



EPA Region 7 TMDL Review

TMDL ID:IA 04-UDM-0140-L_0

State: IA

Document Name: BIG CREEK LAKE

Basin(s): MIDDLE DES MOINES

HUC(s): 07100004

Water body(ies): BIG CREEK LAKE

Tributary(ies): BIG CREEK, LITTLE CREEK, TURKEY CREEK

Pollutant(s): E. COLI

Submittal Date:9/10/2010

Approved:Yes

Submittal Letter

State submittal letter indicates final Total Maximum Daily Load(s) (TMDL) for specific pollutant(s)/water(s) were adopted by the state, and submitted to EPA for approval under section 303(d) of the Clean Water Act [40 CFR § 130.7(c)(1)]. Include date submitted letter was received by EPA, date of receipt of any revisions, and the date of original approval if submittal is a phase II TMDL.

This TMDL was formally submitted by the Iowa Department of Natural Resources to the U.S. Environmental Protection Agency on September 10, 2010. Revisions to the TMDL were sent by email on April 22, 2011.

Water Quality Standards Attainment

The water body's loading capacity (LC) for the applicable pollutant is identified and the rationale for the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources is described. TMDL and associated allocations are set at levels adequate to result in attainment of applicable water quality standards (WQS) [40 CFR § 130.7(c)(1)]. A statement that WQS will be attained is made.

Big Creek Lake is impaired based on the results of the IDNR-University of Hygienic Laboratory (University of Iowa) summer beach monitoring program for the pathogen indicator bacteria (*Escherichia coli* [*E. coli*]). Samples were collected once a week, from mid-April to mid-October 2000 to 2008. The collected samples exceeded the IDNR's WQS of 126 *E. coli* organisms per 100 milliliters (mL). A percentage of the samples exceeded the IDNR's single-sample maximum criterion (235 *E. coli* organisms per 100 mL) during the 2000-2008 recreation seasons. *E. coli* impairs primary contact recreation and presents human health issues within the water body.

The loading capacity is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. During mid-range flow, loads originate from minor occurrences of local runoff, failed septic tanks and cattle in the lake. At mid-range, 40-60 percent recurrence interval range, the loading capacity at midpoint is 20 cubic feet per second (cfs), 33 cfs and 12 cfs for midpoint, maximum and minimum flow ranges, respectively. The loading capacity targets for this TMDL are at mid-range, 6.2E+10 organisms per day (orgs/day) for the geometric mean and 1.2E+11 orgs/day for the single sample maximum.

The EPA agrees attainment of the loading capacity should result in the attainment of WQS.

Numeric Target(s)

Submittal describes applicable WQS, including beneficial uses, applicable numeric and/or narrative criteria. If the TMDL is based on a target other than a numeric water quality criterion, then a numeric expression, site specific if possible, was developed from a narrative criterion and a description of the process used to derive the target is included in the submittal.

The water quality criterion for pathogen indicator (*E. coli*) is listed below and is published in the *Iowa Administrative Code 567, Chapter 61 Water Quality Standards*:

Water Body ID	Designated Uses	Impaired Uses	<i>E. coli</i> Criteria
IA 04-UDM-0140-L_0	Primary Contact Recreation Use (Class A1), Aquatic Life (Class B)(WW1), Human Health (Class HH)	Primary Contact Recreation (Class A1)	126 organisms/100 mL geometric mean 235 organisms/100 mL single sample maximum Primary Contact Recreation Period: March 15 to November 15

The 2008 305(b) water quality assessment is provided in Appendix F of the TMDL. For Big Creek Lake, the Class A1 use was assessed as "not supported" based on the results of monitoring for indicator bacteria (*E. coli*). According to the IDNR's assessment and impaired listing methodology, if monitoring shows that greater than ten percent of samples exceed the single sample maximum, a lake is partially supported for Class A1 use and is impaired.

The WQS exceedances, compliance targets and flow and load duration curves were used to set pollutant allocations. The monitored *E. coli* concentrations were multiplied by the daily flow to get the daily loads that are plotted with the load duration curve. The maximum allowable load for a recurrence percentage is the flow multiplied by the geometric mean and single sample maximum curves. The *Soil and Water Assessment Tool* and the *EPA Bacteria Indicator Tool* were also used to develop targets for this TMDL. The *Soil and Water Assessment Tool* is a watershed model used to simulate hydrology, washoff and transport of bacteria, while the *EPA Bacteria Indicator Tool* is a bacteria source evaluation spreadsheet.

The loading capacity was calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. At mid-range, 40-60 percent recurrence interval range, the loading capacity at mid range is 20 cfs, 33 cfs and 12 cfs for midpoint, maximum and minimum flow range, respectively. The loading capacity targets for TMDL are at mid-range, 6.2E+10 orgs/day for the geometric mean and 1.2E+11 orgs/day for the single sample maximum.

Pollutant(s) of concern

An explanation and analytical basis for expressing the TMDL through surrogate measures (e.g., parameters such as percent fines and turbidity for sediment impairments, or chlorophyll-a and phosphorus loadings for excess algae) is provided, if applicable. For each identified pollutant, the submittal describes analytical basis for conclusions, allocations and margin of safety (MOS) that do not exceed the LC. If submittal is a phase II TMDL there are refined relationships linking the load to WQS attainment. If there is an increase in the TMDL there is a refined relationship specified to validate the increase in TMDL (either load allocation (LA) or waste load allocation (WLA)). This section will compare and validate the change in targeted load between the versions.

The WQS for *E. coli* bacteria are set based on both the geometric mean of 126 orgs/100 mL and the single sample maximum concentration of 235 orgs/100 mL; these are direct measures. The wasteload allocation is zero pounds per day (lb/day) because there are no permitted facilities in the watershed. The load allocation is set at the remainder of the TMDL loading curve after removing allowances for the wasteload allocation and margin of safety. Nonpoint sources have been identified as the contributing factor of bacteria loads delivered to Big Creek Lake.

Pollutant loading for this TMDL is divided into two components, episodic and continuous. Episodic is comprised of livestock and wildlife fecal material that is periodically transported during precipitation events. Continuous loading includes discharges from septic tanks, manure from cattle in and near watershed streams and feces from geese and deer near the lake.

One of the IDNR's assessment methods for evaluating pathogen indicator criteria states that if 10 percent or more of samples exceed the *E. coli* criterion, the water body is considered to be impaired for its recreational use. To estimate existing bacteria loads, the 90th percentile of observed bacteria concentrations within each flow condition determined by a load duration curve is multiplied by the median flow for each condition. The *EPA*

Bacteria Indicator Tool model is used to estimate the maximum bacteria load available for washoff by land use. However, only a fraction of the bacteria available for washoff is actually delivered to the lake. This fraction delivered by precipitation is the existing load during runoff conditions.

The criteria used to determine attainment of WQS is explained in the 305(b) report assessment protocol described in Appendix F of the TMDL.

Source Analysis

Important assumptions made in developing the TMDL, such as assumed distribution of land use in the watershed, population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources, are described. Point, nonpoint and background sources of pollutants of concern are described, including magnitude and location of the sources. Submittal demonstrates all significant sources have been considered. If this is a phase II TMDL any new sources or removed sources will be specified and explained.

The Big Creek Lake watershed area is 47,666 acres, including the lake. Without the lake, the watershed has a drainage area of 46,911 acres and a watershed to lake ratio of 62. This watershed has a high lake to area ratio. Big Creek Lake watershed is comprised of 1,038.6 acres of farmstead, 751.7 acres of parkland, 831 acres of pasture/hay, 38,725 acres of row crop, 931 acres of timber, 2,277 acres of ungrazed grass, 2,2751.5 acres of urban/roads, 23.3 acres of vineyard and 816.1 acres of water.

Located in the Des Moines Lobe ecoregion, Big Creek Lake's topography is glaciated and is a poorly drained landscape with many ponds and marshes in the areas between ridges with no drainage outlets. The glaciated area is part of the Prairie Pothole Region that extends north and west into Canada. The southern boundary of the Des Moines Lobe is a glacial end moraine.

The last glacier entered Iowa in an advanced surge and diminished 2,000 years later leaving a poorly drained landscape of unconsolidated deposits from the melting ice, sands and gravels, and clay and peat from glacial lakes. Today, curved bands of ridges and knobby hills among irregular ponds and wetlands, punctuate the glaciated landscape.

The Des Moines Lobe ecoregion, one of the youngest and flattest surfaces in Iowa, is predominantly agriculture. The land is gently rolling with the moraines having the most relief, and the morainal ridges, hammocky knob and kettle topography contrast with the flat plains of ground moraines, former glacial lakes and outwash deposits.

The central feature of Big Creek State Park and a popular outdoor recreation area is Big Creek Lake. Big Creek Lake is a publicly-owned lake in central Iowa in Polk County, three miles north of Polk City. The two primary tributaries that flow into the lake are Big Creek and Little Creek. Another tributary is Turkey Creek, which flows to the lake from the east. These streams were impounded to create Big Creek Lake in 1977 during the construction of the Saylorville Reservoir. Big Creek State Park was also established at this time. Big Creek Lake was primarily developed as a flood control measure to protect Polk City. The lake is comprised of a swimming beach and ten miles of multi-use trails.

The Saylorville project was designed as a dam to prevent the reservoir from backing up into Polk City and flooding it. Big Creek was also dammed thus creating an impoundment called Big Creek Lake. The Diversion Dam was built across Big Creek north of Polk City with an outlet to Saylorville Reservoir. The outlet channel runs one mile to a spillway before discharging into Saylorville Reservoir.

Big Creek Lake's elevation of water surface is maintained at about 920 feet and it discharges into Saylorville Reservoir over a wide weir at the end of a long channel. The discharge varies with the flow into the lake. Normally, the lake water surface elevation does not vary much from the elevation of the weir crest; the exception is during long dry periods when evaporation exceeds flow into the lake and the water surface elevation drops below the weir crest. Outlet channel flow can be as high as 3,000 cfs during wet periods, on average. During dry periods the average discharge is zero and the surface water elevation can drop five-to six-feet below the weir crest elevation. When this occurs the only discharge from the lake is the continuation of the original stream past the dam. This discharge is a constant four cfs with the purpose of maintaining stream integrity downstream. The water surface elevation of Saylorville Reservoir fluctuates over a considerable range. As a result, it is possible for Saylorville Reservoir to back up into Big Creek Lake.

Big Creek Lake has wastewater collection and treatment facilities that were originally designed as no discharge systems, but had recent discharges that were made on an emergency basis. They have been discontinued.

In the absence of an National Pollutant Discharge Elimination Systems permit, the discharges associated with sources were applied to the load allocation, as opposed to the wasteload allocation for purposes of this TMDL. The decision to allocate these sources to the load allocation does not reflect any determination by the EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDL with some sources treated as load allocations, the EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL are found to be, or become, NPDES regulated discharges, their loads must be considered as part of the calculated sum of the wasteload allocations in this TMDL. Wasteload allocation in addition to that allocated here is not available.

There are no NPDES point sources in the watershed, but there are about 329 onsite septic tank systems in the watershed. It is estimated that 25 percent are not functioning properly. It is assumed that these are continuous year round discharges.

The nonpoint sources of pollutants in the watershed have two components. One is episodic and comprised of livestock and wildlife fecal material that is periodically transported during precipitation events, wash-off load from the bacteria accumulated on land surfaces when it rains. The other is continuous loading from leaking septic tank systems, cattle manure in and near streams, and feces from geese in and near the lake. Loads from cattle in tributary streams and faulty septic tank systems occur as criteria excursions during dry and low flow periods. Data indicates there are no elevated sample loads at low flow conditions, and the maximum existing load condition occurs during storm events when runoff and bacteria concentrations are the highest.

The bacteria sources have been estimated for the peak five month recreation season, May through September. The statutory recreational season runs from March 15 to November 15, but excursions have been monitored only during the peak season. There are about 10,862 hogs in confinement in the watershed. The manure from these confinements is stored and land applied to cropland. Manure distribution to the fields are nearest to the confinements in the fall and spring. The proximity of manure application is low to medium. Some application fields are relatively distant from the lake. The potential for recreation season *E.coli* impacts is reduced by the fall and spring timing of manure application as shown in the manure management plans.

There are not any criteria exceedances above 68 percent recurrence (none above the dry/low flow conditions). This means that the continuous sources, such as cattle in the stream and faulty septic tank systems, alone are not causing the impairment. The runoff duration curve shows that 87 percent of samples exceeding the SSM criteria were collected when flows were less than 60 percent recurrence (all at mid-range to high flow conditions). This implies that sources that are usually considered to be continuous (cattle in tributary streams and septic tank systems) are not the causes of impairment and addressing these will have little effect on the lake water quality.

Some *E. coli* contribution to Big Creek Lake originates from the feces of warm blooded animals near the water body. Sources include wildlife (primarily deer and geese in the park), grazing animals in pastures, direct deposit of cattle manure in tributary streams, land application of manure and faulty septic tank systems in the watershed. There is an estimated 548 deer in the watershed and 129 in the park or in close proximity to the lake. The deer are in the park year round and have an increased source potential because of their proximity to the lake. It is assumed that both cattle and horses are on pasture throughout the recreation season. There is an estimated 530 cattle and 39 horses in the watershed. These grazing animals have a medium potential to deliver bacteria loads to the lake since many of the operations are relatively distant from the sampling locations. Of the 530 cattle in pastures, one to six percent of those on pasture are assumed to be in the tributary streams on a given day during the recreation season.

Any Concentrated Animal Feeding Operation (CAFO) that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is the EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance. However, many large CAFOs (mostly the poultry and swine sectors) contend that they do not discharge and therefore are not required to obtain an NPDES permit. It is the EPA's opinion that many of the "no discharge" CAFOs may not have adequate land application area to ensure the agronomic uptake of land applied waste or are not designed, constructed, operated or maintained so that they will not discharge. Furthermore, there are many Animal Feeding Operations that meet the definition of a medium CAFOs (i.e., discharge via a man-made conveyance) but are unpermitted and have not limited their impact on waters by applying Best Professional Judgment to effluent reductions under a permit.

There are no permitted CAFOs listed in this TMDL, therefore the wasteload allocation has been set to zero. Animal Feeding Operations and unpermitted CAFOs are considered under the load allocation because there is currently not enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by the EPA that such a facility does not meet the definition of a CAFOs nor that the facility does not need to obtain a permit. To the contrary, a CAFOs that discharges has a duty to obtain a permit. If it is determined that any such operation is a CAFOs that discharges, any future wasteload allocation assigned to the facility must not result in an exceedance of the sum of the wasteload allocations in this TMDL as approved.

All known sources have been considered.

Allocation - Loading Capacity

Submittal identifies appropriate WLA for point, and load allocations for nonpoint sources. If no point sources are present the WLA is stated as zero. If no nonpoint sources are present, the LA is stated as zero [40 CFR § 130.2 (i)]. If this is a phase II TMDL the change in LC will be documented in this section.

At mid-range flow exceedance, 40-60 percent recurrence interval range, the loading capacity at mid-point is 20 cfs, 33 cfs and 12 cfs for midpoint, maximum and minimum flow range, respectively. The loading capacity targets for this TMDL at mid-range are 6.2E+10 orgs/day for the geometric mean and 1.2E+11 orgs/day for the single sample maximum.

There are no permitted point sources in the Big Creek Lake watershed, therefore, the wasteload allocation is zero.

The load allocation is set at the loading capacity minus the 10 percent margin of safety. There are separate load allocations for the geometric mean and single sample maximum.

The margin of safety is an explicit 10 percent of the loading capacity for both the geometric mean and single sample maximum criteria, at each recurrence interval target.

The EPA agrees this is an appropriate loading capacity.

WLA Comment

Submittal lists individual WLAs for each identified point source [40 CFR § 130.2(h)]. If a WLA is not assigned it must be shown that the discharge does not cause or contribute to WQS excursions, the source is contained in a general permit addressed by the TMDL, or extenuating circumstances exist which prevent assignment of individual WLAs. Any such exceptions must be explained to a satisfactory degree. If a WLA of zero is assigned to any facility it must be stated as such [40 CFR § 130.2(i)]. If this is a phase II TMDL any differences in phase I and phase II WLAs will be documented in this section.

There are no permitted point sources in the Big Creek Lake watershed, therefore, the wasteload allocation is zero.

The EPA agrees this is an appropriate wasteload allocation.

LA Comment

Includes all nonpoint sources loads, natural background, and potential for future growth. If no nonpoint sources are identified the LA must be given as zero [40 CFR § 130.2(g)]. If this is a phase II TMDL any differences in phase I and phase II LAs will be documented in this section.

At mid-range flow exceedance, 40-60 percent recurrence interval, the load allocation for the geometric mean criteria of 126 *E. coli* orgs/100 mL is 7.1E+10 orgs/day.

At mid-range flow exceedance, 40-60 percent recurrence interval, the load allocation for the single sample maximum criteria of 235 *E. coli* orgs/100 mL is 1.3E+11 orgs/day.

The EPA agrees this is an appropriate load allocation.

Margin of Safety

Submittal describes explicit and/or implicit MOS for each pollutant [40 CFR § 130.7(c)(1)]. If the MOS is implicit, the conservative assumptions in the analysis for the MOS are described. If the MOS is explicit, the

loadings set aside for the MOS are identified and a rationale for selecting the value for the MOS is provided. If this is a phase II TMDL any differences in MOS will be documented in this section.

The margin of safety is an explicit 10 percent of the loading capacity for the geometric mean and single sample maximum criteria for each recurrence interval target.

At mid-range flow exceedance, 40-60 percent recurrence interval, the geometric mean margin of safety is 7.9E+09 orgs/day.

At mid-range flow exceedance, 40-60 percent recurrence interval, the single sample maximum margin of safety is 1.5E+10 orgs/day.

The EPA agrees this is an appropriate margin of safety.

Seasonal Variation and Critical Conditions

Submittal describes the method for accounting for seasonal variation and critical conditions in the TMDL(s) [40 CFR § 130.7(c)(1)]. Critical conditions are factors such as flow or temperature which may lead to the excursion of WQS. If this is a phase II TMDL any differences in conditions will be documented in this section.

Bacteria samples are estimated for the peak five month recreation season, May through September. Seasonal variation for this TMDL is defined in the IDNR's WQS as the recreation season, March 15 through November 15. During this peak season exceedances are monitored because that is when samples are collected. Bacteria loads are not cumulative in the lake because bacteria can decay over time.

Maximum runoff and bacteria concentrations are highest during storm events producing the existing maximum loads. Due to elevated loads and flows, bacteria concentration often exceed criteria. Bacteria loads from cattle in streams and failing septic tanks during dry and low flow periods also lead to criteria violations. There is no record of elevated sample loads at the low flow condition.

Seasonality and any critical conditions have been addressed in the submittal.

Public Participation

Submittal describes required public notice and public comment opportunity, and explains how the public comments were considered in the final TMDL(s) [40 CFR § 130.7(c)(1)(ii)].

This TMDL was placed on public notice starting August 15 and ending September 7, 2010. No comments were received during the comment period.

On March 22, 2010, a stakeholder's meeting was held at the Ankeny Natural Resources Conservation Service office. Lake water quality issues and bacteria sources were identified and discussed. Information obtained at this meeting was used for the development of this TMDL. On August 19, 2010, another public meeting was held from 6 to 8 p.m. at the Polk County Community Center.

Monitoring Plan for TMDL(s) Under Phased Approach

The TMDL identifies a monitoring plan that describes the additional data to be collected to determine if the load reductions required by the TMDL lead to attainment of WQS, and a schedule for considering revisions to the TMDL(s) (where phased approach is used) [40 CFR § 130.7].

There are two separate existing monitoring efforts supported by the IDNR. One effort is the University Hygienic Laboratory (University of Iowa) that collects three to six samples between April and October. These samples are analyzed for nutrients, suspended solids, temperature, pH, chlorophyll and transparency. Another effort is the IDNR's beach monitoring program in which samples are collected weekly at the park beach and analyzed for *E. coli*.

These two monitoring efforts provide information on the biannual 305(b) water quality assessment and currently form the foundation of the Big Creek Lake monitoring program. This data is sufficient to assess lake water quality because it can detect impairments. The evaluation of pollutant sources, the impacts of specific and implemented best management practices and trends over time require a more detailed and comprehensive monitoring approach.

Tables 5-1 and 5-2 of the TMDL lists information for watershed stream and in-lake monitoring,

consecutively. Watershed stream monitoring includes: 1) measurement of continuous flow is stage measured hourly from April to October, 2) event sampling of phosphorus, nitrogen, suspended solids and *E. coli* are taken once an hour for at least 24 hours and 3) grab sampling of phosphorus, nitrogen, suspended solids and *E. coli*, in addition to field measurements of pH, dissolved oxygen and flow; these samples will be taken once or twice a month from April to October and 4) long-term sampling for phosphorus, nitrogen, suspended solids and *E. coli* to evaluate long term trends and best management practices effectiveness will be taken once or twice a month for 5 to 10 years, April to October.

In-lake monitoring includes: 1) continuous discharge from the lake will be measured hourly ice out to ice in, 2) daily precipitation near the lake will be monitored long term and year round and 3) beach *E. coli* samples will be collected once a week, May through October, at the lake's swimming beach to determine if water is safe for swimming.

Reasonable Assurance

Reasonable assurance only applies when less stringent WLAs are assigned based on the assumption of nonpoint source reductions in the LA will be met [40 CFR § 130.2(i)]. This section can also contain statements made by the state concerning the state's authority to control pollutant loads.

States are not required under Section 303(d) of the Clean Water Act to develop TMDL implementation plans and the EPA does not approve or disapprove them. However, the IDNR included implementation plans in this TMDL to provide information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL. The EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL. Therefore, discussion of reduction efforts relating to point and nonpoint sources can be found in the implementation section of the TMDL, and are briefly described below.

The IDNR has the authority to issue and enforce state operating permits. Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to the IDNR should provide reasonable assurance that instream WQS will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for wasteload allocations to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL's combined nonpoint source load allocations and point source wasteload allocations do not exceed the WQS-based loading capacity and there is reasonable assurance that the total maximum daily load's allocations can be achieved. Funding assistance for controlling nonpoint sources of bacteria loads are available, such as the Clean Water Act Section 319 grants. These grants will be used for implementing best management practices into the load allocations.

Some best management practices can be identified for implementation. The primary focus needs to be on nearby sources in the Lakeshore sub-watershed. These sources include geese on the beach and nearby locations, deer throughout the forested park, and horses in the equestrian campground and on park trails. Reductions in these loads will require changes in the way wildlife and horse manure are managed. Best management practices for reducing pathogen indicators in the Lakeshore sub-watershed include: 1) reduce the geese numbers and the time they spend on and near the lake, especially the beach area; 2) remove goose feces from the beach area daily and remove it outside of the watershed; 3) reduce the deer population in the park; 4) slow down the runoff from the equestrian campground with detention basins in drainage areas; 5) remove horse manure from the equestrian campground outside of the watershed daily and 6) limit horses on trails near the lake and remove trail manure daily outside of the watershed.

There are other bacteria sources in the Big Creek Lake watershed but distance, time, sedimentation basins, ponds and wetlands dampen their impacts. These sources include continuous septic tanks, cattle in the stream and the pasture and applied manure sources that are available for washoff during raining seasons. Best management practices for reducing pathogen indicators in the Big Creek Lake sub-watershed include: 1) limit livestock access to waterways in pastures and provide alternate watering sources; 2) control manure in runoff using incorporation or subsurface application to physically separate fecal material from surface runoff; 3) place buffer strips along tributaries to slow and divert runoff and 4) repair or replace improperly connected and malfunctioning septic tank systems.

Below are objectives and a suggested schedule to reduce *E. coli* in Big Creek Lake.

1. Identify, assess and rank the potential sources within a quarter mile of the lakeshore. Select best management practices for each source. Complete by May 2011.
2. Begin implementation of the best management practices by priority ranking for the sources identified in

- step 1. Reduce the identified source pathogen loading 25 percent by May 2012.
3. In 2012, begin the process of identifying, assessing and ranking watershed bacteria sources and selecting best management practices outward from the tributary streams in quarter-mile increments every year.