TMDL SYNOPSIS

Key Features

Project Name:	Beargrass Creek watershed fecal coliform TMDLs
Location:	Jefferson County, KY
Scope/Size:	Beargrass Creek watershed, approximately 60 mi^2
Major Tributaries:	Middle Fork, Muddy Fork, and South Fork Beargrass Creek
303(d)-Listed Segments:	South Fork, RM 0.0-2.7 and 2.7-13.6, Middle Fork, RM 0.0-2.0, 2.0-2.9, and 2.9-15.3 and Muddy Fork, RM 0.0-6.9
Pollutant(s):	Fecal coliform, an indicator for the presence of pathogenic organisms
Causes:	Municipal point sources, Urban runoff/storm sewers, Land disposal, Combined sewer overflows, Sanitary sewer overflows
Land Use Type:	Urban
TMDL Issues:	Point and nonpoint
Data Sources:	USGS stream flow monitoring, MSD and NEXRAD rainfall data, MSD continuous water quality monitoring data, MSD water quality sampling data, MSD collection system flow monitoring data, LOJIC GIS data, UK Department of Civil Engineering data
Control Measures:	KPDES permits, 319 Watershed Based Plans Kentucky Watershed Framework Initiative, Federal Consent Decree

Summary:

The Kentucky 2010 303(d) Report identifies 35.8 miles of stream segments in the Beargrass Creek watershed (see Figures S.1 and S.2) as not supporting the designated use of primary contact recreation (swimming) due to fecal coliform impairment (Kentucky Division of Water [KDOW], 2008). These include 13.6, 15.3 and 6.9 mile segments of the South Fork, Middle Fork and Muddy Fork of Beargrass Creek, respectively. Although the main stem of Beargrass Creek (i.e. the 1.8 mile segment downstream of the confluence with Muddy Fork) was not listed for fecal coliforms in the 2010 303(d) report, compliance of this segment with the associated water quality standards was verified as part of the overall TMDL analysis.

A comprehensive Water Quality Tool (WQT) that links together several sophisticated computer models was used in developing total maximum daily fecal coliform loads for Beargrass Creek (Tetra Tech, et. al., 2007). For the purposes of representing Beargrass Creek, the watershed (and

its associated sub-watersheds – i.e. Muddy Fork, Middle Fork, and South Fork) was subdivided into 31 sub-basins as shown in Figure S.3. The computer generated simulated flows and fecal loadings for each of these sub-basins (taking into consideration both point and nonpoint loadings) which were then simulated as being transported down through the channel and sewer systems associated with each of the sub-basins until the flows and loads were simulated exiting Beargrass Creek. Numerical results from these 31 sub-basins were aggregated into 11 larger reporting sub-basins (Figure S.3) whose outlets corresponded to existing water quality monitoring stations, or the physical outlet of a particular sub-watershed (i.e. Muddy Fork, Middle Fork, South Fork, and Beargrass Creek). Results were then translated to the individual stream segments as shown in Figure S.2.

Table S.1 Summary of Cumulative Annual Loadings (cfu) per River Mile and Source Category

SUB-WATERSHED/ River Mile	SUB-BASIN	Existing Loadings (cfu/yr) Total	Existing Wasteload (cfu/yr) SSO Sources	Existing Wasteload (cfu/yr) CSO Sources	Existing Wasteload (cfu/yr) MS4 Sources	Existing Wasteload (cfu/yr) KPDES Sources	Existing Wasteload and Load (cfu/yr) Groundwater Sources
BEARGRASS CREEK WATERSHED							
River Mile 0.5-1.8	SMS000	2.14E+16	4.96E+09	8.24E+15	1.31E+16	1.27E+13	8.95E+13
MUDDY FORK BEARGRASS CREEK							
River Mile 0.0-6.9	SMU000	1.99E+15	1.05E+07	0.00E+00	1.99E+15	2.76E+09	2.16E+12
MIDDLE FORK BEARGRASS CREEK							
River Mile 0.0-2.0	SMI000	6.60E+15	1.51E+09	1.04E+15	5.52E+15	0.00E+00	3.89E+13
River Mile 2.0-2.9	SMI004	6.04E+15	1.51E+09	6.74E+14	5.34E+15	0.00E+00	3.15E+13
River Mile 2.9-15.3	SMI002	5.39E+15	1.51E+09	4.65E+14	4.91E+15	0.00E+00	2.18E+13
SOUTH FORK BEARGRASS CREEK							
River Mile 0.0-2.7	SSF000	1.19E+16	3.38E+09	6.40E+15	5.48E+15	1.27E+13	3.87E+13
River Mile 2.7-13.6	SSF001	8.37E+15	1.66E+09	2.95E+15	5.39E+15	1.27E+13	1.59E+13

An application of the WQT to Beargrass Creek has revealed that the existing system will not satisfy the Kentucky primary recreational water quality standards, even with the removal of all the sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). As a consequence, some type of additional load reduction strategy is necessary. Once the WQT model for Beargrass Creek was calibrated and validated, the associated point and nonpoint loads for each sub-basin were reduced until the in-stream water quality criteria were satisfied. The final loads, resulting in compliance with the water quality standard (inclusive of the margin of safety), constitute the TMDL for each sub-basin.

Two different water quality conditions were evaluated for system compliance: 1) a chronic condition in which the 30 day geometric mean of predicted values (i.e. 200 cfu/100 ml for May through October and 1000 cfu/100 ml for November through April) were satisfied 90% of the time and 2) an acute condition in which the maximum observed values (i.e. less than 400 cfu/100 ml during May through October and less than 2000 cfu/100 ml for November through April) were satisfied for 80% of the time.

Two different potential management scenarios were investigated for possible use in meeting the water quality criteria and establishing the TMDL: 1) CSO storage/treatment along with associated nonpoint source (NPS) and groundwater reductions (including complete elimination of all SSOs), and 2) Sewer separation along with associated NPS and groundwater reductions (including complete elimination of all SSOs). Multiple computer analyses were performed for each scenario before a final set of reductions was found that satisfied the criteria discussed previously. It should be emphasized that although the two scenarios show examples of how the water quality standard might be obtained, additional means to accomplish this may be determined and selected in the future.

For each scenario, a 95% reduction in the NPS fecal coliform load was initially assumed. Groundwater load reductions ranged from 40% in Muddy Fork to 97.6% in the lower reach of Beargrass Creek. For load reduction scenario I, all CSO discharge volumes were assumed to be reduced by 50% with the associated concentration of the remaining discharge reduced by 95%. For load reduction scenario II, all CSO discharges were assumed to be eliminated. Excess stormwater that was originally diverted to the CSOs was now assumed to discharge directly to the stream. The loads associated with these discharges were also assigned a reduction of 95%, consistent with the other NPS load reductions.

Both scenarios resulted in fecal coliform exceedance thresholds lower than a 20% level for maximum criteria (i.e. 9.6% to 17.5%) and lower than a 10% level for geometric mean criteria (i.e. 0% to 8.80%). In fact, scenario II results in exceedance thresholds of 11.4% for the maximum criteria and 1.9% for the geometric mean criteria. It should be recognized, however, that sewer separation is normally a costly enterprise, especially in highly urbanized areas and will likely not eliminate the need for additional treatment or reduction of any residual NPS. As a consequence, because scenario I may provide a more cost effective management scenario while still providing for an adequate margin of safety (MOS); this scenario was used as the basis of determining the TMDLs for each of the sub-watersheds.

Subsequent to the initial completion of the TMDL, regulators from Region 4 of USEPA ruled that the chronic criteria should be satisfied with a compliance percentage of 100% as opposed to the 90% criteria that had been specified by Kentucky Division of Water and that was the basis of the load reductions associated with the computer analyses associated with this TMDL. In response, additional adjustments to the loads were made to raise the chronic compliance rate from 90% to 100%. This was achieved by imposing additional load reductions on the groundwater loading component. A summary of the final load reductions to satisfy the associated TMDLs for this scenario is provided in Table S.2.

Once the TMDL for the watershed has been determined, the associated load must be allocated between KPDES-permitted loads (i.e. wasteload allocations) including both the Kentucky Pollution Discharge Elimination System (KPDES) point source and municipal separate storm sewer systems (MS4) nonpoint source and non KPDES-permitted nonpoint source loads (i.e. load allocations). The difference between the initial existing load and the associated TMDL allocations provides the amount of required load reduction. The groundwater source is hypothesized as being associated with leaking sewers and surface water sources that have migrated into the groundwater. Since the leaking sewer source is ultimately related to permitted sources (through a KPDES permit), part of the groundwater load has been treated as an illegal

wasteload and its WLA set at zero. The remaining groundwater source has been designated as a non-KPDES-permitted nonpoint source and its allowable load is specified under the load allocation. Further research may need to be conducted to determine the precise distribution of sources as related to the groundwater contribution.

Table S.2 Summary of Loading Reductions to Achieve the TMDL

SUB-WATERSHED	STATISTIC	Average Annual Reduction	WASTELOAD REDUCTION SSO Sources	WASTELOAD REDUCTION CSO Sources	WASTELOAD REDUCTION MS4 Sources	WASTELOAD REDUCTION KPDES Sources	WASTELOAD and LOAD REDUCTION Groundwater Sources
BEARGRASS CREEK MAINSTEM							
River Mile 0.5 - 1.8	Maximum	96%	100%	98%	95%	0%	88%
MUDDY FORK BEARGRASS CREEK							
River Mile 0.0 – 6.9	Maximum	95%	100%	NA	95%	0%	46%
MIDDLE FORK BEARGRASS CREEK							
River Mile 0.0-15.3 (entire impaired reach)	Maximum	95%	100%	98%	95%	0%	91%
River Mile 0.0 - 2.0	Maximum	95%	100%	98%	95%	0%	91%
River Mile 2.0 – 2.9	Maximum	95%	100%	98%	95%	0%	90%
River Mile 2.9 – 15.3	Maximum	95%	100%	98%	95%	0%	88%
SOUTH FORK BEARGRASS CREEK							
River Mile 0.0 –13.6 (entire impaired reach)	Maximum	96%	100%	98%	95%	0%	86%
River Mile 0.0 – 2.7	Maximum	96%	100%	98%	95%	0%	86%
River Mile 2.7 – 13.6	Maximum	97%	100%	98%	95%	0%	69%

Summarizing the TMDL and associated allocations presents some challenges, because different types of sources are present on different days and the relevant water quality standards allow a certain percentage of excursions. The allocations are most clearly summarized in terms of annual loads; however, recent court rulings require that all TMDLs and associated allocations contain an explicit daily component. Therefore, the allocations are first expressed on an annual average basis. The daily component is then expressed consistent with USEPA (2007) guidance through specification of a daily average and a daily "maximum" value, which provide a basis for evaluation of future monitoring data. The daily average is simply the average annual load from the TMDL scenario divided by 365.25 days (which combines days with and without wet weather flows), while the maximum value is expressed as the 95th percentile of daily values from the continuous simulation. Use of the 95th percentile, rather than the absolute maximum, helps protect against the possible presence of anomalous outliers in the model simulation and adds an additional Margin of Safety to the TMDL. In determining the final TMDL value, an implicit margin of safety of approximately 10% was used by requiring that the water quality standards

were met with a greater frequency than required. A summary of the TMDL and the associated load allocations for each stream mile and stream segment are provided in Tables S.3 – S.4

The Morris Forman Wastewater Treatment Plant does not discharge directly to Beargrass Creek; however, 57 combined sewer overflows are permitted under this facility (permit # KY0022411). For the purpose of this study, the aggregate loads associated with these sources are summarized in the Existing Wasteload (CSO sources) column in Table S.1 and the Wasteload Allocations (CSO sources) columns in Tables S.2-S.3. In addition, the Louisville MS4 area is permitted under KPDES number KYS000001 and the Kentucky Transportation Cabinet MS4 under permit number KYS000003. For the purpose of this study, the aggregate loads associated with these sources are summarized in the Existing Wasteload (MS4 sources) column in Table S.1 and the Wasteload Allocations (MS4 sources) columns in Tables S.2-S.3.

Table S.3 Annual Cumulative Allocations to Achieve the TMDL

SUB-WATERSHED/ River Mile	STATISTIC	Average Annual Loadings (cfu/yr)	Wasteload Allocation (cfu/yr) SSO Sources	Wasteload Allocation (cfu/yr) CSO Sources	Wasteload Allocation (cfu/yr) MS4 Sources	Wasteload Allocation (cfu/yr) KPDES Sources	Load Allocation (cfu/yr) Groundwater Nonpoint Sources
BEARGRASS CREEK WATERSHED							
River Mile 0.5-1.8	Total	8.70E+14	0.00E+00	2.05E+14	6.41E+14	1.27E+13	1.03E+13
MUDDY FORK BEARGRASS CREEK							
River Mile 0.0-6.9	Total	1.01E+14	0.00E+00	0.00E+00	9.95E+13	2.76E+09	1.17E+12
MIDDLE FORK BEARGRASS CREEK							
River Mile 0.0-2.0	Total	3.05E+14	0.00E+00	2.60E+13	2.76E+14	0.00E+00	3.46E+12
River Mile 2.0-2.9	Total	2.87E+14	0.00E+00	1.68E+13	2.67E+14	0.00E+00	3.15E+12
River Mile 2.9-15.3	Total	2.60E+14	0.00E+00	9.00E+12	2.54E+14	0.00E+00	2.72E+12
SOUTH FORK BEARGRASS CREEK							
River Mile 0.0-2.7	Total	4.40E+14	0.00E+00	1.60E+14	2.61E+14	1.27E+13	5.50E+12
River Mile 2.7-13.6	Total	3.49E+14	0.00E+00	7.39E+13	2.57E+14	1.27E+13	4.90E+12

Table S.4 Average Daily and 95% Percentile Allocations to Achieve the TMDL by Stream Segment

SUB-WATERSHED/ River Mile	STATISTIC	Average Annual Loadings (cfu/day)	Wasteload Allocation (cfu/day) SSO Sources	Wasteload Allocation (cfu/day) CSO Sources	Wasteload Allocation (cfu/day) MS4 Sources	Wasteload Allocation (cfu/day) KPDES Sources	Load Allocation (cfu/day) Groundwater Nonpoint Sources
BEARGRASS CREEK WATERSHED							
River Mile 0.5 - 1.8	Average	6.58E+10	0.00E+00	5.46E+10	1.06E+10	0.00E+00	6.01E+08
	95%	4.11E+11	0.00E+00	3.32E+11	7.52E+10	0.00E+00	4.23E+09
MUDDY FORK BEARGRASS CREEK							
River Mile 0.0 – 6.9	Average	2.76E+11	0.00E+00	0.00E+00	2.72E+11	7.57E+06	3.20E+09
	95%	1.91E+12	0.00E+00	0.00E+00	1.90E+12	7.57E+06	1.37E+10
MIDDLE FORK BEARGRASS CREEK							
River Mile 0.0-15.3 (entire impaired reach)	Average	8.36E+11	0.00E+00	7.12E+10	7.55E+11	0.00E+00	9.47E+09
	95%	6.01E+12	0.00E+00	4.66E+11	5.48E+12	0.00E+00	6.27E+10
River Mile 0.0 - 2.0	Average	5.08E+10	0.00E+00	2.51E+10	2.48E+10	0.00E+00	8.45E+08
	95%	3.27E+11	0.00E+00	1.61E+11	1.59E+11	0.00E+00	5.91E+09
River Mile 2.0 - 2.9	Average	7.46E+10	0.00E+00	1.43E+10	5.91E+10	0.00E+00	1.19E+09
	95%	5.32E+11	0.00E+00	9.37E+10	4.29E+11	0.00E+00	9.24E+09
River Mile 2.9 – 15.3	Average	7.11E+11	0.00E+00	3.18E+10	6.72E+11	0.00E+00	7.44E+09
	95%	5.13E+12	0.00E+00	2.08E+11	4.87E+12	0.00E+00	4.79E+10
SOUTH FORK BEARGRASS CREEK							
River Mile 0.0-13.6 (entire impaired reach)	Average	1.20E+12	0.00E+00	4.38E+11	7.16E+11	3.48E+10	1.51E+10
	95%	8.07E+12	0.00E+00	2.68E+12	5.30E+12	3.48E+10	6.39E+10
River Mile 0.0 - 2.7	Average	2.50E+11	0.00E+00	2.36E+11	1.21E+10	0.00E+00	1.73E+09
	95%	1.54E+12	0.00E+00	1.44E+12	8.58E+10	0.00E+00	7.29E+09
River Mile 2.7 – 13.6	Average	9.55E+11	0.00E+00	2.02E+11	7.04E+11	3.48E+10	1.34E+10
	95%	6.54E+12	0.00E+00	1.24E+12	5.21E+12	3.48E+10	5.67E+10

In addition to these KPDES permits, the watershed also contains four additional KPDES permits as summarized in Table S.5 and shown in Figure S.4. In the absence of extensive data sets for these sites, an assumption was made that each of these sites is operating at its permitted wasteload (i.e. permitted discharge*200 cfu/100 ml). Thus, the associated TMDL for each of these point sources is simply equal to this corresponding wasteload (see Table S.5). As a result, no wasteload reduction is required. The existing wasteloads and the wasteload allocations for all MS4 sources (i.e. Tables S.1 – S.4) thus reflect the total wasteload in each subbasin and stream reach, minus any wasteload associated with any of the any permitted point sources (i.e. Table S.5) that happen to discharge to that associated subbasin or stream reach.

Table S.5 TMDL (Wasteload Allocations) Associated with KPDES Sites

KPDES Permit	Description	Subwatershed	River Mile	Permitted Discharge (MGD)	TMDL (cfu/day)
KY0057061	Louisville Zoo: Outfall 001 Outfall 002	300	South Fork 2.7-13.6	4.6	1.27E+13
KYG400146	Residence	940	Muddy Fork	0.0005	1.38E+09
KYG400206	Residence	910	Muddy Fork	0.0005	1.38E+09
KYG400349	Residence	400	South Fork 2.7-13.6	0.0005	1.38E+09

Note: Any expanding or future KPDES-permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 10:031.

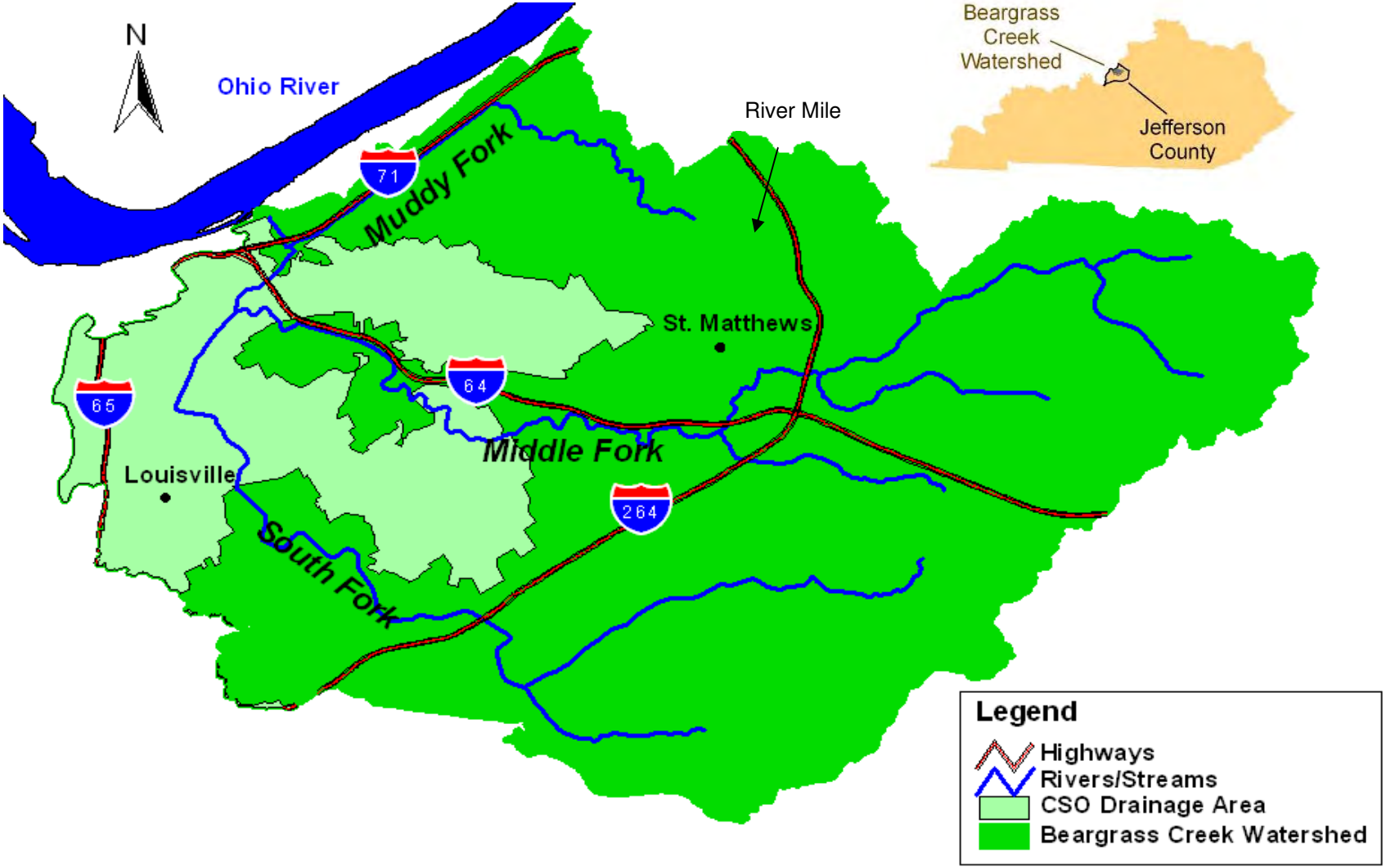

Figure S.1 Location of Beargrass Creek Watershed (Developed using data from LOJIC, 2007)

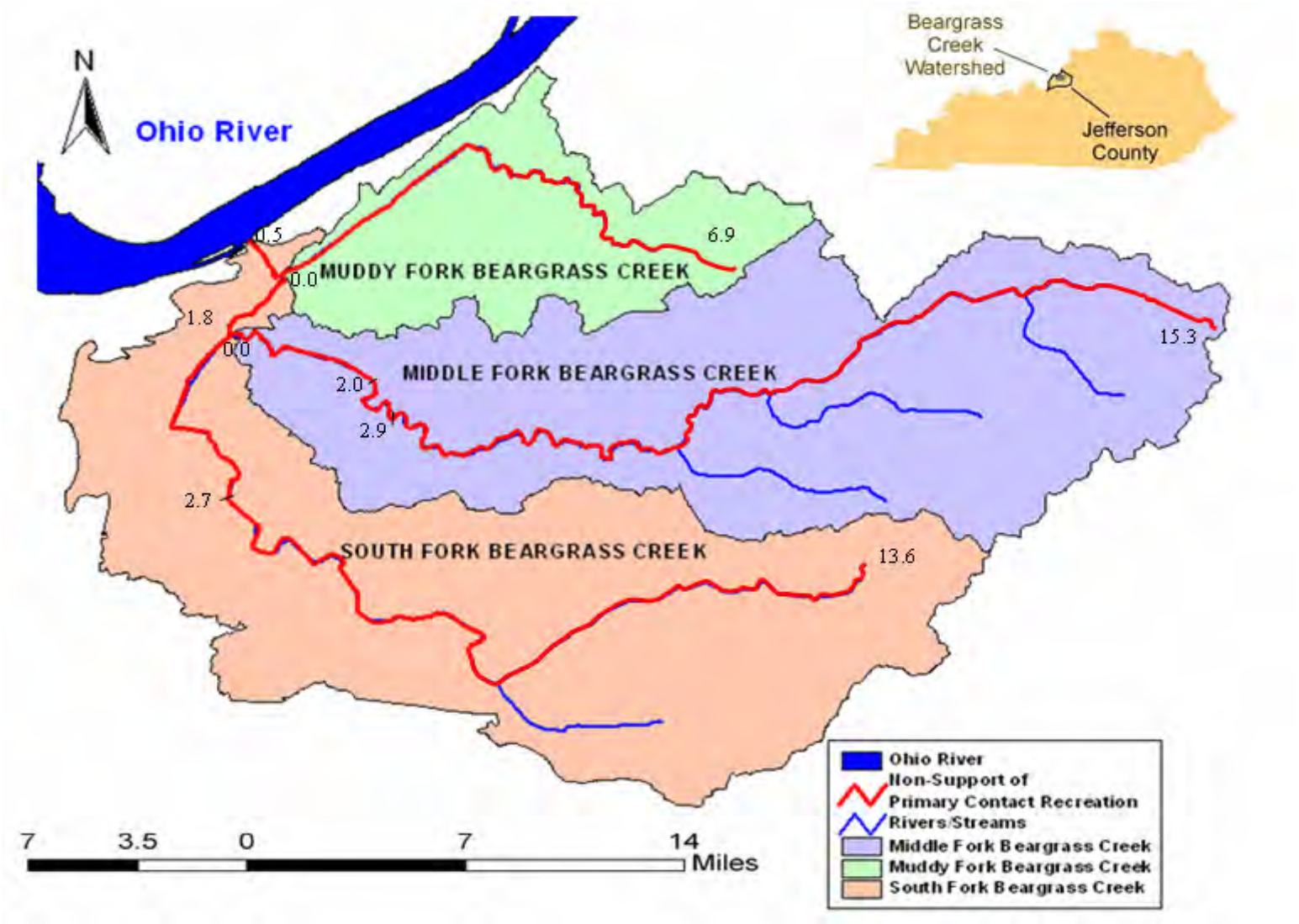

Figure S.2 Impaired Stream Segments and Stream Miles in the Beargrass Creek Watershed (Developed using data from KDOW, 2008; and base map from LOJIC, 2007)

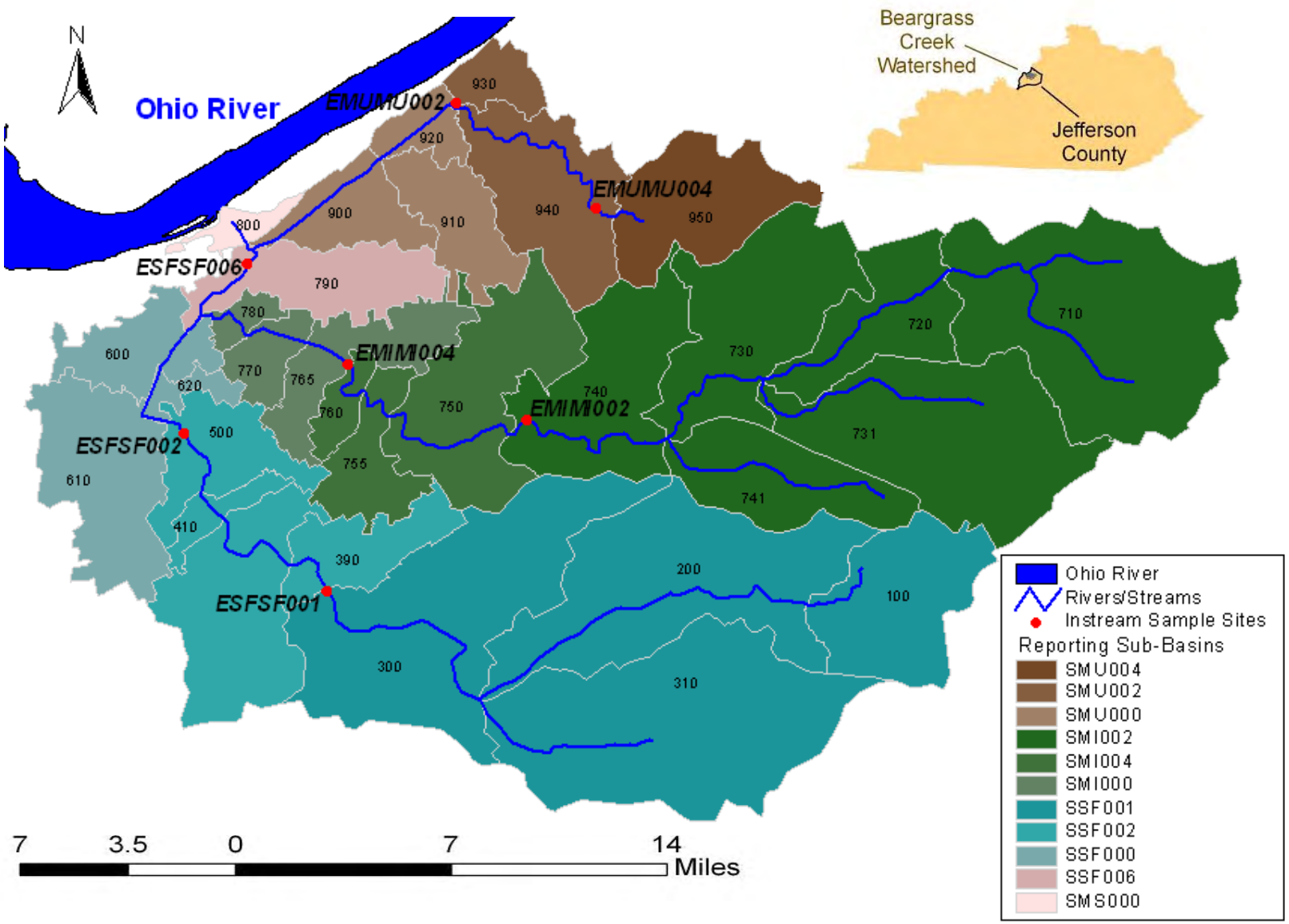

Figure S.3 Sub-basins and Monitoring Stations (Developed using data from Tetra Tech et. al., 2007)

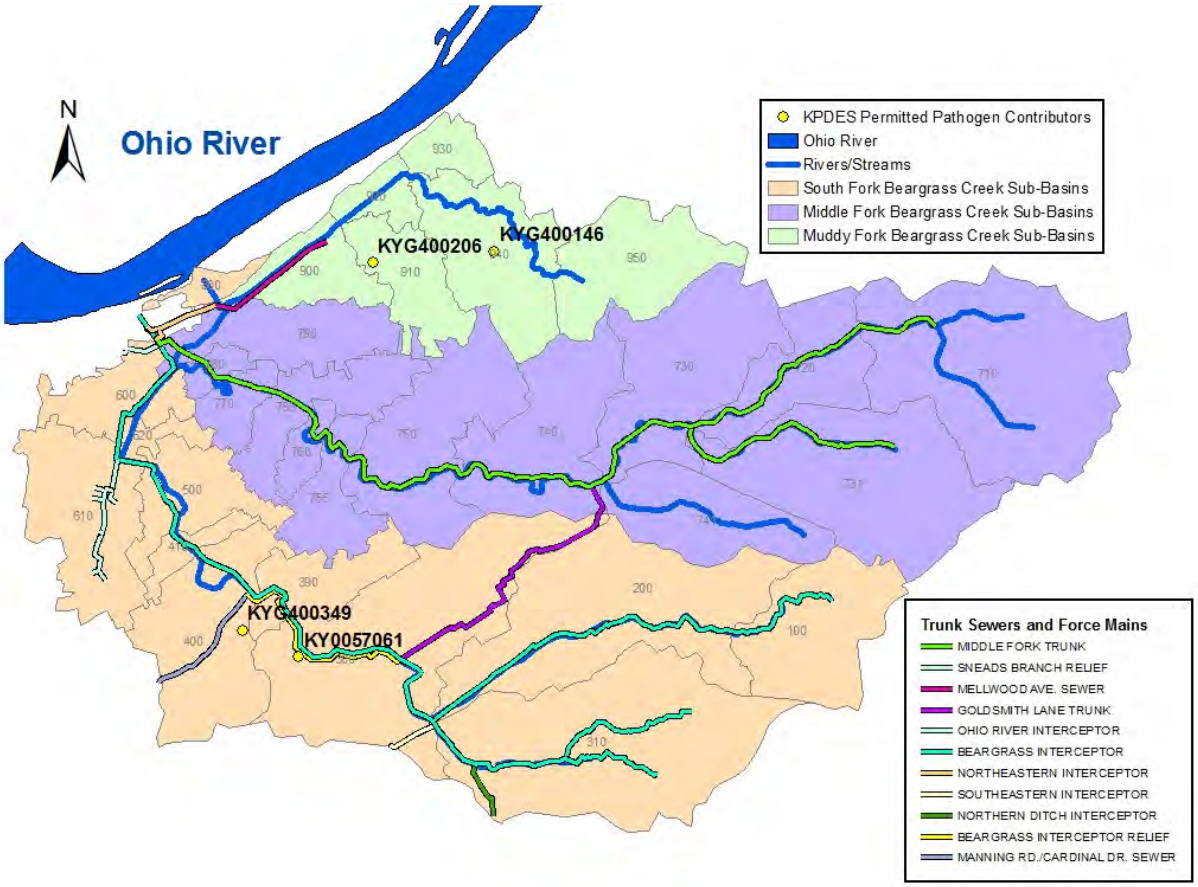

Figure S.4 KPDES Permitted Fecal coliform Contributors

The Goal of the TMDL

The goal of the TMDL is to identify potential load and wasteload reductions that could be potentially used to satisfy the water quality standards for Beargrass Creek. The TMDL report is a planning document and is not a regulatory or enforcement document. However, the TMDL, where applicable, may be used in support of regulatory decisions via general or specific discharge permits or through the specific provisions of a consent decree as per Sections 303(d)(2) and 303(e) of the Clean Water Act. In addition, the TMDL may be used to help guide the activities of non-regulatory programs. As with many TMDLs, it should be emphasized that the specific load and wasteload reductions scenarios considered by this TMDL may or may not be economically feasible or physically achievable with existing technologies or currently available best management practices. As a consequence, additional analyses may be required (e.g. through a Long Term Control Plan) in order to identify or refine such solutions. At a minimum, however, the TMDL does identify and quantify relative sources of impairment along with theoretical load or wasteload reductions that would be necessary to achieve water quality standards, and as such, provides a starting point for any future investigations or associated load or wasteload reduction projects.

Modifications

In the future, KDOW may adjust the individual wasteload allocations (WLA) in this TMDL to account for new information or circumstances that develop or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. New information generated during TMDL implementation may include, among other things, monitoring data, best management practices (BMPs) effectiveness information and land use information. KDOW will propose adjustments only in the event that any adjusted individual WLA will not result in a change to the total WLA. The adjusted WLA will be set at a level necessary to implement the applicable water quality standard (WQS). KDOW will notify EPA of any adjustments to this TMDL within 30 days of their adoption.