteload Allocation minus the Margin of Safety.

**LA = LC – WLA – MOS**

The Load Capacity or TMDL is based on the curve in Figure 5. The Margin of Safety is based on the standard deviations that result for each segment of the curve. Results are in Table 5.

## 6. MARGIN OF SAFETY (MOS)

A margin of safety (MOS) is necessary due to uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

(1) Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
(2) Implicit - Incorporate the MOS as part of the design conditions for the waste load allocation and the load allocation calculations (making conservative assumptions in the analysis itself).

The measurement and simulation of fecal coliform concentrations includes many uncertainties and possible sources of error.

Sources of error during sampling and measurement include:

- Variability of bacteria counts within the cross-section of a stream
  (Two samples from the same location but in different parts of the stream may vary)
- Variability of bacteria results collected on a given day and the meaning of an individual sample relative to an average daily concentration
  (Two samples from the same location collected at different times of day can have varying results)
- Potential contamination by monitoring equipment
- Potential decay or growth of bacteria during transport to the laboratory

Sources of error for the simulation of bacteria concentrations include:

- Uncertainty about the average daily coliform production of cows and humans
- Bacteria content of poultry litter
- Decay rate of bacteria from different sources on the land and in the water

Cows are known to spend a significant amount of time standing in streams, particularly during hot weather. It is difficult, however, to quantify precisely how much time they spend in the stream or how that time is related to the amount of manure defecated. Also, the karst features of this watershed were not taken into account. Finally, the impact of a pollutant is dependent on the stream flow and therefore, on weather conditions.

Even with efforts to minimize the sampling and measurement errors, the uncertainties on the inputs cannot easily be reduced. For this TMDL, the Margin of Safety will be the standard deviations that result for each segment of the curve in Figure 5, based on the variability of the weather.

Because flows are different from one year to another, the fecal coliform load that results in a concentration of 200 colonies per 100 ml varies. Based on the 30-year long simulation, the department has calculated the average flow frequency curve that can be expected during any year. For each frequency value, the standard deviation of the flows that occur with that frequency was calculated and multiplied by 200 colonies/100ml to obtain the standard deviation of the load capacity. These standard deviations were then averaged within each flow segment. Results are in Table 5.

**Table 5. Fecal Coliform Load Allocations and Percent Reductions in Pollutant Load Needed to Meet Water Quality Standards**

| Flow Probability (%) | 0-15 (Storm flows) | 15-50 (Mixed Flows) | 50-100 (Base flows) |
|---|---|---|---|
| LC(cfu) | 1.4114E+12 | 4.4492E+11 | 1.6614E+11 |
| MOS (cfu) | 5.3109E+11 | 1.4097E+11 | 9.2589E+10 |
| WLA (cfu) | 4.5455E+08 | 4.5455E+08 | 4.5455E+08 |
| LA (cfu) | 8.7985E+11 | 3.0349E+11 | 7.3096E+10 |
| Measured data geomean (cfu) | 5.7677E+12 | 6.[illegible]848E+11 | 2.6324E+11 |
| Reduction (cfu) | 4.8878E+12 | 3.4499E+11 | 1.9014E+11 |
| Reduction (%) | 85 % | 53 % | 72 % |

## 7. SEASONAL VARIATION

Shoal Creek is designated for whole body contact recreation during the period from April 1 to October 31. During this season, human activities increase in and around the stream. The TMDL addresses seasonal variation by associating a daily load to every flow. The critical season extends from June to October when the flow is at its lowest and the stream use is at its peak.

## 8. MONITORING PLANS UNDER THE PHASED APPROACH

Monitoring of flows, water quality and DNA host identification will be terminated at the end of 2003. Future water quality monitoring will track the changes during and after implementation of alternative management practices.

In order to observe and quantify the temporal variation of water quality indicators in Shoal Creek, monitoring of water quality occurred frequently at one location (Highway 97 bridge). A few samples were collected at other points and from springs to obtain data that could confirm or contradict the water quality data collected at Highway 97. These verification data sets did not have a sufficient number of samples to adequately characterize the water quality of tributaries or springs. This might be a consideration in future monitoring plans.

Crowder College is under contract with the department to collect fecal coliform data at the Hwy 97 bridge through mid 2004. Post implementation monitoring will commence three years after the strategies discussed in the next section are implemented. Fecal coliform and *E. coli* data will be

collected. Other parameters may be collected, but the sampling plan will be based on the assessment needs that exist at the time post implementation monitoring is initiated. One option is to obtain data through 319 grants that may be awarded in the Shoal Creek watershed in the future.

All Missouri TMDLs are phased. If future monitoring reports reveal that water quality standards are not being met, this TMDL will be re-opened and re-evaluated.

## 9. IMPLEMENTATION

Efforts have already occurred in the Shoal Creek watershed to deal with excessive nutrients reaching the creek. From 1995 – 2000, a 319 grant provided education on poultry litter land application. The positive result was that phosphorus levels in soil decreased. Also, there is an Agricultural Nonpoint Source Special Area Land Treatment (AgNPS SALT) Project that was recently completed. It was funded from 1997 until June 2003. The first objective of this project was to educate and train landowners in nutrient management. Future monitoring will reveal the impact and effectiveness of this project. Although these projects were aimed at nutrient management, the BMPs employed also help reduce the amount of bacteria entering the stream.

Additionally, there is a current 319 project that impacts upper Shoal Creek. The Elk River and Shoal Creek 319 Project was initiated in 2002 and a good start has been made. Some of the aims of the project are enrolling farms in Comprehensive Nutrient Management Plans, constructing stacking sheds, installing livestock watering wells in combination with rotational grazing systems, adding exclusion fencing along the riparian corridor, and conducting a feasibility study of transporting litter out of the watershed to intensive crop production areas in need of nitrogen and phosphate fertilizers.

Several scenarios were run using the SWAT model to assess which alternative management practices would lead to stream fecal coliform concentrations that would meet water quality criteria. The following scenarios were evaluated:

- Scenario 1: no septic discharge, a 50 percent reduction of cattle standing in the streams, and a 50 percent reduction of the nonpoint source load
- Scenario 2: no septic discharge, no cattle standing in the streams, and a 50 percent reduction of the nonpoint source load
- Scenario 3: no septic discharge, a 50 percent reduction of cattle standing in the streams, and a 66 percent reduction of the nonpoint source load
- Scenario 4: no septic discharge, no cattle standing in the streams, and a 66 percent reduction of the nonpoint source load

The frequency curves that result from the simulation of the scenarios are shown in Figure 7. The figure shows that 85 to 90 percent of concentration values that result from the implementation of scenarios 3 and 4 are lower than 200 colonies per 100 mL

However when looking at the variation of the 30-days average concentrations over time, scenario 3 produces a geometric average that goes above 200 colonies/100mL every single year. Scenario 4 only has a few similar events occurring during the last 10 years and was limited to when poultry litter is applied just before rain events (Figure 8).