Use Attainability Analyses

of a Main Stem Reach

of the

Marmaton River

Bourbon County, Kansas and Vernon County, Missouri

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ABSTRACT

The main stem of the Marmaton River within the study area was found to be in attainment for contact recreational use. Evidence of existing recreational use supports the continuation of contact recreational use designation as currently provided on the Kansas portion of the river. The Marmaton River was found not to be in attainment with regard to the stream's special aquatic life use designation. Fish sampling within several segments of the river reveal a reduced assemblage of fish species when compared to previous records of known occurrence of fish species. Analysis of the macroinvertebrate community indicated degradation of the community in river reaches below the City of Fort Scott. High levels of PAH's, metals and nutrients (i.e., nitrogen) are believed to the causes of impairment to the aquatic invertebrates. Potential sources of observed pollutants may be urban stormwater runoff and discharges from a local wastewater treatment facility.

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I. INTRODUCTION

The use attainability analyses (UAA) of the Marmaton River was a collaborative effort of the U.S. Environmental Protection Agency (USEPA) Region 7 Environmental Services Division (ENSV) and the Central Plains Center for BioAssessment (CPCB). The study is one in a series of collaborative efforts between the USEPA Region 7 ENSV, located in Kansas City, Kansas, and the CPCB, located at the University of Kansas in Lawrence, Kansas. This study was designed to characterize the main channel conditions of the Marmaton River and to further develop and refine use assessment procedures and analyses. This UAA was conducted to assesses the attainability of aquatic life and recreational uses of the lower portion of the main-stem of the Marmaton River.

This use attainability assessment is designed to determine aquatic life and recreational use attainability and attainment and to identify any potential causes of impairment of the Marmaton River. The assessment documents both attainable and existing uses. Study sites were located in Bourbon County, Kansas and in Vernon County, Missouri. Predominantly agricultural, the watershed is composed primarily of row crop and pasture along with urban, grassland, forest and other land use/land covers (LULC). The study will also serve as baseline information for future aquatic life and recreational studies. Field sampling and assessments were conducted in July of 1999.

Marmaton River Use Designations

This study was confined to the lower main-stem portion of Marmaton River, segment numbers: 5, 7 & 8; Sub-basin: Marmaton; Basin: Marais Des Cygnes (KDHE, 1999). The State of Kansas has classified the Marmaton River aquatic life and recreational designated uses as 'special' and 'contact', respectively. Marmaton River is also classified for the following designated uses: domestic water supply; food procurement; groundwater recharge; industrial water supply; irrigation and; livestock watering. However, this study addresses only aquatic life and recreational uses.

The State of Missouri designates the Marmaton River for 'Protection of Warm Water Aquatic Life and Human Health - Fish Consumption', 'Livestock & Wildlife Watering' and 'Irrigation'. A brief definition and discussion of aquatic life and recreation uses as identified and used by the States of Kansas and Missouri is provided below.

Aquatic Life Use

The Kansas Administrative Regulations (K.A.R. 28-16-28, 1999) contain the state's water quality standards and define aquatic life use as the use of surface water for the maintenance of the ecological integrity of streams, lakes and wetlands, including the sustained growth and propagation of native aquatic life, indigenous or migratory semi-aquatic life, or terrestrial wildlife directly or indirectly dependent on surface water for survival. Stream segments are

designated under one of the following three aquatic life use sub-categories: 1) *Special aquatic life use waters* - Surface waters that contain combinations of habitat types and indigenous biota not commonly found in the state, or surface waters that contain representative populations of threatened or endangered species; 2) *Expected aquatic life use waters* - Surface waters containing habitat types and indigenous biota commonly found or expected in the state; and 3) *Restricted aquatic life use waters* - Surface waters containing indigenous biota limited in abundance or diversity by the physical quality of the habitat compared to more suitable habitats in adjacent waters. Habitat availability and habitat diversity in restricted aquatic life use waters are severely limited due to natural deficiencies or artificial modifications.

The State of Missouri classifies streams as either cold-water fishery, cool-water fishery, protection of aquatic life (general warm-water fishery) or protection of aquatic life (limited warm-water fishery). Descriptions of each designation are as follows: 1) *Cold-water fishery* - Water in which naturally occurring water quality and habitat conditions allow the maintenance of a naturally reproducing or stocked trout fishery and other naturally reproducing populations of recreationally important fish species; 2) *Cool-water fishery* - Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a sensitive, high-quality sport fishery (including smallmouth bass and rock bass) and other naturally reproducing populations of recreationally important fish species; 3) *Protection of aquatic life (General warm-water fishery)* - Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a wide variety of warm-water biota, including naturally reproducing populations of recreationally important fish species and; 4) *Protection of aquatic life (Limited warm-water fishery)* - Waters in which natural water quality and/or habitat conditions prevent the maintenance of naturally reproducing populations of recreationally important species.

Recreational Use

Recreational use is defined in the State of Kansas standards as either contact recreational use or noncontact recreational use. The designations for contact use are as follows: 1) *Contact recreational use* - Recreation where the body is immersed in surface water to the extent that some inadvertent ingestion of water is probable. This use includes, but is not limited to, swimming, skin diving, water skiing, boating, mussel harvesting and wind surfing. State water quality standards require that surface waters designated for contact recreational use shall not exceed a 200 fecal coliform count per 100 ml water sample outside of mixing zones; 2) *Secondary contact* - Recreation where ingestion of surface water is not probable. This use includes, but is not limited to, wading, fishing, trapping and hunting. State water quality standards require that surface waters designated for noncontact recreational use shall not exceed a 2,000 fecal coliform count per 100 ml water sample outside of mixing zones.

The State of Missouri designates streams for recreational use under whole-body contact recreation or human health protection (fish consumption and secondary contact recreation). A brief description of each is as follows: 1) *Whole-body contact recreation* - Activities in which there is direct human contact with the raw surface water to the point of complete body

submergence. Water so designated is intended to be used for swimming, water skiing or skin diving. 2) *Human health protection (fish consumption and secondary contact recreation)* - Secondary contact recreation assumes limited physical contact with the water without likelihood of water ingestion.

Study Objectives

The main goals of any UAA are to determine use attainability, use attainment and causes of impairment (if any). Use attainability is an estimation of what single or multiple designated uses are achievable. Use attainment is the determination of whether a designated use (i.e., special aquatic life use, expected aquatic life or restricted aquatic life) is currently being achieved. When a use is currently not being achieved the potential causes of impairment can be identified using biological, chemical and physical analyses.

The goals of this study were to characterize the main stem conditions of the Marmaton River and to further develop and refine use assessment field procedures and analyses. The project will attempt to determine the similarity and attainability of Kansas Segments 5, 7 and 8. This project is one in a series of use assessment studies conducted in collaboration with the Kansas Biological Survey (KBS) designed to develop procedures for use assessment monitoring (i.e., habitat, fish, macroinvertebrate, primary production, water and sediment chemistry) and data analyses and interpretation. The question central to this study is whether or not expected aquatic life and primary contact recreation uses are attainable in Marmaton River. The primary hypothesis tested was that based on comparisons of a number of biological, physical and chemical variables there were no significant (statistical or observational) biological differences between upstream and downstream monitoring sites.

USEPA has produced the Technical Support Manual: Waterbody Survey and Assessments for Conducting Use Attainability Analyses (USEPA, 1983) for guidance on how to conduct Use Attainability Analyses. Three clear objectives were identified for the completion of a successful UAA. Those objectives have been incorporated in this Marmaton River use attainability analysis and are listed as follows:

1) Assess aquatic life and recreational uses that could be attained in the Marmaton River (segments 5, 7 & 8), if not currently being attained (*attainability*).
2) Determine current aquatic life and recreational use currently being achieved in Marmaton River (segments 5, 7 & 8) (*attainment*).
3) Identify *potential causes of impairment*, if any, to attaining the designated aquatic life use in the Marmaton River (segments 5, 7 & 8).

II. METHODS

A description of the monitoring activities and data analyses are provided below for the aquatic life and recreation use assessment of Marmaton River. Watershed monitoring methods were taken primarily from the Kansas Biological Survey's Ecotoxicological Program's Watershed Monitoring Manual (1993).

Monitoring Design and Implementation

Physical environmental characteristics must be taken into consideration when designing a monitoring study (USEPA, 1991). Hydrology, climate, landform, geology and soils are physical variables that influence a stream's flora and fauna, instream and nearstream habitat, water chemistry and stream morphology. An attempt must be made within the study design to minimize watershed and stream differences attributed to these large-scale determinants by selecting watersheds having similar climatic and landscape factors.

Monitoring Design

The monitoring design was structured so that two related but separate assessment efforts could be conducted. The first was to assess existing and potential biological, physical and chemical conditions of the Marmaton River and to statistically evaluate factors associated with individual segments of the Marmaton River relative to their upstream and downstream location in reference to the City of Fort Scott, Kansas. The comparison of river segment conditions in Marmaton River with upstream land use and stream conditions in addition to the assessment of historic and current aquatic life data was used to determine aquatic life use attainability and attainment. Secondly, recreational potential was evaluated in Marmaton River. Recreational use was assessed by instream and nearstream monitoring and geographic analysis.

Monitoring Locations

The Marmaton River watershed is located primarily within the Kansas/Missouri Transitional Woodlands (40c) of the Central Dissected Plains (40) ecoregion, while portions of its headwaters occur within the Osage Cuestas (40b) an other sub-ecoregion of this ecoregion (Chapman, 1999). Current thought suggests that aquatic life fauna should be similar within the Central Irregular Plains ecoregion due to common conditions such as climate, geology, soil, riparian habitat and substrate type. Monitoring site 1 was located in Missouri approximately two miles from the state line. Site 2 was on Kansas stream segment 5. Sites 3 and 4 were located within Kansas stream segment 7 while sites 5 and 6 occurred along Kansas stream segment 8 (Figure 1).

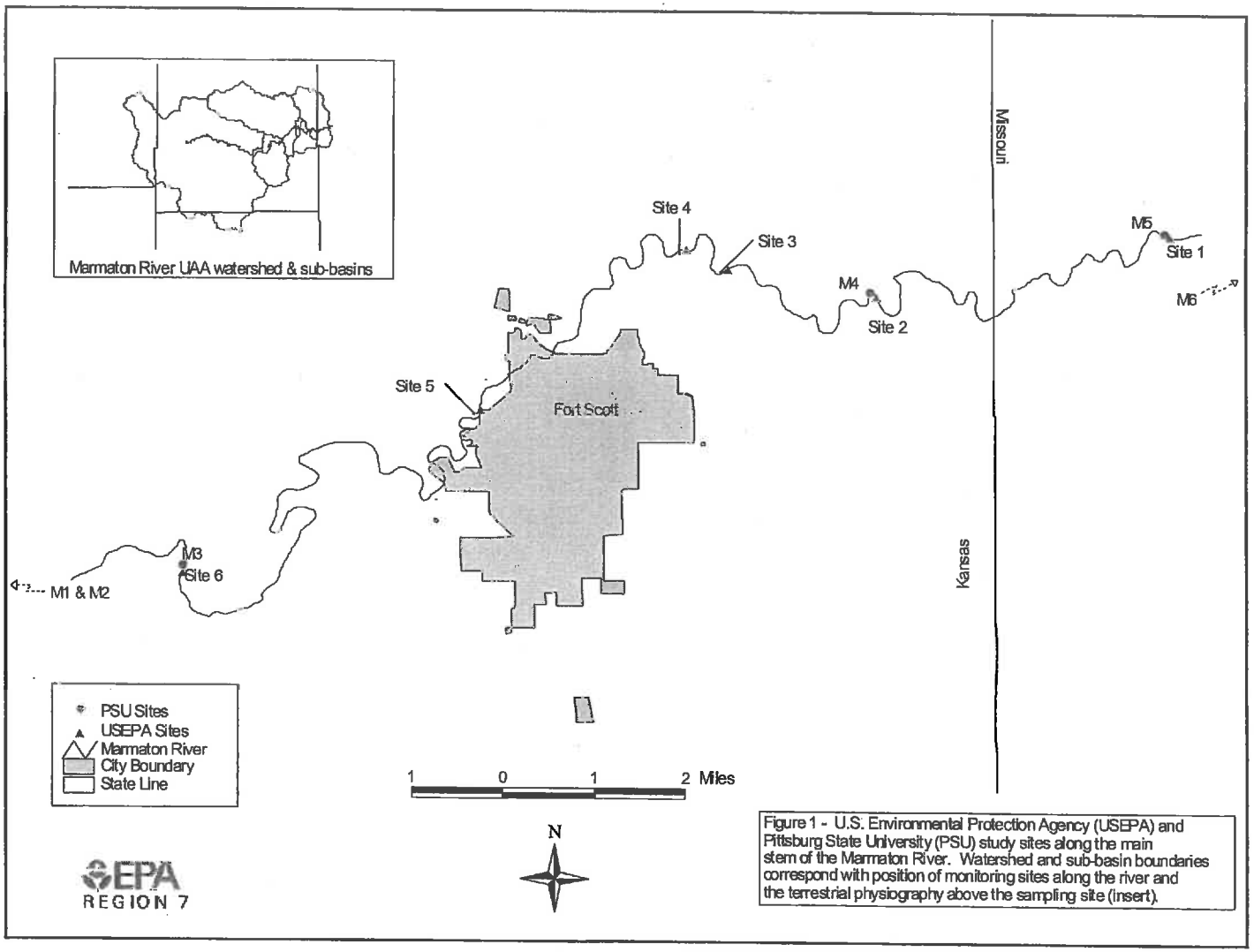

Figure 1 - U.S. Environmental Protection Agency (USEPA) and Pittsburg State University (PSU) study sites along the main stem of the Marmaton River. Watershed and sub-basin boundaries correspond with position of monitoring sites along the river and the terrestrial physiography above the sampling site (insert).

To facilitate the broad sampling demands of this study (e.g., water, sediment, fish) 100-meter monitoring segments (sites) were identified at six locations along the main stem of the stream. To fully characterize biological communities present in the stream, an attempt was made to locate monitoring sites on stream segments having the three major macrohabitats (pool, riffle and run) typically associated with pool/riffle sequence stream systems. At each site, both water column and sediment samples were collected along with periphyton, phytoplankton, coliform, macroinvertebrate and fish samples. A number of habitat variables were also identified and measured at each site. Within each study site, water column and sediment samples were collected at the upper, middle and lower portions of the sampling segment (referred to as sub-sites). The incorporation of sub-site sampling for some measurement variables was deemed necessary to measure and account for within site variability. These samples increased the within watershed sample number to eighteen (6 sites x 3 sub-site samples) enhancing the comparisons of between and within monitoring site conditions.

Aquatic Life Monitoring

All field work was conducted from July 12, 1999 through July 20, 1999. The field crew included personnel from USEPA Region 7 and CPCB. Chemical analyses were primarily conducted by the Region 7 ENSV. Phytoplankton and periphyton analyses were conducted at the Ecotoxicology Laboratory of the Kansas Biological Survey (KBS; Lawrence, KS). Fish and macroinvertebrate samples were sorted, identified and enumerated by USEPA personnel from USEPA's Region 7 Environmental Services Division.

Assessment of Primary Producers

Chlorophyll *a* concentrations were obtained from periphyton samples taken from the stream area adjacent to the top of site. Three periphytometers with 5 glass slides each were placed in the stream above the upstream end of each site. Flow, depth and densiometer readings were taken upon placement of the samplers. Periphytometers were to colonize for five days. Prior to removal, depth and densiometer readings were again taken at each periphytometer location. One or more slides from each periphytometer were randomly selected and the accumulated periphyton scraped into a scintillation vial containing 10ml of basic methanol.

Water samples used to determine chlorophyll *a* estimates for phytoplankton were collected at each sub-site soon after the periphytometers were removed. At each sub-site a 250ml grab sample of stream water was taken and placed on ice in a closed cooler. The samples were transported to the KBS Ecotoxicology Laboratory and kept at 4°C in the dark until processing. Algae samples were analyzed fluorometrically to determine chlorophyll *a* and pheophytin *a* values for phytoplankton (µg/l) and periphyton (µg/m^2).

Macroinvertebrate Community Monitoring and Taxonomic Identification

Using a D-frame collecting net (500 μm mesh), one-minute traveling kick samples were taken within each macrohabitat (i.e., pool, riffle and run) found in a site. Hard substrates, submerged vegetation, algal mats and/or other habitat elements within a macrohabitat were kicked and disturbed, and the material collected in the D-frame sampling net. Large debris were removed from the sampling net and attached organisms removed from this material and transferred along with the remaining sample into labeled jars containing 10% buffered formalin. Ambient water was used to adjust the final preservative concentration to about 5 percent. In the laboratory, the samples were emptied into a 196 μm sieve, rinsed with tap water and large debris were discarded. Any invertebrates found clinging to the debris were removed and returned to the sample. The initial formalin preservative was replaced with an 80% buffered ethanol preservative. Samples were placed in white, flat-bottomed photo trays for sorting and identification. Taxonomic identifications were made to the family level using the Guide to the Common Freshwater Invertebrates of the Midwest (Huggins, et. al., 1981) and the Introduction to Aquatic Insects of North America (Merrit and Cummins; 1996) at the Region 7 ENSV laboratory.

Fish Sampling and Taxonomic Identification

Fish samples were obtained using a combination of seining and electrofishing techniques. Due to the depth of the monitoring sites, only a wadeable 20 meter sub-section of each of these microhabitats was both seined and electrofished. Generally the whole macrohabitat was delineated and enclosed by 1/8 inch mesh block nets and when necessary sub-sections within macrohabitat by a second set of block nets. Sub-section sampling efforts consisted of a minimum of four seine passes and then electrofishing each macrohabitat until few or no additional fish were taken. Then the entire monitoring site was electrofished from a 14-foot boat platform utilizing standard large river electrofishing equipment. All fish obtained from seining and electrofishing were placed in labeled Ziplock bags and five-gallon buckets containing 10% buffered formalin. Fish for fish tissue analysis were collected separately by seining and/or electrofishing in stream segments above or below each 100-meter site. Lengths and width of each individually sampled macrohabitat and sub-section were obtained and used to calculate individuals/unit area.

Fish samples were sorted by species and enumerated at USEPA Region 7 ENSV laboratory in Kansas City, Kansas. Several days prior to sorting the formalin solution in each sample container was repeatedly washed in tap water then 70% isopropyl alcohol was added to each container after sticks, rocks and other debris were removed from each sample. The samples were identified to species level using the Handbook of Fishes of Kansas (Cross, 1967) and Fishes in Kansas (Cross and Collins, 1995).

Habitat Assessment

Habitat assessments, the evaluation of the physical characteristics and condition of a waterbody (MacDonald, 1991) are an essential mechanism to determine the ecological health of a waterbody and are increasingly being used across the country. Stream habitat can be defined as all "physical attributes that influence or provide sustenance to organisms within the stream" (Klemm, 1997). Habitats and associated conditions vary naturally within and between streams. Variation in the amount and types of habitat can account for much of the variation in the structure and function of biological communities occupying stream ecosystems. Habitat assessments are necessary to identify whether differing aquatic community conditions are due to habitat or water quality differences. If the Marmaton River has relatively the same habitat and flow conditions upstream and downstream, it is reasonable to assume that the various measures of aquatic life would be similar. Thus, if habitats and habitat quality are similar, comparative differences found in aquatic life variables between Marmaton River segments might be attributed to observed differences in water quality of the streams. Consequently, habitat conditions in and near (i.e., riparian areas) Marmaton River monitoring sites were quantified and compared to each other to assess what effects on the biota, if any, were related to habitat and what effects were the result of water quality.

One of the results of a large multi-year regional assessment of agricultural nonpoint source pollution within USEPA Region 7 was the development of a habitat assessment procedure specifically for Midwestern watersheds (KBS, 1993). The KBS habitat assessment methodologies provide quantitative links between habitat, biological, water, sediment and land use data (variables). Because the habitat assessment procedures provide quantitative measures of habitat and watershed variables, statistical comparisons, correlations and assessments can be made to relate watershed habitat conditions to stream ecosystem quality (e.g., water quality, fish diversity).

Within each 100-meter stream segment, macrohabitats (pool, riffle and run) were identified and a number of quantitative measures of these habitats and the general stream segment were made. The following habitat information and data were recorded in the field: 1) Site Diagram; 2) Weather Conditions; 3) General Comments; 4) Riparian Width; 5) Riparian Condition; 6) Dominant Riparian Species/General Comments; 7) Livestock Access; 8) Stream Channel Width; 9) Stream Shading; 10) Debris Loading; 11) Areas of Active Erosion; 12) Areas of Undercutting and Vegetative Cover; 13) Substrate (Substrate Class, Organic Content, Aquatic Vegetation Habitats) and; 14) Water Depth.

The Habitat Development Index (HDI) is a sample specific habitat evaluation procedure that is used in conjunction with macroinvertebrate sampling. The HDI is an index developed by KBS specifically for macroinvertebrate sampling (Huggins and Moffett, 1988). The HDI is composed of seven parameters and is calculated for each macrohabitat sampled for macroinvertebrates. A total HDI score was calculated for each of the three invertebrate samples collected in the 100-meter stream segments. The HDI values for each of the three individual

samples were summed to obtain an overall HDI score for each site. The HDI parameters are based on measures of: 1) Average Depth; 2) Velocity Range; 3) Riffle Substrate Score; 4) Organic Detritus and Debris; 5) Algal Mass Presence; 6) Macrophyte Presence and; 7) Bank Vegetation.

Chemical Sampling

Water column and sediment samples were analyzed for priority pollutants, nutrients, urban pesticides and metals (see Appendix 1 for list of analytes). Within each site, water column and sediment samples were taken at the upper end of the site (i.e., upstream area), the middle portion of the site and at the bottom portion of each site (i.e., downstream area). Thus within each site, three water and sediment samples were obtained representing sub-site conditions found within a stream segment (i.e., site). Each sediment sample was homogenized thoroughly and placed in two 8-ounce jars and two 40-ml vials. Water column and sediment samples were preserved in the field, if required, and all samples placed on ice in coolers for transportation to the laboratory for analysis.

Fish Tissue Monitoring

Fish tissue monitoring has been conducted in U.S. EPA Region 7 for the Regional Ambient Fish Tissue (RAFT) monitoring program since the 1970's by the Environmental Services Division. Details on fish collection, storage and transportation can be found in the Region 7 standard operating procedure titled Sampling Fish for Tissue Residue Determinations, No. 2334.13A (Littell, 1990). Fish were collected at each monitoring site for tissue but no attempt was made to associate these fish with any specific area at these sites, due to the highly mobile nature of most fish species.

Watershed and Land Use / Land Cover (LULC) Analysis

The geographic information system software utilized for digitizing, analysis and map preparations were ESRI's ArcView 3.2. Watershed and sub-basin boundaries corresponding to the Marmaton River monitoring sites were identified, delineated and digitized on screen using digital raster graphic scanned topographic maps (U.S. Geological Survey 7.5 minute maps). Land use / land cover data for the Marmaton River watershed was derived from Kansas and Missouri National Land Cover Data (NLCD) data sets. NLCD land cover data was produced through a cooperative project between USEPA and USGS utilizing 30 meter resolution Landsat thematic mapper (TM) data.

The extent (km^2) of each LULC class found in each watershed or sub-basin was converted to percent coverage to remove the influence of basin size when comparing LULC between and among drainage areas. Since the water quality and biota at any specific site is affected by only that portion of the watershed that drains to the site, upstream (sub-basins) sites are basically nested within the larger watershed (i.e., most downstream site). Thus, the

downstream site is influenced by the total watershed where as sub-basins draining to midstream sites are comprised of the cumulative area of all upstream sites. In essence, each site along the stream continuum is affected by the cumulative influences of all drainage areas upstream of the site location.

Recreational Use Assessment

Fecal coliform analysis was conducted as a measure of attainment (i.e., what are the current conditions as related to fecal coliform levels?). Fecal coliform grab samples were taken at each sub-site with pre-sterilized Nasco® Whirl-Pak containers. Samples were placed on ice and transported the KBS Ecotoxicological Laboratory. Appropriate dilutions were made and sample water filtered through a gridded membrane filter. The fecal coliform test used M-FC broth with rosaic acid and samples were incubated at 44°C for a 24-hour period. Confirmation tests were run using EC medium MPN tubes on all plates having identified fecal colonies.

Human population assessments for the area within a one-kilometer wide stream corridor were conducted using GIS methods to determine the residential population within one-half kilometer on either side of the Marmaton River. The assumption was that the larger the residential population in proximity to a creek, the greater the potential for contact recreational use of the stream. US Census (DASC, 1994) data from 1990 were used in combination with a digitized stream coverage to create a 0.5 kilometer buffer around the stream channel to determine nearstream population levels. While the 0.5 kilometer corridor width was subjectively chosen, this width was thought to address two general concerns. The primary concern was selection of a width that might represent a local neighborhood where most people lived within reasonable walking distance to the stream (i.e., six blocks or less). The other concern was the creation of a polygon of sufficient width to capture most of the information in the population plots that were obtained from the US Census data.

In 1997 a recreational use index (RUI) survey (Appendix 2) was designed to subjectively evaluate stream and riparian conditions relative to recreational use issues not evaluated by fecal coliform and nearstream population analyses (Welker and Huggins, 1997). The RUI was used to assess three areas directly or indirectly related to actual and potential recreational use of streams: evidence of existing use; attainability; and attainment. Existing use was determined from past or present evidence of the use of sites by waders, swimmers, fisherman and others (e.g., foot prints, foot trails, rope swings, docks, fishing gear). Existing use was scored as either occurring or not (i.e., yes or no). Attainability was assessed using a number of factors including stream bank angle, stream bank height, stream depth, sand/gravel bar presence and potential for use. Attainment was scored using a number of conditions associated with hazards and aesthetics. Hazards were divided into near stream sharps and obstacles, instream sharps and obstacles and presence of point discharge(s). Aesthetics were divided into near stream debris, instream debris, nearstream flora and geological formations, presence of riffle and waterfalls, water clarity and odor. A total of fourteen categories were scored, five for attainability and nine for attainment. Each one of the fourteen categories was scored subjectively from 0 to 3, thus a maximum total

possible was a score of 42 for a given site.

Statisitical/Data Analysis

Data analysis was conducted with the aid of Number Cruncher Statistical System software (NCSS 97) and manuals (NCSS, 1997) and by geographic information systems. In general, three types of statistical analyses were performed on study variables. Model I analysis of variance (ANOVA) testing was conducted to determine if there were statistically significant differences between groups (e.g., streams, habitats) for each parameter or variable (taxa richness, habitat, LULC, water and sediment data). Aquatic life, habitat, LULC, water column and sediment variables were tested for statistically significant differences among sites and sub-basins using general linear model analysis of variance (GLM-ANOVA) procedures. One important aspect of general linear models is that they are less affected by non-normal data. Typically, variables used in GLM-ANOVA tests had eighteen measurements (n=18) for each watershed (6 sites with 3 sub-site samples). If a statistical significance was found between the treatment (site) groups, the Duncan's post-hoc test was performed to determine stream site groupings. Duncan's test is a multiple-comparison test that examines all pair-wise comparisons among means and identifies those groups that differ from each other. Spearman-rank correlation matrices were calculated for the different data sets (macroinvertebrates, fish, habitat, water column data and sediment data) and correlation matrices constructed to identify correlations between stream, watershed and habitat variables. An alpha level equal to or less than 0.05 was used to determine significance in all ANOVA and correlation analysis. The selection of the level of significance is somewhat arbitrary in nature and does not necessarily indicate biological significance or non-significance. However, the use of a alpha level ≤ 0.05 has become a standard in research.

Multiple regression, one the most commonly used statistical methods (Afifi, 1990), was performed on those variables found to be significant by GLM-ANOVA and correlation analyses. Multiple regression analysis computes the least squares best fitting linear function of one or more variables. Sokal and Rohlf (1981) suggest that two main purposes of multiple regression analysis are to first "establish a linear prediction equation that will enable a better prediction of a dependent variable Y than would be possible by any single independent variable X" and then to "estimate and fit a structural model to 'explain' variation in the observations of Y in terms of the independent variables X". Only significant regression models (alpha ≤ 0.05) comprised of significant independent variables (alpha ≤ 0.05) are presented for discussion.

Macroinvertebrate and fish community data were analyzed using USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (USEPA, 1999). Rapid Bioassessment Protocols (RBP) metrics for macroinvertebrate metrics used to evaluated the Marmaton River invertebrate biota are categorized as richness measures (total number of taxa; number of ephemeroptera, plecoptera and trichoptera taxa [EPT]; number of ephemeroptera taxa; number of plecoptera taxa and; number of trichoptera taxa), composition measures (per cent EPT and; percent ephemeroptera), tolerance/intolerance measures (number of intolerant taxa; percent

tolerant organisms and; percent dominant taxon), feeding measures (percent filterers and; percent grazers and scrapers) and habit measures (number of clinger taxa and; percent clingers). Index of Biotic Integrity (IBI) metrics were used to evaluate fish community results. Metrics identified as "Midwestern United States" were selected for use in this study (USEPA, 1999). Those metrics were total number of species, number of darter species, number of sunfish species, number of sucker species, number of intolerant species, percent green sunfish species, percent omnivores, percent insectivorous cyprinids, percent top carnivores, number of individuals and percent hybrids.

Macroinvertebrate and fish taxa data were inputted into ECOMEAS (Ecological Measurements Program), a software program developed by KBS (1985) to compute a number of similarity and diversity indices. Total abundance, taxa richness and diversity were calculated for macroinvertebrate and fish community data using ECOMEAS. Species (or taxa) abundance was defined as the total number of individuals (macroinvertebrate or fish) at a site or total number of individuals/unit of measure (fish). Fish abundance was calculated as the number of fish per 100 meters of stream channel length. Thus, the number of individual fish collected within the 20-meter sub-segments that were intensively seined were multiplied by five and added to the number of fish collected by electrofishing the entire 100-meter site. Fish richness values were determined as the number of fish species collected at each site. Macroinvertebrate abundance was reported as the number of macroinvertebrates per site, the sum of three sampling efforts (i.e., 60 second kick sample). Due to limited study resources macroinvertebrates were identified only to the family level. Thus, macroinvertebrate richness values were based on the number of families identified at a site. While species or generic level taxonomic discrimination is preferred in most aquatic studies, family level classifications can reveal much about community structure especially when used in comparative studies (Kaesier et. al., 1978).

III. RESULTS

The main goals of any Use Attainability Analyses are to determine use attainability, use attainment and causes of impairment (if any). Use attainability is an estimation of what single or multiple designated uses are achievable. Use attainment is the determination of whether a designated use (i.e., special aquatic life use, expected aquatic life or restricted aquatic life) is currently being achieved. When a use is currently not being achieved the potential causes of impairment can be identified using biological, chemical and physical analyses. For convenience, monitoring results and analyses are arranged into several separate sections: aquatic life, recreational use, chemical analysis, geographic analysis, analysis of variance, regression analysis and stressor identification.

Aquatic Life Use Analysis

Metrics for fish and macroinvertebrates used were taken from USEPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (1999). The Ecological Measurements Program (ECOMEAS) developed by KBS was used to calculate Gleason's Diversity Index, richness and abundance values for fish and macroinvertebrate samples collected within each site. Macroinvertebrate and fish community data were used to generate several community measures (including diversity indices, taxa richness and abundance) of proven value in bioassessments (e.g., Karr, et. al., 1986; Plafkin, 1989; MacDonald, 1991; Klemm, 1994).

Fish Community

Fish community was data collected by EPA personnel at six monitoring stations in the main channel of the Marmaton River (see Appendix 3a). In addition data collected independently during the same sampling season throughout the Marmaton River watershed by Pittsburg State University (PSU) personnel were utilized (Goodrich, 2001). The PSU data included three samples taken from major tributaries above Ft. Scott, three samples taken from major tributaries below Ft. Scott and six samples in the main-channel. Data from the lowermost sample, taken below Nevada, MO and its wastewater treatment plant (WWTP) was not included because it is outside of the scope of the UAA and subject to the effects of urban land use and Nevada's WWTP.

Rapid Bioassessment Protocol (RBP) Metrics

Presented below are RBP metric results for the Marmaton River monitoring stations.

Index of Biotic Integrity

Index of Biotic Integrity (IBI) metric results for fish community data are presented in Table1. The metrics used are the Midwestern United States category found in the USEPA Rapid Bioassessment Protocols for Use in Wadeable Stream and Rivers (1999) and are similar to the RBP V presented in Plafkin et al. (1989). Stations identified as S6 – S1 were sampled by EPA personnel. Stations identified as M1 – M4 were sampled by PSU personnel. Mean values of the IBI metrics for each Kansas stream segment and Missouri are presented in Table 2.

Species Richness

Species richness ranged from 26 species near Redfield, KS at station M2, to 7 species immediately downstream of Ft. Scott, KS at station S4. Mean richness was highest (22 species) in KS stream segment 12, which is the uppermost segment of the main channel. Mean richness was lowest (9 species) in segment 7, just below Ft. Scott, KS and its WWTP. Richness recovered in segment 5 and in Missouri.

Generally species richness increases with stream size (order) due to a number of physiochemical factors. Physical habitat diversity usually increases with stream size allowing for a greater stream size because of the buffering effect of larger water volumes. Chemical habitat extremes, particularly low dissolved oxygen and high water temperatures, occur more frequently in upper watershed areas often limiting species richness, especially during late summer. Therefore, it would be expected theat species richness should increase in a downstream direction in the Marmaton River main channel.

Number of Darter Species

The mean number of darter species was highest (4 species) in segment 12 and lowest (1 species) in segment 7. The number of darter species increased downstream of segment 7 in segment 5 and Missouri. Darters are representative of clear-water riffle habitat. The presence of darters in segments 7, 5 and Missouri suggests that physical habitat exist downstream of Ft. Scott suitable for clear-water riffle dwelling species.

Number of Sunfish Species

This metric was highest in segment 12, lowest in segment 7, then increased in downstream segments 5 and Missouri. Like darters, sunfish prefer clear water because they are visual predators. High quality habitat, both instream and nearstream areas, are important for the diversity of terrestrial and aquatic organisms that sunfish utilize as food.

Number of Sucker Species

Sucker species were not represented well in the Marmaton River Watershed. Many sucker species are sensitive to chemical and physical habitat degradation.

Table 1 - Fish Index of Biotic Integrity (IBI) metric results for monitoring sites on the Marmaton River. Metrics used are the Midwestern United States category in the USEPA Rapid Bioassessment Protocols (1999).

Metrics	Segment 12		Segment 8			Segment 7		Segment 5		Missouri	
	M1	M2	M3*	S6*	S5	S4	S3	M4*	S2*	S1*	M5*
Species Richness	17	26	13	12	14	7	11	12	19	10	18
Darter Species	2	5	1	1	2	0	1	3	3	1	3
Sunfish Species	6	6	4	2	4	1	1	0	4	2	2
Sucker Species	0	2	0	1	0	1	0	0	0	0	1
Intolerant Species	3	6	1	1	2	0	0	2	2	0	2
% Green Sunfish	0	5	3	7	0	0	5	0	1	2	1
% Omnivores	30	10	15	38	80	83	66	82	67	63	48
% Insectivorous Cyprinids	10	21	32	1	0	0	0	1	3	0	0
% Top Carnivores	1	2	4	3	3	4	5	10	8	12	5
Number of Individuals	142	148	51	348	1706	71	116	202	237	334	43
% Hybrids	1	1	0	0	0	0	0	0	0	0	1
Gleason's Diversity Index	6.48	9.83	5.94	2.05	1.88	1.64	2.31	4.31	3.48	1.72	8.53

M1 - M5 = Pittsburg State University monitoring sites.
S1 - S6 = U.S. Environmental Protection Agency monitoring sites.
*May be some spatial overlap of sampling stations in a stream segment.

Table 2 - Mean values of IBI metric results for each Kansas stream segment and sample stations in Missouri on the Marmaton River.

Metrics	Mean IBI Values for each Segment				
	Segment 12	Segment 8	Segment 7	Segment 5	MO
Species Richness	22	13	9	16	14
Darter Species	4	1	1	3	2
Sunfish Species	6	3	1	2	2
Sucker Species	1	0	1	0	1
Intolerant Species	5	1	0	2	1
% Green Sunfish	3	3	3	1	2
% Omnivores	20	44	75	75	56
% Insectivorous Cyprinids	16	11	0	2	0
% Top Carnivores	2	3	5	9	9
Fish/100 meters	154	702	94	220	189
% Hybrids	1	0	0	0	1
Gleason's Diversity Index	8.16	3.29	1.98	3.90	5.13

Number of Intolerant Species

The mean number of intolerant species was highest (5 species) in segment 12, no intolerant species were found in segment 7. Intolerant taxa were not well represented in the other segments or in Missouri, but were present. Usually the number of sensitive taxa increases with stream size (Smale and Rabeni, 1995).

Percent Green Sunfish

The percent of green sunfish, commonly used as an indicator of stream degradation, was inconclusive. The mean percentages in Kansas stream segments 12, 8, and 7 were consistent, but fell in segment 5 and in Missouri.

Percent Omnivores

The mean percent of omnivores was highest in stream segments 7 and 5. This result was attributable to the high percentage of red shiners among samples in those segments. Red shiners are known to be very tolerant of degraded conditions and often become the dominant species in areas of poor chemical and or physical habitat (Cross and Collins, 1995).

Percent Top Carnivores

The percent of top carnivores is a measure of the trophic diversity of a fish community, the idea being that trophic diversity is directly related to biotic integrity because of the number of trophic levels needed to support top carnivores. The mean of this metric steadily increased from upstream to downstream segments. Examination of species composition among the top carnivores shows that channel catfish make up a large proportion of this group in segments 7, 5, and in Missouri. Channel catfish are tolerant of degraded physical and chemical conditions because of their ability to utilize a wide variety of food items, and their capability to tolerate low dissolved oxygen and highly turbid conditions.

Percent Hybrids

Hybrid individuals were largely absent from the samples. The assumption of this metric is that the frequency of hybridization increases with stream degradation.

Gleason's Diversity Index

Gleason's diversity is a measure combining both species richness and the relative number of individuals among species (evenness). It can be considered a measure of the extent which a community is dominated by a few species. Stream segment 7 had the lowest mean value (1.98) indicating the community is dominated by a small number of species. Domination by one or more species in a community is often an indication that conditions have been altered to the point where biological integrity has broken down.

Additional Fish Community Metrics

Presented below are fish community metric results in addition to the RBP metric results.

Percent Darters

Percent darters values varied greatly between individual stations in most segments with the exception of segment 8 (Table 3). Mean percent darters was lowest in segment 8. Segments 12, 7, and 5 had consistent values around 5 percent, and Missouri had the highest percent darters (Table 4). The variability between stations in individuals segments may indicate that their abundance is controlled more by the microhabitat characteristics of individual stations rather than segment-wide characteristics or problems.

Percent Sunfish

Percent sunfish steadily decreased in a downstream direction probably as a result of increased sedimentation and turbidity in downstream segments.

Percent Red Shiners

Red shiners probably represent the most tolerant fish species in the watershed making them a useful indicator species for environmental degradation. Mean percent red shiners was highest for the segments downstream of Ft. Scott (segments 7, 5 and Missouri). Together the segments upstream of Ft. Scott had a mean percent red shiners of 26, downstream segments had a mean of 58 percent red shiners.

Percent Tolerant Individuals

This metric was dominated by red shiners and mirrored the results for percent red shiners. Percent of individuals as tolerant species rapidly increased from segments 12 downstream to segment 8 then decreased in Missouri. Above Ft. Scott, segments 12 and 8 together had a mean of 35 percent tolerant individuals. Below Ft. Scott, segments 7,5 and Missouri together had a mean of 64 percent tolerant individuals.

Percent Intolerant Individuals

Intolerant individuals were only abundant in segments 12, Missouri, and station S2 in segment 8. Intolerant species were absent from segment 7 immediately downstream of Ft. Scott.

Table 3 - Additional fish community metrics results for monitoring sites on the Marmaton River.

Additional Metrics	Segment 12		Segment 8			Segment 7		Segment 5		Missouri	
	M1	M2	M3*	S6*	S5	S4	S3	M4*	S2*	S1*	M5*
% Darters	2	7	1	1	0.5	0.0	11	0.5	10	1	19
% Sunfish	9	14	8	8	3	4	5	0	4	3	2
% Red Shiners	20	5	12	29	76	52	52	80	66	59	43
% Tolerant Individuals	30	14	19	46	77	57	66	82	66	64	47
% Intolerant Individuals	7	10	1	0	2	0	0	1	7	0	17

*May be some spatial overlap of sampling stations in a stream segment.

Table 4 - Mean values of additional fish community metrics results for monitoring stations on the Marmaton River.

Additional Metrics	Mean Values Values for each Segment				
	Seg. 12	Seg. 8	Seg. 7	Seg. 5	Mo.
% Darters	5	1	5.5	5	10
% Sunfish	12	6	5	2	3
% Red Shiners	13	39	52	73	51
% Tolerant Individuals	22	47	62	74	56
% Intolerant Individuals	9	1	0	4	9

Fish Species Richness in the Marmaton River Watershed

Samples taken from the entire watershed in the summer of 1998 yielded a total of 44 species (Table 5). The main channel below Ft. Scott exhibits only 59% of the species richness of the entire watershed. The main channel above Ft. Scott exhibits 77% of the species richness of the entire watershed. All watershed areas located above Ft. Scott had a species richness of 39 as did all watershed areas located below Ft. Scott. Species richness in tributary watersheds below Ft. Scott is 17% higher than species richness in tributary watersheds above. Generally species richness in tributary streams flowing into large order streams is higher than the richness of tributary streams flowing into streams of lower order. The main channel above Ft. Scott supports 26% more species than its tributaries, however the main channel below supports 13%

fewer species than its tributaries. The main channel below Ft. Scott should also be capable of supporting more species than its tributaries. This data indicates that tributary watersheds below Ft. Scott may be serving as a refuge for species that may no longer be able to persist in the main channel because of physical and/or chemical degradation.

Table 5 - Fish species richness values calculated from monitoring stations in the Marmaton River watershed, including richness for the entire watershed and selected sub-areas of the watershed.

Watershed Area	Richness
Marmaton watershed	44
Entire Watershed above WWTP	39
Entire Watershed below WWTP	39
Main Channel above WWTP	34
Main Channel below WWTP	26
Tributaries above WWTP	25
Tributaries below WWTP	30

Species in Need of Conservation (SINC) and Threatened Species

The following SINC and Threatened species were collected in the Marmaton River at the 1998 monitoring stations.

SINC Species

River Redhorse (*Moxostoma carinatum*) - One individual was captured at station M2 in segment 12, this specimen was identified in the field and released due to its rarity.

Greenside Darter (*Etheostoma blennioides*) - Individuals were captured at stations both upstream and downstream of the WWTP.

Threatened Species

Hornyhead Chub (*Nocomis biguttatus*) - Nine individuals were captured at station M2 in segment 12.

Macroinvertebrate Community

Macroinvertebrate metric results for each monitoring sites are presented in Table 6 (also see Appendix 3b). The benthic metrics used are also taken from USEPA's RBP manual (1999) and are identified as 'best candidate benthic metrics' in the manual. Site richness was determined by identifying and listing all unique macroinvertebrate families and fish species

occurring in samples from a site (see Appendices 3a and 3b for monitoring site species lists). Tolerance values, trophic state and functional feeding group categories for metric calculations were taken from RBP manual. Total Number of Taxa ranged from a low of 7 taxa (sites 4 & 6) to a high of 10 (sites 1 & 5). Site 4 had no intolerant taxa while all other sites had at least one taxa recorded. Percent EPT at Site 4, below the Fort Scott wastewater treatment discharge, was noticeably lower than % EPT values for other monitoring sites in the study. Overall, percent EPT ranged from 42% at Site 4 to 90% at Site 2.

Table 6 - Macroinvertebrate metric results for monitoring sites on the Marmaton River. Metrics used are identified as best benthic metrics in USEPA's Rapid Bioassessment Protocols (1999).

	Site 1 (Missouri*)	Site 2 (5*)	Site 3 (7*)	Site 4 (7*)	Site 5 (8*)	Site 6 (8*)
Total Number of Taxa	10	8	9	7	10	7
EPT (individuals/sample)	91	618	135	16	300	45
Ephemeroptera (individuals/sample)	83	282	104	6	261	43
Plecoptera (individuals/sample)	0	1	0	0	0	1
Trichoptera (individuals/sample)	8	335	31	10	39	2
% EPT	75	90	67	42	73	76
% Ephemeroptera	68	41	51	16	64	73
Number of Intolerant Taxa	1	1	1	0	1	2
% Tolerant Organisms	0	0	0	0	<1	0
% Dominant Taxon	56	49	48	26	61	69
% Filters	7	49	15	26	10	3
% Grazers and Scrappers	86	51	81	68	89	93
Clinger Taxa (individuals/sample)	7	59	42	10	28	10
% Clingers	6	9	21	26	7	17
% Chironomidae**	16	1	8	26	18	4
Abundance**	122	687	201	38	410	59
Gleason's Diversity Index**	2.082	1.225	1.697	1.924	1.662	1.717

* = Kansas stream segment number; Monitoring site 1 is in Missouri approximately two miles from state line.
** = additional to RBP core metrics

Recreational Use Assessment

Recreation use (and potential use) was assessed using fecal coliform monitoring, nearstream population analysis and an on-site recreational use survey. Presented below are the data for the fecal coliform testing, nearstream population assessment and recreational use index (RUI) for each stream.

Fecal Coliform Data

Fecal coliform counts were found to be well below the State of Kansas threshold value of 200 colonies per 100 ml at all monitoring sites. Average colony counts (n=3) ranged from 63.3 to 93.3 colonies per 100 ml at the six monitoring stations along the main stem of the Marmaton River (Table 7).

Nearstream Residential Population

A simple GIS-based modeling approach was utilized to determine the residential population in each sub-basin and within 0.5 km of the stream segment associated with each sub-basin. Population estimates were made on a individual and additive basis (Table 8). The main stem of the Marmaton River was digitized from digital raster graphics (USGS topographic maps) data and used in the nearstream analysis. Total human population estimated to be living in the 1.0 kilometer stream corridor (both sides of stream) was 2858 while approximately 8548 individuals live within the entire watershed. Thus about 32% of the residents inhabiting in the largest delineated watershed, were thought to live within 500 meters of the Marmaton River.

Recreational Use Index

Evidence of existing use (wading, fishing and limb lines observed) was noted at Marmaton River monitoring site 2, 3, 5 and 6. If evidence of existing use has been found, the site was considered to meet the designation of contact recreational use and no further assessment/scoring was required. However, all recreational use factors were assessed at each site regardless of evidence of existing uses and the results are provided in Table 9. Attainability (potential) scores were low for all stream sites suggesting access to these sites was moderately difficult with channels having relatively steep, tall banks and riparian margins comprised of dense riparian ground cover that tended to restrict physical movement. As previously mentioned, signs of existing use were observed at four of six monitoring sites even though the stream was moderately hard to access. The scoring of attainment (status) is divided into aesthetics and hazards. Aesthetics scored fairly low due to a lack of distinct geologic formations, riffles and waterfalls, but also due to presence of debris of anthropogenic origin both in and near the stream. Sites 1,2,3 and 6 were rated as having no or few hazards present. Little or no sharpes or obstacles and no point sources were present at these sites. A large amount of debris, sharp items and obstacles were observed at Site 4 lowering both aesthetics and hazards scores at that site.

Table 7 - Mean (n = 3) fecal coliform colony counts (# / 100ml) for Marmaton River sample sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Colonies / 100 ml	90	93.3	63.3	96.6	76.6	83.3

Table 8 - Sub-basin total populations and nearstream residential populations (within 0.5 kilometer of either side of the stream). Additive or cumulative populations estimates are also provided.

Sub-basin	Sub-basin Total Population	Sub-basin Additive Population	0.5 Kilometer Buffer Population	0.5 Kilometer Buffer Additive Population
1	525	8548	104	2858
2	1119	8023	78	2754
3	137	6904	61	2676
4	1381	6767	1381	2615
5	2157	5386	742	1234
6	3229	3229	492	492

Table 9 - Mean Recreational Use Index (RUI) scores for monitoring sites located on the Marmaton River.

Site	Evidence of Existing Use	RUI Site Values (42pts. possible)	Attainability (15pts. possible)	Attainment (27pts. possible)	Attainment-Aesthetics (18pts. possible)	Attainment-Hazards (9pts. possible)
1	no	21.8	3.3	18.5	9.5	9.0
2	yes	29.3	6.0	23.3	15.0	8.3
3	yes	22.1	1.8	20.3	11.3	9.0
4	no	18.4	2.8	15.6	9.6	6.0
5	yes	21.4	5.6	15.8	11.3	4.5
6	yes	25.0	5.5	19.5	10.5	9.0

Chemical Analysis

Water column and sediment samples were analyzed for metals, polycyclic aromatic hydrocarbons (PAHs), pesticides and other general chemical parameters. Water column samples were also analyzed for nutrients. Fish tissue samples were analyzed for Region 7 Regional Ambient Fish Tissue (RAFT) status parameters. The following tables for water and sediment sample results list the highest value found at each monitoring site for the analyte detected (Tables 10 and 11). Few water quality constituents were observed to occur within the water column at elevated levels except for heavy metals and nitrogen. Heavy metal concentrations were found at levels that exceeded either state of federal aquatic life criteria along most of the stream course. Total Kjeldahl Nitrogen ranged form 1.05 mg/l to 1.96 mg/l at Site 4 compared with a mean value of 0.60 mg/l at Site 6. Stream sediment were found to be contaminated by a variety of compounds ranging from oil & grease to pesticides (Table 11). As with water column samples, lead and cadmium levels in sediment samples tended to be high, especially within the lower portions of the study area. Site 4, which is located downstream of Fort Scott, Kansas, was the only site at which a number of PAH compounds were noted to occur at rather high concentrations. Contaminant estimates for fish tissue were base on a single sample per site (Table 12). See Appendix 4 for parameters analyzed for but not found above detection limits at any monitoring sites.

Table 10 - Water quality parameter concentrations found in exceedance of either State of Kansas, State of Missouri and/or USEPA aquatic life criteria. Total hardness values are in mg/l while all other water quality parameter measures are in µg/l. Values in bold indicate exceedance of criteria.

Parameter	Site #	Sample #	Hardness (Total)	Conc.	KS Acute	KS Chronic	MO Acute	MO Chronic	USEPA*
Lead	1	111	152	56.1	N/A	N/A	104	**16**	286.9
Lead	1	115	151	23.1	N/A	N/A	104	**16**	284.6
Lead	2	121	151	42.7	275.9	**21.5**	N/A	N/A	284.6
Cadmium	3	131	159	4.77	7.2	**1.3**	N/A	N/A	**4.5**
Copper	3	135	145	161	**30.2**	**19.5**	N/A	N/A	**31.4**
Lead	5	155	131	59.4	230.3	**17.9**	N/A	N/A	239.3
Lead	6	163	170	47.8	320.9	**25.0**	N/A	N/A	328.9

* = values not to exceed at any one time
N/A = not applicable

Table 11 - Analyte concentrations of concern observed in sediment samples at Marmaton River monitoring sites. Provided for comparison purposes are levels of concern or 'threshold values' published by USEPA's Office of Science and Technology (USEPA, 1997).

Parameter	Site	Sample #	Concentration	SQC ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	SQAL ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)
Cadmium	1	112	29.8 mg/kg	-	1.2	9.6	5.1	9.6	-	.676	4.21
Lead	1	112	70.6 mg/kg	-	46.7	218	450	660	-	30.2	112
Manganese	1	112	7490 mg/kg	-	-	-	-	-	-	-	-
Cadmium	2	124	15.5 mg/kg	-	1.2	9.6	5.1	9.6	-	.676	4.21
Lead	2	124	66.1 mg/kg	-	46.7	218	450	660	-	30.2	112
Manganese	2	124	4240 mg/kg	-	-	-	-	-	-	-	-
DDT	3	136	1.0	-	.00158	.0461	.009	.015	-	.00389	.0517
Oil & Grease	3	136	954 mg/kg	-	-	-	-	-	-	-	-
Mercury	3	132	0.033 mg/kg	-	.15	.71	.59	2.1	-	.13	.696
Anthracene	4	144	110 µg/kg	-	.0853	1.1	.96	13	-	.0469	.245
Chrysene	4	142/144	390 µg/kg	-	.348	2.8	2.8	9.2	-	.108	.846
Fluoranthene	4	142	730 µg/kg	620	.6	5.1	2.5	30	620	.113	1.494
Phenanthrene	4	144	370 µg/kg	180	.240	1.5	1.5	6.9	180	.0867	.544
Pyrene	4	142	630 µg/kg	-	.655	2.6	3.3	16	-	.153	1.398
Oil & Grease	4	142	2000 mg/kg	-	-	-	-	-	-	-	-
Cadmium	4	142	15.2 mg/kg	-	1.2	9.6	5.1	9.6	-	.676	4.21
Lead	4	142	65.6 mg/kg	-	46.7	218	450	660	-	30.2	112
Manganese	4	142	3300 mg/kg	-	-	-	-	-	-	-	-
Mercury	4	142	0.068 mg/kg	-	.15	.71	.59	2.1	-	.13	.696
Zinc	4	142	376 mg/kg	-	150	410	410	1600	-	124	271
Oil & Grease	5	152	1360 mg/kg	-	-	-	-	-	-	-	-
Oil & Grease	6	162	1250 mg/kg	-	-	-	-	-	-	-	-

SQC = Sediment quality criteria (Draft, USEPA)
SQAL = Sediment quality advisory levels (Draft, USEPA)
ERL = Effects range-low (Long et. al., 1995)
ERM = Effects range-median (Long et. al., 1995)
AET-L = Apparent effects threshold-low (Barrick et. al., 1988)
AET-H = Apparent effects threshold-high (Barrick et, al., 1988)
TEL = Threshold effects levels (FDEP, 1994)
PEL = Probable effects levels (FDEP, 1994)
- = no information available

Table 12 - Analytic values of concern associated with Green Sunfish tissue samples obtained at each study site on the Marmaton River. Provide for comparison purposes are USEPA and FDA levels of concern.

Analyte	Site	Concentration (mg/kg)	USEPA Risk 10^{-5} (ppm)	USEPA Noncancer r Hazard Quotient = 1 (ppm)	FDA Guidance / Action / Tolerance Level (ppm)
DDD	3	0.0037	0.45	-	5
DDE	3	0.0026	.032	-	5
Mercury	4	0.053	-	1.1	1
Chlordane, cis-	5	0.0076	0.083	0.65	0.3
Chlordane, trans	5	0.0061	0.083	0.65	0.3
Chlordane, technical	5	0.12	0.083	0.65	0.3
Dieldrin	5	0.0083	0.0067	0.54	0.3
Heptachlor Epoxide	5	0.0028	0.012	0.14	0.3
Nonachlor, trans	5	0.0071	0.083	0.65	0.3
Trifluralin	5	0.013	14	81	-
Selenium	5	3.52	-	54	-

Anthropogenic Related Compounds (ARC)

Many of the samples from the Marmaton River revealed the presence of water and sediment pollutants. Some of these pollutants have criteria or published threshold values, but there is little or no information on the effects of combinations of contaminants in aquatic environments. In recognition of the fact that the co-occurrence of toxicants does occur in aquatic ecosystems and can lead to joint toxicity as a result of exposures to combinations of contaminants (Butler, 1978; Hoffman, 1995; Rand, 1995), an indicator concept was developed to express the potential exposure to multiple toxicants (Welker, 1998). This index (Anthropogenic Related Compounds or ARC) is a richness index based on the summed occurrence of toxicants that are anthropogenic in origin and are known to occur in the water and/or sediment of aquatic ecosystems (e.g., stream segment, stream network). Naturally occurring chemical species such as metals and salts, which could be naturally occurring but at high (i.e., background) levels, were not included as compounds in the ARC indices. A separate richness value (i.e., ARC value) for each medium was determined for each site. Like the additive model for biological taxa richness, the occurrences of each unique anthropogenic compound were summed to determine the ARC score. An ARC index value was generated for both the water column (ARC_w) and sediment (ARC_s) for each site (Table 13). In addition a combined ARC index (ARC_{ws}) was developed to measure the cumulative occurrence of anthropogenic compounds found in either water or sediment at a monitoring site or within a stream. In the ARC_{ws} index when an anthropogenic compound is found in both water and sediment samples its

occurrence is summed in the index as a one indicating only that it was present at the site or stream in one or more of the sampled media. It is evident from Table 13 that the most numerous co-occurrences of anthropogenic compounds are at sites located downstream of Fort Scott, Kansas and the wastewater treatment discharge.

Table 13 - Summary of Anthropogenically Related Compounds (ARC) found in water, sediment, water & sediment and fish tissue media at each monitoring site.

Site	ARCwater	ARCsediment	ARCwater & sediment	ARCfish tissue
1	4	2	5	2
2	4	1	4	4
3	4	8	11	4
4	3	6	8	1
5	4	1	4	8
6	3	1	3	1
total stream reach	4	10	14	12

Geographic Analysis

The results of the geographic analysis of watershed and sub-basin LULC are provide in Table 14. The watershed and all sub-basins are predominantly agricultural. Pasture and row crop are the highest percentage of land use in all sub-basins. Forest, grassland and urban have significant areal extent in some sub-basins. Table 14 provides information on individual sub-basins and is not cumulative information. However, effects observed at each monitoring site result from cumulative upstream conditions. For example, circumstances observed at Site 4 reflect watershed conditions upstream in sub-basins 4, 5 and 6.

Table 14 - Percent of land use/land cover (LULC) classes found to comprise each of the sub-basins and watersheds of the study streams.

Sub-basin #	Area (km^2)	% Urban	% Forest	% Wetland	% Grassland	% Water	% Pasture	% Row Crop	% Shrubland	% Small Grain
1	41,230.71	0	7	3	1	0	41	47	0	1
2	32,181.30	5	20	2	2	1	46	24	0	0
3	16,085.97	12	3	0	1	0	44	40	0	0
4	64,517.82	4	9	1	7	1	40	39	0	0
5	16,142.82	10	10	1	19	2	33	24	0	0
6	64,484.19	0	14	2	18	1	37	27	1	0

Analysis of Variance - Marmaton River Monitoring Site Comparisons

A number of water quality variables were found to be statistically different between the monitoring sites on the Marmaton River. Six of the nine variables were sediment related contaminants, while all factors were significantly elevated at Site 4 (Table 15). The results of Duncan's test were graphically displayed with monitoring sites either being grouped (i.e. group means not different from each other) or as occurring separately (significantly different from others). Group means were arranged by relative value along a linear continuum (line) representing the low to high range of relative values. Only two groups were identified as being different with regard to PAH contamination. Site 4 formed the single high PAH group while all other sites formed the low concentration group. Three groups were recognized based on the concentration of mercury in the sediment. The low mercury group was composed of both upstream and downstream sites while Site 3 constituted a mid-range group and Site 4 was the high concentration group. Similarly, TKN groups consisted of a Site 6 group (low TKN levels), a moderate concentration group of both up and downstream sites and the single site group (Site 4) which had the highest TKN values. Site 4 also was found to represent the group with the highest chlorophyll *a* or pheophyton *a* values for periphyton. The group or groups having low plant pigment concentrations were either composed of Sites 1, 2 and 3 (chlorophyll *a* group) or were separate single membership groups (pheophyton a group).

Table 15 - Variables that were found to be statistically different between monitoring sites ($\alpha = 0.05$) and corresponding results for Duncan's multiple-comparison test. Underlined site(s) indicate group affiliations.

Parameter	Media	Power (β-1)	Duncan's Multiple Comparison Test (Value Range) Low----------High
anthracene	sediment	0.83	2 5 6 1 3 — 4
chrysene	sediment	0.71	2 5 6 1 3 — 4
fluoranthene	sediment	0.76	2 6 5 1 3 — 4
phenanthrene	sediment	0.79	2 6 5 1 3 — 4
pyrene	sediment	0.74	2 5 6 1 3 — 4
mercury	sediment	0.87	6 2 5 1 3 — 4
total kehldahl nitrogen (TKN)	water	0.84	6 — 5 1 2 3 — 4
chlorophyll *a* (periphyton)	biological	0.78	3 2 1 — 6 5 — 4
pheophyton *a* (periphyton)	biological	0.71	3 2 1 — 6 5 — 4

1 = Site 1 2 = Site 2 3 = Site 3 4 = Site 4 5 = Site 5 6 = Site 6

Regression Analysis

Multiple regression analysis refers to the technique of investigating straight-line relationships among two or more variables (NCSS, 1997). The relationship investigated is of one dependent variable (response) and one or more independent variables often referred to as predictors (NCSS, 1995). The model analyzes linear or straight-line relationships between dependent variable and independent variables with any curvilinear relationship being ignored. The variance of the dependent variable is considered to be the same for all related independent variables (Afifi, 1990).

Prior to multiple regression modeling, Spearman-rank correlation analysis was conducted to identify associations between pairs of variables. This procedure was used as a data reduction technique and to identify candidate variables for regression modeling. Listed below are several multiple regression models found to be significant at the $\alpha = 0.05$ level.

The results of a series of simple linear regression analysis indicated that a number of PAH compounds (i.e., anthracene, chrysene, fluoranthene, phenanthrene and pyrene) in addition to zinc, mercury and non-volatile solids when used as dependent variables explained between 67% to 86% of the variability of observed changes in % EPT (Table 16). All independent variables in these models displayed a negative relationship with the dependant variables indicting that increases in these contaminants could cause major reductions in the macroinvertebrate variable.

Table 16 - Results of significant simple regression models where percent Ephemeroptera-Plecoptera-Trichoptera (EPT) was used as the dependent variable.

Dependent Variable	Independent Variable	Media	Relationship (- or +)	R^2
% EPT	Anthracene in sediment	sediment	-	.84
% EPT	Chrysene in sediment	sediment	-	.86
% EPT	Fluoranthene in sediment	sediment	-	.85
% EPT	Phenanthrene in sediment	sediment	-	.82
% EPT	Pyrene in sediment	sediment	-	.85
% EPT	Zinc in sediment	sediment	-	.67
% EPT	Mercury in sediment	sediment	-	.76
% EPT	Solids - Non volatile	water	-	.75

Stressor Identification

In an attempt to help identify potential stressors causing aquatic life impairment, parameters (variables) associated with each monitoring site were compared to measures from the monitoring site immediately upstream except for site 6 (Table 17). Increases or decreases of individual variables (e.g., PAHs, % EPT) were noted based on magnitude and pattern of occurrence (i.e., are numerous increases/decreases occurring in a particular segment). A weight of evidence approach was used in which information and results of the segment evaluations (i.e., Kansas stream segments) and the statistical analyses (e.g., ANOVAs and regressions) was used to identify potential stressors. Monitoring site 1 was located approximately two miles west of the state line in Missouri and site 2 was within Kansas stream segment 5. Monitoring sites 3 and 4 were located downstream of Fort Scott, Kansas in stream segment 7 and monitoring sites 5 and 6 were within Kansas stream segment 8.

A number of chemical parameters were found to increase in segment 7. Significant increases in PAHs were observed. Anthracene, chrysene, flouranthene, phenanthrene and pyrene all had statistically significant increases measured at Site 4 when compared to Site 5 (immediately upstream) and to all other monitoring sites. Oil & grease and total kjeldahl nitrogen were highest at site 4 (segment 7). In addition, the highest levels of lead, zinc and mercury were observed at site 4. Total number of anthropogenic compounds in both water and sediment (ARC_{ws}) was greatest in segment 7 (Sites 3 and 4).

In characterizing the main stem of the Marmaton River it appears that Segment 7 is a biologically degraded segment. Both the macroinvertebrate variables, % EPT and macroinvertebrate abundance were comparatively reduced from site 5 to site 4 while the % Chironomidae metric was noticeably elevated at Site 4. Habitat does not appear to be involved in the decline in macroinvertebrate health. The Habitat Diversity Index (HDI), a indices of macroinvertebrate habitat, was highest at monitoring site 4, indicating that the macroinvertebrate samples were obtained from very complex and diverse habitats and microhabitats. Typically, high HDI scores are positively correlated to high taxa richness and abundance, if water quality is not a limiting factor (Anderson, 1990).

Both fish abundance and taxa richness were lowest at monitoring site 4(segment 7). A 50% decline in fish richness was observed between Sites 5 and 4. Only seven species of fish were found to occur at monitoring site 4. Likewise, at steep drop in total abundance of fish was observed at site 4. The number of individuals captured dropped from 1706 to 71 at sites 5 and 4, respectively.

Mean chlorophyll *a* concentration were noticeably higher at monitoring sites 4, 5 and 6 with site 4 chlorophyll *a* levels being about 33% higher than upstream values. It is unclear why values for all sites downstream of Site 4 were so depressed when compared to sites 4 through 6.

Table 17 - Potential stressor and response variables found at monitoring sites located on State of Kansas stream segments 5, 7 and 8 on the Marmaton River.

Parameter	Media	Site 1 (Missouri*)	Site 2 (5*)	Site 3 (7*)	Site 4 (7*)	Site 5 (8*)	Site 6 (8*)
Anthracene (µg/kg)	sediment	32.3	30.2	37.3	81.5	30.8	30.8
Chrysene (µg/kg)	sediment	30.0	28.0	90.7	270.7	28.7	28.7
Flouranthene (µg/kg)	sediment	30.0	28.0	117.3	467.3	28.7	28.7
Phenanthrene (µg/kg)	sediment	34.5	32.2	57.5	249.0	33.0	32.8
Pyrene (µg/kg)	sediment	29.0	27.5	123.3	410.3	28.0	28.2
Lead (mg/kg)	sediment	38.2	37.7	29.2	48.1	25.1	19.9
Mercury (mg/kg)	sediment	0.024	0.018	0.03	0.046	0.018	0.011
Zinc (mg/kg)	sediment	102.7	82.4	92.9	200.7	139.4	56.5
Oil & Grease (mg/kg)	sediment	654	605	905	1129	1056	925
Total Kjeldahl Nitrogen (mg/l)	water	1.01	1.10	1.11	1.36	0.78	0.60
ARC_{ws}	water/sediment	5	4	11	8	4	3
%EPT	biological	75	90	67	42	73	76
Macroinvertebrate Abundance	biological	122	687	201	38	410	59
%Chironomidae	biological	16	1	8	26	18	4
Habitat Diversity Index (HDI)	biological	7.0	7.3	7.0	9.0	7.6	8.7
Fish Abundance	biological	334	237	116	71	1706	348
Fish Richness	biological	10	19	11	7	14	12
Chlorophyll *a* (ug/l)	biological	478	273	193	3320	2213	2021

* = Kansas stream segment number; Monitoring site 1 is in Missouri approximately two miles from state line.

Fish Habitat

Listed below in Table 18 are habitat parameters measured at each monitoring that could effect fish community structure. Habitat parameters vary somewhat across monitoring sites and stream segments but overall the habitat data show a general similarity between stream segments. Flow, channel width and stream shading are similar across monitoring sites and stream segments. Undercut bank volume differs among stream segments due to the relatively large volume of undercut bank found at monitoring site 6. No dramatic differences were observed in overhanging vegetative cover, submerged fine woody debris and/or submerged coarse woody debris. Submerged heavy woody debris does stand out as stream segment 7 appears to have appreciably more heavy debris when compared to the other stream segments. Substrate throughout the study

area is generally a gravel/sand/hard clay mix with the exception of site 4 which has a higher percentage of soft silt (possible urban runoff contribution) and no gravel. Amount of near stream erosional area was less in segment 7 when compared to the other two stream segments.

A fish habitat richness index rated all three stream segments as having similar habitats. The fish habitat richness score is a general index that accounts for occurrence of habitat features (i.e., coarse woody debris, stream shading) within a stream segment. What the fish habitat richness index portrays is out of the 15 fish habitat variables selected for this study, 14 variables were present in each stream segment (not necessarily the same variables). In general, the stream segments appear to be similar in regards to fish habitat and therefor should support similar fish communities. However, taking a look at the Kansas monitoring sites by stream segments shows a difference in fish richness. Kansas stream segment 5 had a richness score of 19, segment 7 had a richness score of 7 and segment 8 a richness of 13. Also, species in need of conservation (SINC) have been sampled within segments 5 (current study) and 8 (KDHE; Appendix 5).

Table 18 - Habitat parameters measured at monitoring sites on the Marmaton River potentially related to fish community structure.

Parameter	Site 1 (Missouri*)	Site 2 (5*)	Site 3 (7*)	Site 4 (7*)	Site 5 (8*)	Site 6 (8*)
Flow (m/sec)	6.1	7.3	6.3	6.3	4.0	6.4
Channel Width (m)	35.2	44.8	43.2	43	46.6	37.6
Stream Shading	8.8	10.8	12.2	11.35	12.3	9.7
Undercut Bank Volume (m^3)	0	0	6.5	0	0	24.8
Overhanging Vegetative Cover (m^2)	2.5	0	9	0	6.9	0
Submerged Fine Woody Debris (m)	0	11.9	5	4.8	4.6	1.7
Submerged Coarse Woody Debris (m)	1.8	4.3	20.4	22	22.5	37.5
Submerged Heavy Woody Debris (m)	0	33.5	29.4	62.2	4.5	31.2
Bedrock Substrate (% area)	16.7	3.3	0	0	0	0
Cobble Substrate (% area)	10	13.3	40	3.3	20	13.3
Gravel Substrate (% area)	50	46.7	23.3	0	53.3	56.7
Sand Substrate (% area)	23.3	6.7	13.3	13.3	0	3.3
Hard Clay Substrate (% area)	0	23.3	20	36.7	20	26.7
Soft Silt Substrate (% area)	0	6.7	3.3	46.7	6.7	0
Erosional Area (m^2)	400	222	0	26.3	450	0
Fish Habitat Richness	14		14		14	

* = Kansas stream segment number; Monitoring site 1 is in Missouri approximately two miles from state line.

IV. DISCUSSION

The main goals of any Use Attainability Analyses are to determine use attainability, use attainment and causes of impairment (if any). Use attainability is an estimation of what single or multiple designated uses are achievable. Use attainment is the determination of whether a designated use (i.e., special aquatic life use, expected aquatic life or restricted aquatic life) is currently being achieved. When a use is currently not being achieved the potential causes of impairment can be identified using biological, chemical and physical analyses.

Recreational Use

Use Attainability

The nearstream residential population estimates and a number of the RUI components of the recreational use study were used to evaluate attainability for recreational use of the stream. In addition, these methodologies allow for a systematic evaluation of recreational use. It was assumed that as the population density within the stream corridor increased, so did the potential for recreational activity. It was also assumed that as the nearstream population density increased there was a concurrent increase in the frequency of relative stream use. However, there are no known threshold population levels that have been associated with either increases or decreases in the level of contact or noncontact recreational use. The number of people living within one half kilometer of either side of the main stem of the Marmaton River was determined to be 2,858. This population was not uniformly distributed along the stream corridor and some reaches had comparatively high densities suggesting high use opportunities. Many other factors can influence the extent and frequency of human uses of the stream environment. Some of these factors were assessed in the RUI. Stream access was evaluated on the basis of vegetation barriers to the channel, bank heights and physical entry into the stream channel. Access to the various Marmaton River sites was judged to vary from easy to difficult. All sites had steep banks (bank angles greater than 45°) that were often over 2 meters in height. However, despite dense riparian cover and high banks, evidence of existing recreational use was observed at four of six monitoring sites. Fishing and wading activities were noted at sites 2, 3, 5 and 6 by members of the field crew during the five days of field work. Based on these data and observations the use designation of contact recreation appeared to be warranted for Marmaton River segments 5, 7 and 8.

Use Attainment and Potential Causality

Segments 5, 7 and 8 of the Marmaton River are designated for contact recreational use under Kansas water quality standards. Fecal coliform results from this study suggested that the Marmaton River would meet the Kansas contact recreation use in these same stream segments. However, RUI scores indicated that trash and debris conditions at some sites resulted in a variety of site conditions ranging from aesthetically degraded to potentially hazardous. The presence of

debris appeared to be principally due to dumping and discarding of trash and large items from bridge overpasses. The area in around monitoring Site 4 was particularly afflicted by illegal dumping. As an example, during the course of monitoring Site 4, an act of illegal dumping of 6 to 10 large trash bags full of domestic waste was observed and reported to authorities.

Aquatic Life Use

Three objectives were identified and investigated in the aquatic life use analysis. The first objective, attainability, was to evaluate the potential of the stream to have and maintain a reasonably representative aquatic life community. Attainability is most typically defined not by existing water quality conditions, but by the opportunities created by physical conditions (i.e., flow, substrate, cover) and similarities in aquatic life community structure in comparison to reference conditions or historical information (e.g., fish records of occurrence). In determining the attainable uses for Marmaton River, this study gathered information which documented the status of the biological community associated with various stream segments and compared these upstream and downstream communities to each other. The second objective was to determine if the Marmaton River was in attainment with regard to its designation as "special aquatic life use waters". Special aquatic life waters are surface waters that contain combinations of habitat types and indigenous biota not commonly found in the state and/or surface waters that contain representative populations of threatened or endangered species. This objective was addressed by assessing historic and current information on the fish community of the main stem of this river. The second objective was also addressed through direct examination of physical and chemical constituents found in the sediment and water of the Marmaton River. In addition, chemical data from the water column and sediment were used to determine if state or federal water quality criteria are met and, therefore, uses are attained. The third was to determine what factors might be causing non-attainment. The following discussion addresses these areas of concern.

Use Attainability

A review of current literature and records indicate that the Marmaton River supports a highly diverse fish fauna warranting a special aquatic life use designation. Examination of information obtained from the Kansas Department of Health and Environment (KDHE) revealed that as many as 39 fish species are known to have occurred in the Marmaton River (Appendix 5). The list of fish species compiled by KDHE found in Appendix 5 is from collections obtained by Kansas Fish and Game Commission (1978); KDHE (1985-86) and; Kansas Department of Wildlife and Parks. Individual study values were much lower and ranged from 29 fish species recorded in 1996 above Ft. Scott by Kansas Fish and Game to 15 and 10 species collected below Ft. Scott by KDHE in 1985 and 1986, respectively.

Fish community monitoring data collected by this study and by PSU found a total of 44 species present in the Marmaton River and tributaries(Appendix 6). In contrast, this study found the lowest number of fish species, 7 species, at monitoring site 4 directly below Ft. Scott in Kansas stream segment 7. The highest number of species found at an individual monitoring sites

were 26 species found by PSU above Ft. Scott in Kansas stream segment 12 (site M2) and 19 species collected by this study well below Ft. Scott in Kansas stream segment 8 (site 2).

Both stream and riparian habitat conditions were found to be relatively similar between monitoring sites. The single exception was the higher percent of silt substrate at site 4 compared to other sites. In general, bottom substrates at nearly all sites were a mixture of gravel/cobble/sand except for site 4 which was devoid of gravel but exhibited a concurrent increase in the percent of soft silt. Similar habitat variables included channel width, riparian width, riparian condition, discharge and stream shading.

Use Attainment

The Marmaton River does not appear to be in attainment as for designation of special aquatic life use. The macroinvertebrate community is apparently impaired at monitoring Site 4 (segment 7), below the city of Fort Scott. The invertebrate community shows a loss of intolerant taxa (EPT) and dominance of chironomidae. Total number of individuals obtained at Site 4 with standard sampling technique was well below what would be expected in a healthy stream or stream segment. This was concluded after examining the relative changes in water and biological quality parameters associated with both upstream and downstream sites and stream segments.

A comparison of fish data collected during this study to historical records would also support the finding of non-attainment. Of the five monitoring stations sampled in Kansas (Site 1 was located in Missouri) the number of fish species identified ranged from a low of 7 to a high of 19 species present at sites 4 and 2, respectively. Also, the SINC species *Ethostoma blennioides* was found in segment 8 (site 5) and has been documented to occur in segment 5 by KDHE (Appendix 5). The species has not found at either sites 3 or 4 in Kansas stream segment 7 pointing to degradation of that stream segment directly below the City of Fort Scott.

Potential Causality

Urban nonpoint source runoff and point source effluent from the municipal waste water treatment facility are potential causes of impairment to the stream fauna. Increased concentrations of PAHs which are often associated with urban stormwater runoff were found below the City of Fort Scott (Site 4). PAHs can be traced to automobile, truck and rail transportation and associated petrochemical products use. In addition to the normal automobile use and traffic in and around Fort Scott, a large railroad yard and associated facilities is located near the river and adjacent to the city is wastewater treatment plant. Sources of PAHs are oil drippings, gasoline and diesel fuel products spilled and deposited on highways, streets, driveways and parking lots, which are then transported into streams during precipitation events. Site 4 also had elevated concentrations of lead, zinc, mercury, oil & grease and total kjeldahl nitrogen. Overall this site had a comparatively high number of anthropogenic derived compounds in water and sediment samples (ARC_{ws}).

Summary

The main stem of the Marmaton River was found to be in attainment for contact recreational use. Evidence of existing use was found that would support the continuation of contact recreational use designation. The main stem of the Marmaton River was found not to be in attainment with regard to the stream's special aquatic life use designation. Fish sampling reveal a significant lack of fish species when compared to records of known occurrence of fish species. Macroinvertebrate sampling showed degradation of the invertebrate community below the City of Fort Scott. Increase levels of PAH's, oil & grease, metals and nitrogen are believed to the principal cause of impairment to the aquatic invertebrates. Potential sources may be non-point, transportation related chemicals and point source, waste water treatment related constituents.

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Appendix 1 - Recommended water and sediment parameters and recommended containers, preservatives and holding times for Use Assessment Analyses.

	Water			Sediment		
Parameter	Container	Preservative	Holding Time	Container	Preservative	Holding Time
Volatile Suspended Solids	1 L cubitainer	4° C	7 days	---	---	---
Total Suspended Solids	1 L cubitainer	4° C	7 days	---	---	---
Total Dissolved Solids	1 L cubitainer	4° C	7 days	---	---	---
Nitrate	1 L cubitainer	4° C	2 days	---	---	---
Nitrite	1 L cubitainer	4° C	2 days	---	---	---
Alkalinity	1 L cubitainer	4° C	14 days	---	---	---
Hardness	1 L cubitainer	4° C	180 days	---	---	---
Ammonia	1 L cubitainer	4° C/H_2S0_4	28 days	---	---	---
Total Kjeldahl Nitrogen	1 L cubitainer	4° C/H_2S0_4	28 days	---	---	---
Total Phosphorus	1 L cubitainer	4° C/H_2S0_4	28 days	---	---	---
Chemical Oxygen Demand	1 L cubitainer	4° C/H_2S0_4	28 days	---	---	---
Total Organic Carbon	1 L cubitainer	4° C/H_3PO_4	28 days	8 oz glass	4° C	14 days
Cadmium	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Chromium	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Copper	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Lead	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Manganese	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Mercury	1 L cubitainer	4° C + HNO_3	28 days	8 oz glass	4° C	180 days
Nickel	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Zinc	1 L cubitainer	4° C + HNO_3	180 days	8 oz glass	4° C	180 days
Oil and Grease	32 oz glass	4° C/HCl	28 days	8 oz glass	4° C	28 days
Anthracene	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Chrysene	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days

Appendix 1 (continued) - Recommended water and sediment parameters and recommended containers, preservatives and holding times for Use Assessment Analyses.

	Water			Sediment		
Fluoranthene	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Phenanthrene	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Heptachlor Epoxide	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Phthalate, bis(2-ethylhexyl)	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Pyrene	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
PCB-Arochlor 1254	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
PCB-Arochlor 1260	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Pentachlorophenol	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
2,4-D	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Alachlor	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Atrazine	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
BHC, gamma (lindane)	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Chlordane, Technical	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
DDT-4,4'	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Diazinon	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Dicamba	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Dieldrin	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Dursban (Chorpyrifos)	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Endrin	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Isophenphos	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Metalachlor	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Metribuzin	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days
Pendimethalin (Prowl, Squadron)	128 oz glass	4°C	7 days	8 oz glass	4° C	14 days

Appendix 2

Recreation Use Index field (RUI) sheet.

ecreational Use Index (RUI) Field Sheet

Stream/State/County:_____

Site#:_____

Date:_____

Analyst(s):_____

EVIDENCE OF EXISTING USE

Yes	No

Evidence of existing use are an actual siting of a person swimming, wading, rope swings, information from local community as to use, etc.

ATTAINABILITY

1. Access:

ank Angle	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

=>45 degrees 3=0-45 degrees

Bank Height	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=>2 meters 1=0.5-2.0 meters 3=0-0.5 meter

ream Depth	IT_1	IT_2	IT_3	IT_4
Stream Channel				

=0-1.0 meter 3 =>1.0 meter

nd/Gravel Bar Presence	IT_1	IT_2	IT_3	IT_4
Stream Channel				

=Sand/gravel bar not present. 3= Sand/gravel bar present.

Potential for Use

Stream Corridor	

=Stream is hard to access stream (i.e., thick, continuous riparian corridor). 1=moderately hard to access stream. 2=moderately easy to access stream. 3=Easy to access stream (i.e., close to stream trail, rk &/or residential area, etc.).

I. IMPAIRMENT

Hazards:

ear Stream

arps, obstacles	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=Sharps or non-natural obstacles observed. 3=no sharps or non-natural obstacles observed.

Stream

harps, obstacles	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=Sharps or non-natural obstacles observed. 3=no sharps or n-natural obstacles observed.

In Stream

Potential Discharges

Stream Corridor	

0=point discharge(s) present. 3=no point discharge(s) present.

2. Aesthetics:

Near Stream Debris	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=large item(s) (freezer, construction debris etc.) 1=moderate size item (s)(tire, crate, etc.) or wrappers, cans, plastic bags, etc. 3= no debris observed.

In Stream Debris	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=large item(s) (freezer, construction debris etc.) 1=moderate size item (s)(tire, crate, etc.) or wrappers, cans, plastic bags, etc. 3= no debris observed.

Near Stream Fauna & Geological	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

Presence of mature trees (1pt.) + outcropping or distinct geological formation (1pt.) + diverse vegetation (≥5 species)(1pt.) = Score 0=none of the above present. (Maximum score of 3)

Riffle, Waterfall

Stream Channel	

0=no riffles, waterfalls, etc. 3=presence of riffle(s) &/or natural waterfall(s).

Water Clarity	IT_1	IT_2	IT_3	IT_4
Stream Channel				

0=≥200 NTU 2=25-200 NTU 3=0-25

Odor	IT_1	IT_2	IT_3	IT_4
Left Bank				
Right Bank				

0=unpleasant odor 3=pleasant or not noticeable odor

Attainability Score =_____

Impairment Score =_____

Total Site Score =_____

Appendix 3a - Fish species list for USEPA Marmaton River monitoring sites.

Species	Site 1 (Missouri*)	Site 2 (5+)	Site 3 (7+)	Site 4 (7+)	Site 5 (8+)	Site 6 (8+)
Ameiurus natalis						✓
Aplodinotus grunniens		✓	✓	✓	✓	
Campostoma anomalum	✓	✓				✓
Cyprinella lutrensis	✓	✓	✓	✓	✓	✓
Cyprinus carpio			✓	✓	✓	
Dorosoma cepedianum	✓	✓	✓	✓	✓	
*Ethostoma blennioides**		✓				
Etheostoma flabellare			✓			
Etheostoma spectabile	✓	✓	✓			✓
Gambusia affinis	✓	✓	✓	✓		✓
Ictalurus punctatus	✓	✓	✓		✓	
Ictiobus bubalus				✓		✓
Labidesthes sicculus	✓	✓	✓		✓	✓
Lepisosteus osseus						✓
Lepomis cyanellus	✓	✓	✓			✓
Lepomis macrochirus		✓			✓	✓
Lepomis megalotis					✓	
Lythrurus umbratilis						✓
Micropterus salmoides	✓	✓		✓	✓	
Notropis atherinoides		✓				
Noturus flavus		✓				
Notropis ludibundus		✓				
Percina caprodes					✓	
Percina phoxocephala		✓			✓	
Phenacobius mirabilis		✓				
Pimephales notatus	✓		✓		✓	✓
Pomoxis annularis		✓			✓	
Pylodictis olivaris		✓			✓	

* = Monitoring site 1 is in Missouri approximately two miles from state line.
+ = Kansas stream segment number.

Appendix 3b - Macroinvertebrate taxa list for USEPA Marmaton River monitoring sites.

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Agrionidae	✓				✓	
Baetidae	✓	✓	✓	✓	✓	✓
Chironomidae	✓	✓	✓	✓	✓	✓
Corixidae	✓		✓			
Elmidae	✓	✓	✓	✓	✓	✓
Ephemeridae	✓		✓			
Gomphidae	✓		✓			
Heptageniidae	✓	✓	✓	✓	✓	✓
Hydropsychidae	✓	✓	✓	✓	✓	✓
Libellulidae					✓	
Perlidae		✓				✓
Sialidae	✓	✓	✓	✓	✓	
Stratiomyidae					✓	
Tabanidae				✓		
Tipulidae					✓	✓
Veliidae		✓				

* = Kansas stream segment number; Monitoring site 1 is in Missouri approximately two miles from state line.

Appendix 4 - Compounds analyzed for in water, sediment and fish tissue which were not detected at any monitoring site in Marmaton River.

Water	Sediment Water	Fish Tissue
alachlor	atrazine	benzen, 1,2,4,5-tetrachloro-
anthracene	BHC - gamma(Lindane)	benzene, Pentachloro-
atrazine	captan	BHC - gamma (Lindane)
BHC - gamma (Lindane)	chlordane, technical	cadmium
captan	chlorpyrifos (Dursban)	DDT,4,4'-
chlorpyrifos	diazinon	diazinon
chrysene	dicamba	heptachlor
DDT,4,4'	dieldrin	hexachlorobenzene
diazinon	endrin	lead
dicamba	heptachlor epoxide	nonachlor, cis-
dieldrin	isophenphos (Oftanol)	oxychlordane
endrin	metolachlor (Dual)	PCB 1248
fluoranthene	metribuzin (Sencor)	PCB 1254
heptachlor epoxide	PCB 1260	PCB 1260
isophenphos (Oftanol)	pendimethalin (Prowl)	
mercury	pentachlorophenol	
metribuzin (Sencor)	phthalate, bis(2-ethylhexyl)	
nickel	trifluralin	
PCB 1254	2,4-D(dichlorophenoxyacetic acid)	
PCB 1260		
pendimethalin		
phenanthrene		
phthalate, bis(2-ethylhexyl)		
pyrene		
trifluralin (Treflan)		
zinc, total		

Appendix 5

Kansas Department of Health and Environment list of fish species known to have occurred in the Marmaton River

Table 1. Fish collections taken from Marmaton River mainstem and tributaries. *

	Species:	Scientific Name:	Pawnee Creek	Mill Creek		Marmaton River above Ft. Scott		Marmaton River below Ft. Scott	
			1996	1978	1996	1978	1996	1985	1986
	Longnose Gar	Lepisosteus osseus						X	
	Shortnose Gar	Lepisosteus platostomus						X	
	Gizzard Shad	Dorosoma cepedianum		X	X		X	X	
	Common Carp	Cyprinus carpio			X		X		
	Golden Shiner	Notemigonus crysoleucas		X				X	X
**	Hornyhead Chub	Nocomis biguttatus	X		X		X		
	Suckermouth Minnow	Phenacobius mirabilis			X		X		X
	Red Shiner	Cyprinella lutrensis		X	X	X	X	X	X
	Redfin Shiner	Lythrurus umbratilis	X	X	X		X	X	X
	Sand Shiner	Notropis ludibundus			X		X	X	X
	Bluntnose Minnow	Pimephales notatus		X	X	X	X	X	X
	Fathead Minnow	Pimephales promelas			X			X	
	Central Stoneroller	Campostoma anomalum	X	X	X	X	X		X
	Golden Redhorse	Moxostoma erythrurum	X				X		
	Buffalo sp.	Ictiobus sp.		X	X		X		
	Channel Catfish	Ictalurus punctatus	X			X			
	Yellow Bullhead	Ameiurus natalis	X		X				
	Stonecat	Noturus flavus				X	X		
	Slender Madtom	Noturus exilis	X		X		X		
	Flathead Catfish	Pylodictis olivaris					X		
	Blackstripe topminnow	Fundulus notatus	X		X	X	X	X	X
	Mosquitofish	Gambusia affinis			X				
	Brook Silverside	Labidesthes sicculus	X		X	X	X	X	
	Largemouth Bass	Micropterus salmoides	X	X	X	X	X		
	Spotted Bass	Micropterus punctulatus				X	X		
	Warmouth	Lepomis gulosus	X		X		X		
	Green Sunfish	Lepomis cyanellus	X	X	X	X	X		
	Bluegill	Lepomis macrochirus	X	X	X	X	X		
	Longear Sunfish	Lepomis megalotis	X	X	X	X	X		
	Orangespotted Sunfish	Lepomis humilis			X	X	X	X	X
	Redear Sunfish	Lepomis microlophus					X		
	Hybrid Sunfish	Lepomis sp.					X		
	White Crappie	Pomoxis annularis		X		X	X	X	
	Black Crappie	Pomoxis nigromaculatus					X		
	Logperch	Percina caprodes			X		X	X	
	Slenderhead Darter	Percina phoxocephala					X	X	X
***	Greenside Darter	Etheostoma blennioides	X		X		X		
	Orangethroat Darter	Etheostoma spectabile	X		X		X		
	Fantail Darter	Etheostoma flabellare	X				X		
	# species		14	12	23	14	29	15	10

* collections from 1978 taken by Kansas Fish & Game
collections from 1985 - 1986 taken by Kansas Dept. Health & Environment
collections from 1996 taken by Kansas Dept. Wildlife & Parks

** Threatened species

*** "SINC" species

Appendix 6 - Speceis recorded at all 1998 Marmaton River monitoring stations, including tributaries.

	Main Channel Stations												Tributary Stations					
	Segment 12		Segment 8			Segment 7		Segment 5		Missouri Sites								
Species	M1	M2	M3	S6	S5	S4	S3	M4	S2	S1	M5	M6	WO	MC	PA	W1	W2	ED
Balck bullhead													X					
Black buffalo		X																
Blackstripe topminnow	X	X									X	X		X	X	X		X
Bluegill sunfish	X	X	X	X	X				X		X		X	X	X	X	X	X
Bluntnose minnow	X	X	X	X	X		X	X		X	X	X	X	X	X		X	X
Brook silverside	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Central stoneroller	X	X		X					X	X	X		X	X	X	X	X	
Channel catfish		X			X		X	X	X	X	X	X	X		X		X	
Common carp		X			X	X	X				X	X						
Creek chub														X		X		X
Emerald shiner								X	X			X						
Fantail darter	X	X					X						X		X		X	
Flathead catfish			X		X			X	X								X	
Freckled madtom								X			X							
Freshwater drum					X	X	X		X									
Gizzard shad					X	X	X		X	X	X	X						
Golden redhorse													X			X		
Golden shiner	X																	X
Green sunfish		X	X	X			X		X	X	X	X	X	X	X	X	X	X
Greenside darter		X						X	X		X				X	X	X	
Hornyhead chub		X																
Largemouth bass	X	X			X	X			X	X			X			X		X
Logperch	X	X			X							X	X		X	X	X	X
Longear sunfish	X	X			X								X		X	X	X	
Longnose gar			X	X							X							
Mosquitofish	X	X		X		X	X	X	X	X	X	X				X	X	
Orangespotted sunfish	X	X													X			
Orangethroat darter		X	X	X			X	X	X	X	X	X	X	X	X	X	X	
Quillback																	X	
Red shiner	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Redear sunfish													X					
Redfin shiner	X	X	X	X										X	X	X	X	X
River redhorse		X																
Sand shiner		X							X						X	X	X	
Slender madtom	X	X											X	X	X	X		
Slenderhead darter		X			X			X	X		X	X					X	
Smallmouth buffalo				X		X					X							
Spotted bass	X	X	X										X	X	X			X
Stonecat		X	X					X	X		X	X	X		X	X	X	
Suckermouth minnow									X									
Warmouth																		X
White crappie	X		X		X				X								X	X
White sucker																		X
Yellow bullhead			X	X									X	X	X			X
Richness	17	26	13	12	14	7	11	12	19	10	18	14	18	13	20	18	20	16

S1 - S6 = US Environmental Protection Agency Region 7 monitoring sites (1998)
M1 - M6, WO, MC, PA, D1, D2, LD = Pittsburg State University monitoring sites (1998)

Tributary Streams
WO - Wolfpen Creek, Bourbon County KS
MC - Mill Creek, Bourbon County KS
PA - Paint Creek, Bourbon County KS
D1 - Drywood Creek, Barton County MO
D2 - Drywood Creek, Vernon County MO
LD - Little Drywood Creek, Barton County MO