Appendix H to the Cypress Creek Planning Agency / Clean Rivers Program FY 2004/2005 QAPP

Tankersley Creek Bacterial Source Tracking Special Study Cypress Creek Basin FY2004-2005

Prepared for

Northeast Texas Municipal Water District
P.O. Box 955
Hughes Springs, TX

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By

Paul Price Associates, Inc.
3006 Bee Cave Road, Suite D-230
Austin, Texas 78746

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1.0 INTRODUCTION

In 2000, Tankersley Creek was placed on the Texas Commission on Environmental Quality's (TCEQ's) 303(d) list of waters not meeting their water quality standard. Tankersley Creek was listed for exceeding indicator bacteria levels established for safe contact recreation, and remained on the 2002 303(d) list due to insufficient bacteriological data. A 12-month special study of the bacteriological water quality on the upper Big Cypress Creek and two major tributaries, Tankersley and Hart Creeks was conducted during FY2003 to determine if the impairment was warranted. The study was initiated and the sites monitored under dry and wet weather conditions with the goal of obtaining a broader assessment of the bacterial water quality conditions in the two primary streams draining the Mount Pleasant, Texas are, and of the reach of Big Cypress Creek receiving that drainage. The results of this special study supported the 2002 303(d) listing of Tankersley Creek but did not determine the possible sources.

The Tankersley Creek Bacterial Source Tracking Special Study was initiated in order to: 1) determine the extent of bacterial abundance and evaluate potential impairment throughout the Tankersley Creek Watershed, including Tankersley Lake, Tankersley Creek and Dragoo Creek; 2) identify the hydrologic conditions associated with events of elevated levels of detected bacteria; 3) determine the relation between land use and *E. coli* concentration; and 4) continue the examination of the relationship of Fecal Coliform and *E. coli* results. *E. coli* samples were collected monthly at twelve stations, of which six were historical TCEQ monitoring stations. Fecal coliform bacteria were also collected monthly at these same six sites given that historical data was available for use in comparison and evaluation.

Sample station locations were based on criteria which included sites with road accessibility, sites near industrial or domestic discharges and areas that may potentially receive high non-point source loads. Potential bacterial contamination to rural and urban waterways can come from the wastes of any warm-blooded animal, including humans, grazing animals including cattle and horses, chickens, hogs, and many other animals including wildlife. Human wastes can enter water from poorly operating septic systems, sewage overflows during storm events resulting in improperly treated sewage, leaking sewage pipes, illegal sewage connections, discharges from boats, and improperly treated sewage sludge used for land application. Livestock or chicken manure that reaches ditches or streams will usually lead to high levels of *E. coli*. Manure storages or lagoons that are improperly sited or constructed may leak, contaminating surrounding water. Contamination may result from land application of animal wastes. When heavy rainfall follows an application, or where manure is applied to saturated land surfaces, applied in large quantities, or applied too near a stream, runoff can carry manure into a nearby stream. Wildlife can be a significant contributor in some areas, especially where there are few people, and low livestock or poultry activity. The most direct contributors are waterfowl, although deer, raccoons, and other wildlife living anywhere in the watershed can contribute to bacteria levels in streams. In urban areas, pet wastes can be washed off streets and other impervious surfaces and flow through storm drains directly to lakes and streams.

Water quality monitoring, storm runoff studies, and modeling results which were part of the Lake O' the Pines TMDL program have shown that poultry production, processing, and waste disposal are a source of significant contribution to the nutrient load currently entering Big Cypress Creek from both point and nonpoint sources. Operation of production facilities, particularly the use of poultry litter as fertilizer on pasturelands, may contribute excess nitrogen, phosphorus, oxygen demanding organic matter, and possibly other materials to surface waters. Discharge of treated wastewater from poultry processing facilities under current permit conditions is contributing substantial amounts of nutrients to Big Cypress Creek (Segment 0404) and Lake O' the Pines (Segment 0403). Although differences in single nutrient or dissolved oxygen parameters are seldom statistically significant when comparing streams, those draining watersheds having higher levels of poultry production activity tend to exhibit sets of parameter results consistent with elevated nutrient and oxygen demand loadings (Paul Price Associates, Inc., 2001). Storm-generated surface runoff was shown to be the primary route through which nitrogen and phosphorus (and other pollutants) enter Lake O' the Pines at the bottom of this impaired watershed (Paul Price Associates, Inc., 2003).

There is only one major point source discharge found within the Tankersley Creek watershed. The Southwest Wastewater Treatment Plant (TPDES Permit No. 03017-004 and EPA ID# TX00629361) is located southwest of the City of Mount Pleasant on the north side at FM 127 and approximately 500 feet east of Tankersley Creek. The facility is authorized to treat and dispose of 3,000,000 gallons per day of industrial and domestic wastewater into Tankersley Creek. An additional key objective of the bacterial monitoring study was to begin delineating the importance of potential contributory sources found upstream and downstream of this permitted discharge facility. Another permitted discharger is located near Tankersley Creek north of FM 1734 approximately 0.8 miles upstream from the upper end of Tankersley Lake. TXU Mining Company (TPDES Permit No. 03174-002 and EPA ID# TX0068357) is authorized to treat and dispose of mining effluent from lignite mines located north of IH30 at variable flow rates into a tributary of Tankersley Creek.

Monthly sampling over a 12-month period was conducted at all the special study stations in order to account for changes in variables such as season, temperature and flow. A total of twelve sample locations were selected to provide information on the relative importance of urban/rural sources with the presence of central wastewater collection and treatment facilities (Figure 1-1). This special study was designed to include a large number of site sampling locations to obtain results that are representative of the upper, middle and lower reaches of the Tankersley Creek Watershed. Sampling for this study began on 26 May 2004 and concluded on 26 April 2005.

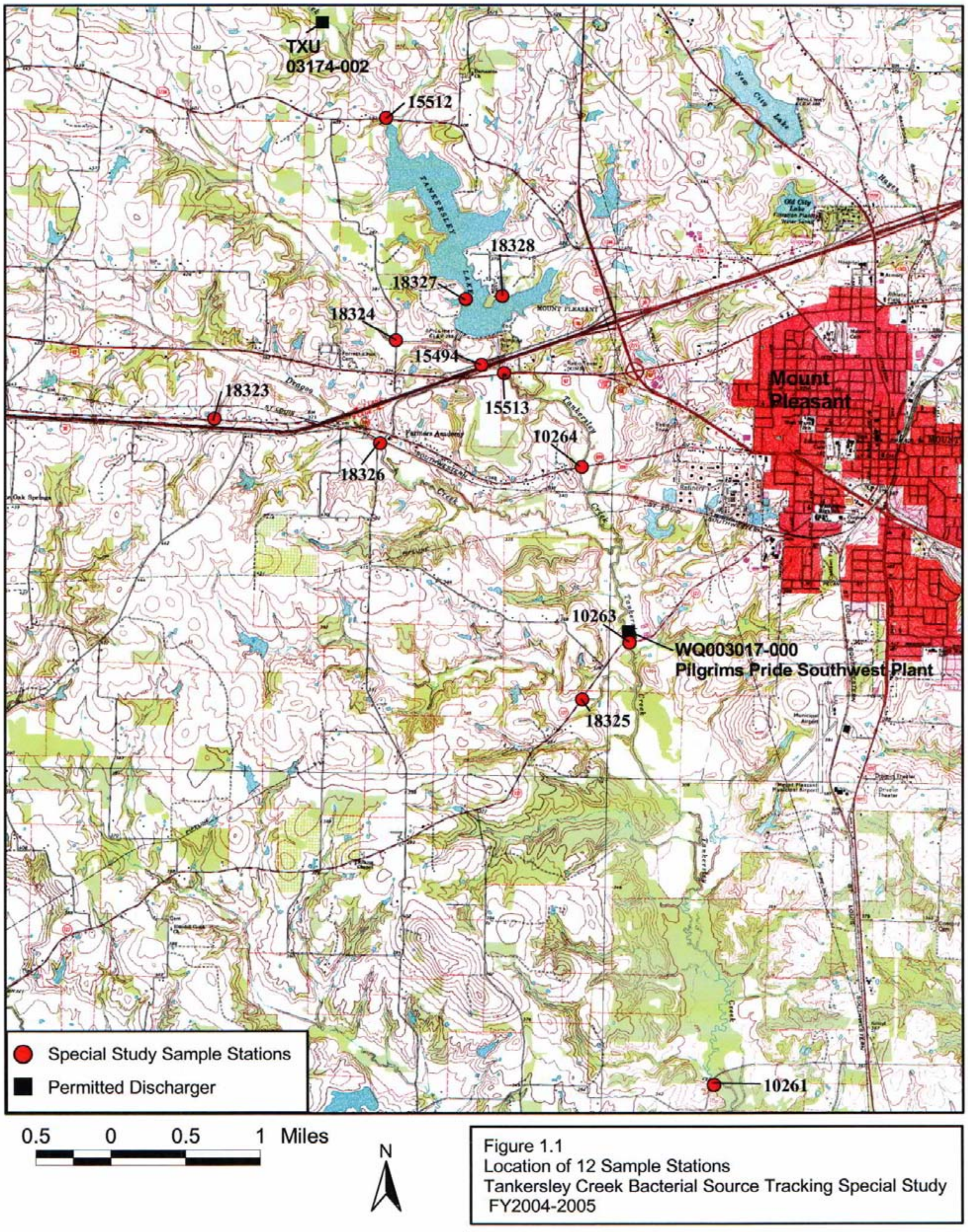

Figure 1.1
Location of 12 Sample Stations
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

2.0 MATERIALS AND METHODS

All instrument calibration, field measurements, sample collection, preservation and transportation, bacteria analysis, data archiving, and quality assurance was performed according to procedures outlined in the FY 2004-2005 Basin wide Quality Assurance Project Plan (QAPP) and Appendix H to the FY2004-2005 QAPP developed for the Cypress Creek Basin Clean Rivers Program (CRP). This QAPP and Appendix incorporates the standards and procedures of the CRP *Program Guidance & Reference Guide FY 2004-2005* (and Appendices) and the 2003 Texas Commission on Environmental Quality (TCEQ) *Surface Water Quality Monitoring Procedures Manual, Volume 1* (RG-415).

2.1 GENERAL DESCRIPTION OF MONITORING LOCATIONS

The Tankersley Creek Watershed is situated in the upper, western portion of the Cypress Creek Basin in a transitional zone (ecotone) between the eastern pine forests and the oak-hickory forest of the post oak woodlands to the west; in respectively the South and East Central Texas Plains Ecoregions (Ecoregions 33 and 35) (Omernik, 1987). Although post oak and blackjack oak constitute the dominant climax overstory vegetation in the western portion of the Cypress Creek Basin, loblolly and shortleaf pine are also common. Bottomland forest is the most mesic (wettest) forested habitat in eastern Texas. It is typically dominated by a dense overstory comprised of water oak, willow oak, sweet gum, black gum and birch. The two major vegetational areas corresponding to the South and East Central Texas Plains Ecoregions are the post oak savanna and the pineywoods.

The aquatic habitats of the study area consisted of intermittent and perennial streams. Most of these are small, meandering streams with abundant cover typically vegetated with mixed hardwoods; unstable banks covered with light to moderate ground cover, streambeds characterized by fine-grained clayey and sandy substrata that show only a small amount of riffle development. Although small amounts of gravel, cobble and large rock were observed in some locations, hard rocky substrates do not appear to be of importance in this watershed. Typically, all creek drainages traverse a landscape dominated by pastureland, although the streams generally exhibit a woody riparian border. Habitat differences within the area sampled were due to factors such as channel morphology, presence of leafy detritus or other organic debris, rooted aquatic vegetation and degree of shading of the channel by riparian forest canopy.

Tankersley Creek, designated as assessment unit 0404b, is an unclassified freshwater stream in the Cypress Creek Basin that extends 8 miles from its confluence with Big Cypress Creek to the upstream perennial portion of the stream northwest of Mount Pleasant in Titus County, Texas (Figure 2-1). Tankersley Creek, the major tributary to Big Cypress Creek in the study area, is composed of slow-flowing pool and glide areas upstream of the Southwest Wastewater Treatment Plant (SWTP). Dragoo Creek is the primary contributor of local surface inflow and enters Tankersley Creek from the west approximately 0.7 mile upstream of the SWTP. Stream flow in Tankersley Creek increases downstream of the SWTP as a result of the variable daily volumes of wastewater discharged just upstream of the FM 127 road crossing.

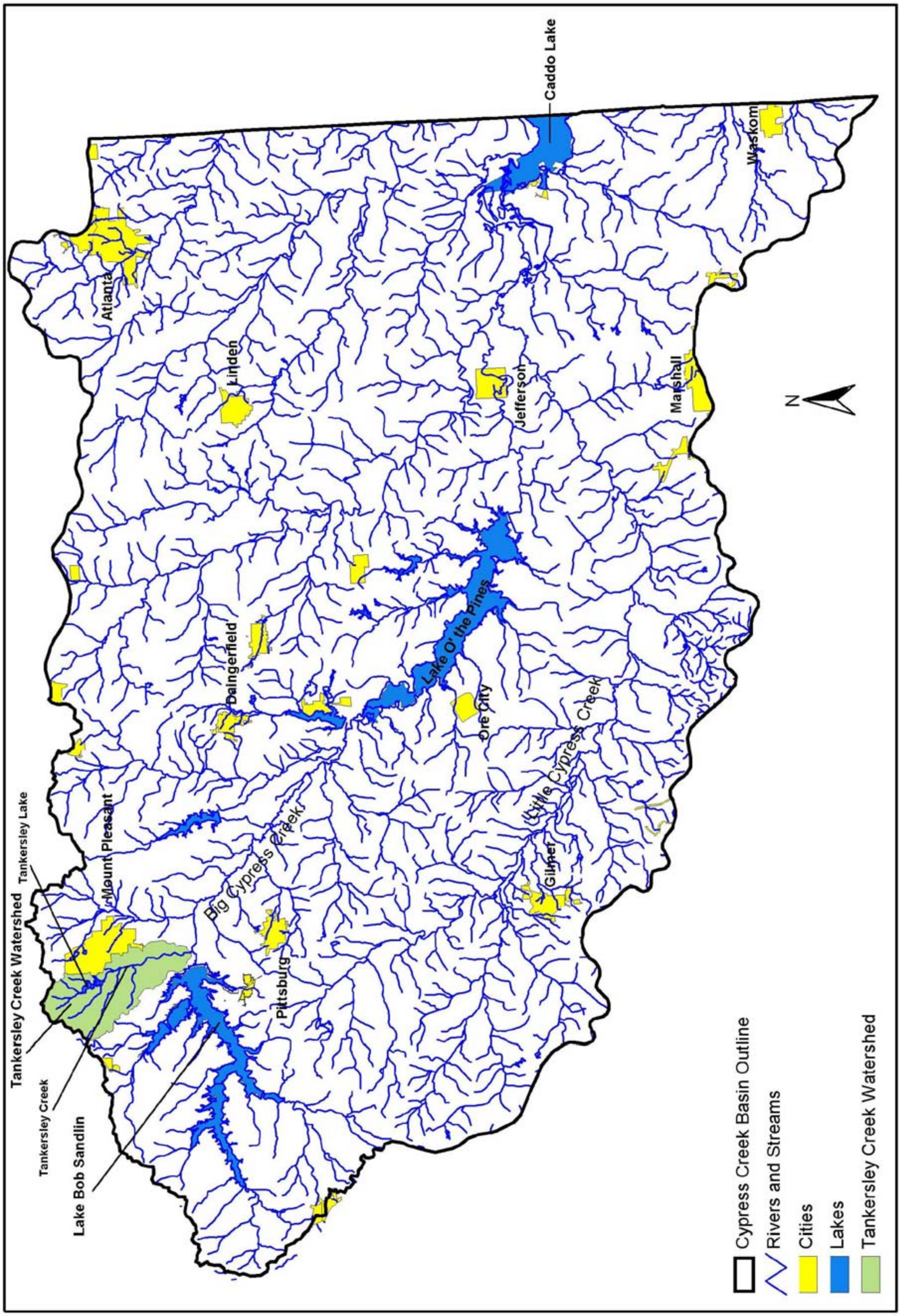

Figure 2-1
Location of the Tankersley Creek Watershed
in the Cypress Creek Basin

2.2 FIELD AND BACTERIAL MONITORING

Field books containing field data collection forms were provided to the field crews for field data recording and record keeping. Entries into the field books included sample date, start time, weather conditions, field personnel present, all field measurements, observations and any other information pertinent to the specific field activity.

Field measurements were monitored for parameters summarized below in Table 2-1 to record seasonal hydrologic and water quality variability concurrent to monthly bacteria sampling. Monthly field data, instantaneous stream flow data and *E. coli* were collected from the twelve locations summarized in Table 2-2. Fecal coliform samples were also collected concurrent with the aforementioned monthly water quality parameters from the six TCEQ historical monitoring sites at stations 10261, 10263, 10264, 15512, 15513 and 15494. The data collection frequency of field and laboratory information collected for the twelve stations monitored during the 12-month period is listed in Table 2-2.

Field measurements of water temperature, dissolved oxygen (DO), conductivity, and pH readings were obtained with a Yellow Springs Instrument (YSI) 610 DM/600 XLM Minilogger. Each YSI data sonde was calibrated according to the TCEQ and manufacturer's recommendations prior to station visits and post-calibrated upon return to the office. Transparency was measured with a 20-cm diameter black-and-white Secchi disc. Cross-sectional flow measurements were taken only during wadeable conditions at most creek stations during each of the twelve surveys to determine stream discharge in cubic feet per second (cfs). The average velocity (ft/s) was determined with a Marsh-McBirney Model 2000 Flo-Mate portable velocity meter and top-setting wading rod. Stream flow discharge in cubic feet per second (ft^3/s) was calculated by multiplying the section width by the section depth (ft^2) by the velocity (f/s).

Table 2-1
Tankersley Creek Monitoring Parameters.

Field Parameters	**Storet Code**
Temperature (°C)	00010
Dissolved Oxygen (mg/l)	00300
Conductivity (uS/cm)	00094
pH (s.u.)	00400
Secchi Depth (m)	00078
Flow (cf/s)	00061
Flow Severity	01351
Flow Measurement Method	89835
Days Since Last Rainfall	72053
Bacteriological Parameters	
Fecal Coliform (org/100mL)	31616
E. coli, IDEXX Colilert (MPN/100mL)	31699

Table 2-2

Tankersley Creek Monthly Event Sample Collection
Fiscal Year 2004-2005

TCEQ Station ID	Site Description	Prog. Code *	SC1/SC2 **	*E. coli* Bacteria	Fecal Coliform Bacteria	Rainfall[1]	Flow Severity	Field[2]	Instant .Flow
10261	Tankersley Creek at FM 3417	SS	NT/CL	12	12	12	12	12	12
10263	Tankersley Creek at FM 127	SS	NT/CL	12	12	12	12	12	12
10264	Tankersley Creek at FM 899	SS	NT/CL	12	12	12	12	12	12
15512	Tankersley Creek at FM 1734	SS	NT/CL	12	12	12	12	12	12
15513	Tankersley Creek at U.S. Hwy 67	SS	NT/CL	12	12	12	12	12	12
15494	Tankersley Creek at Tankersley Road	SS	NT/CL	12	12	12	12	12	12
18323	Unnamed Tributary of Dragoo Creek at IH-30 north frontage road	SS	NT/CL	12	--	12	12	12	12
18324	Unnamed Tributary of Tankersley Creek at Titus CR 1030	SS	NT/CL	12	--	12	12	12	12
18325	Unnamed Tributary of Tankersley Creek at FM 127	SS	NT/CL	12	--	12	12	12	12
18326	Dragoo Creek at Titus CR 2400	SS	NT/CL	12	--	12	12	12	12
18327	Tankersley Lake 360m N and 295 m W of Dam outlet to Tankersley Creek	SS	NT/CL	12	--	12	N/A	12	N/A
18328	Tankersley Lake 390m N and 95m E of Dam outlet to Tankersley Creek	SS	NT/CL	12	--	12	N/A	12	N/A

*The type of sampling being reported (SS=Special Study)
**SC1 is the entity responsible for the basin QAPP (NT= Northeast Texas Municipal Water District); SC2 is the entity collecting the samples (CL = Caddo Lake Institute).
[1]Days since last significant rainfall
[2]Field = Water temperature, dissolved oxygen, conductivity, pH, Secchi depth, and observations

Sterile, styrene 120 and 250 ml Colilert sample bottles purchased from IDEXX Laboratories, Inc. were used for *E. coli* and fecal coliform analysis. The larger container was used for the collection of field splits. Special care was taken to assure that the containers were clean (sterile and posed no threat of contamination to the bacteria samples. All presterilized Colilert plastic bottles used had a clear seal over its cap and contained sodium thiosulfate ($Na_2S_2O_3$) to neutralize the effect of any chlorine present. Any sample bottle whose seal was broken was immediately discarded.

For sampling purposes, the seal and cap were removed being careful not to touch the inside of the cap or bottle. At each creek location, *E coli* samples were taken by holding the sample bottle near the base and dipping it, neck downward, below the water surface. The bottle was turned slightly upward and towards the stream current. During the sampling process, the field collector avoided contact with the inside of the container to prevent contamination and made sure the sample was free from any uncharacteristic floating debris. All samples were stored on ice in a cooler and processed within 6 hours. Fecal coliform sample collection from the six Tankersley Creek locations also followed the same protocol.

The bottles were capped tightly and the samples were placed in a pre-cooled ice chest immediately after collection in order for the sample to quickly chill to a temperature of 4°C. Samples were kept on ice during transportation up to the point of delivery and exchange at the East Texas Baptist University (ETBU) laboratory. All samples met the 8-hour holding time criteria necessary to be considered valid.

2.3 SAMPLE ANALYSIS

Two methods of bacteria sample analysis were utilized in this Special Study effort. The membrane filtration technique was used for the determination of fecal coliform bacteria and the Colilert Quanti-Tray Method was used in the determination of *Escherichia coli* (*E. coli*). Each method requires the collection of a separate 100-milliliter (ml) sample of water. In the laboratory, a predetermined portion of water from each sample bottle was taken to incubate and then observed for the presence of the appropriate bacterial organism. Laboratory blank samples were prepared and analyzed for each indicator bacteria set taken during each monthly collection effort. These blank samples are intended to be free of organisms of interest.

For each fecal coliform sample collected, two different volumes of water were filtered. The filter was pre-rinsed with sterile distilled water, the sample was filtered, and the filtration funnel was rinsed with approximately 25 ml of sterile distilled water. Following the filtration, the membrane filter was transferred to a Petri dish with a paper disk saturated with sterile m-FC media. The dishes were incubated in an inverted position for 24 hours in an incubator at 44.5°C. Following incubation of each plate, the number of positive colonies was recorded and the number of colonies per 100 ml calculated. One laboratory quality control sample was run for each sampling event up to 9 samples. If ten or more samples were collected during the sampling event, two laboratory duplicates were run. Each laboratory duplicate container was clearly identified as a duplicate on the bacteriological log sheets. A laboratory blank was also prepared during each collection date by filling a sterile plastic bottle with reagent-grade water from the laboratory and incubated as described above.

The bacteria analysis for *E. coli* is an enzyme substrate method called Colilert that is analogous to the commonly used multiple tube method. In the laboratory, creek samples were diluted by adding an aliquot of sample to sterile deionized/distilled (DI) water in the sterile Colilert plastic bottle to produce 100 ml of liquid. A pre-packaged container of powdered Colilert reagent (Colilert-18) from IDEXX Corporation was added to each bottle. After the reagent was dissolved in the sample, the contents of each bottle were added to a Quanti-tray, a sterile disposable plastic tray containing 97 wells. Each Quanti-tray was mechanically sealed ensuring the sample was distributed uniformly into the wells. Each Quanti-tray was incubated for 18 hours at 35.0°C ± 0.5°C. Fluorescing (positive) wells were counted under a long-wave ultraviolet (UV) light. The number of positive wells were converted to a most probable number (MPN) value based on the dilution factor and manufacturer-supplied MPN tables. As described above for fecal sample analysis, a laboratory blank was analyzed to test for bias that could result in contamination of samples during any stage of laboratory processing and analysis.

For laboratory duplicate analysis of *E coli*, a 100 ml sample was chosen at random and split into two equal sample test volumes of 50 ml and diluted with 50 ml of sterile non-buffered deionized water to a 100 ml total volume. Sample dilutions did, however, vary by sample date. Sample dilution for *E. coli* followed guidelines as outlined in the "*E. coli Colilert® Quanti-tray® 2002 Method Standard Operating Procedure (Revised 9/28/01) and "Laboratory Quality Assurance Guidance for Colilert®/Enterolert® Analysis Under the Clean Rivers Program (Revised 10/4/01)* provided by the TCEQ.

2.4 CHAIN-OF-CUSTODY RECORDS

Chain-of-custody procedures were established to ensure sample integrity. The sample custody was properly documented to provide a mechanism for tracking each bacteria sample submitted to the ETBU laboratory for *E. coli* and fecal coliform analysis. Sample chain-of-custody protocol was maintained through the receipt of the sample containers, sample collection, transfer between personnel, shipment to the ETBU laboratory and final disposal of the sample. The ETBU custodian examined all arriving samples for proper documentation to determine whether or not the samples met the holding time constraints as specified in the *E. coli* Colilert® Quanti-Tray® 2000 Method Standard Operating Procedure revised on 09/02/04 (i.e., arrive at the laboratory within 6-hours of collection; process sample 2 hours within arriving at the laboratory). The ETBU custodian accepted delivery of valid samples only by signing the final portion of the chain-of-custody form and retained the original copy. The ETBU custodian monitored the progress of the samples through the analysis stage.

3.0 RESULTS

Appendix A presents the complete results of the monthly sampling efforts conducted May 2004 through April 2005 to monitor the abundance and distribution of bacteria that indicate the presence of fecal material originating from warm-blooded animals and birds at twelve locations within the Tankersley Creek watershed. Table 3-1 presents the average values and ranges (minimum-maximum) for water quality parameters measured at the study stations. The station parameter data columns are listed from left to right, with the most downstream station (Station 10261; Tankersley Creek at FM 3417) on the left and the most upstream location (Station 15512; Tankersley Creek at FM 1734) on the right. The mainstream Tankersley Creek station results are those found in the gray shaded columns. Figure 3-1 presents a schematic diagram of the watershed that illustrates the sample location orientation from the headwater reaches to its confluence with Big Cypress Creek. Tributary data is placed to reflect the location of the tributary confluence with Tankersley Creek. Stations 18327 and 18328 are located in Tankersley Lake.

All stations are similar with respect to temperature averages and ranges, high turbidity (low clarity) and in exhibiting consistently high levels of dissolved oxygen throughout the study. Conductivity, a measure of the quantity of dissolved salts present, tends to increase in a downstream direction, particularly below the confluence of Dragoo Creek and the outfall of the Southwest Wastewater Treatment Plant (SWTP). The stream stations all tended to exhibit slightly acid water (below pH 7.0) while Tankersley Lake waters tended to be slightly alkaline, reflecting the shift from the heterotrophic metabolism of the streams to the autotrophic regime of

Table 3-1
Average and (Range) of Concentrations of Water Quality Parameters Measured in the Study Area*

Station	10261	18325	10263	18323	18326	10264	15513	18324	15494	18327	18328	15512
Temperature (°C)	19.48	17.83	20.55	18.1	18.1	18.22	18.75	18	19.17	19.89	19.87	19.76
	(7.05-28.28)	(3.43-28.57)	(10.8-29.41)	(9.62-25.41)	(7.66-29.99)	(6.57-27.6)	(7.23-28.3)	(6.47-25.48)	(7.66-27.68)	(9.62-30.46)	(10.07-30.47)	(7.72-29.24)
Dissolved Oxygen (mg/L)	9.44	10.66	9.79	8.84	9.03	9.35	9.79	9.68	8.56	9.56	9.8	8.11
	(5.99-12.28)	(7.20-11.19)	(7.87-13.18)	(5.76-13.29)	(4.91-14.67)	(4.94-12.98)	(6.34-13.0)	(7.21-13.70)	(4.63-12.72)	(6.82-12.84)	(6.98-12.60)	(4.97-10.94)
Conductivity (mS/cm)	1155	525	1214	815	404	388	405	650	452	210	209	251
	(572-1789)	(250-879)	(415-2111)	(254-1557)	(311-593)	(147-644)	(220-661)	(300-1296)	(219-733)	(181-252)	(180-251)	(195-332)
pH**	(6.47-7.50)	(5.67-7.40)	(6.48-7.46)	(5.52-6.80)	(5.95-7.69)	(5.92-7.24)	(6.1-6.95)	(6.16-7.85)	(6.13-6.93)	(6.87-8.12)	(6.67-8.25)	(5.97-6.92)
Secchi Depth (m)	0.49	0.43	0.74	0.49	0.47	0.51	0.48	0.56	0.41	0.77	0.69	0.75
	(0.24-0.76)	(0.18-1.07)	(0.05-1.40)	(0.20-0.77)	(0.11-1.40)	(0.12-1.30)	(0.25-0.80)	(0.10-0.98)	(0.20-0.69)	(0.47-0.86)	(0.37-0.84)	(0.42-1.50)

* The mainstream Tankersley Creek station results are those found in the gray shaded columns
**pH values were not averaged

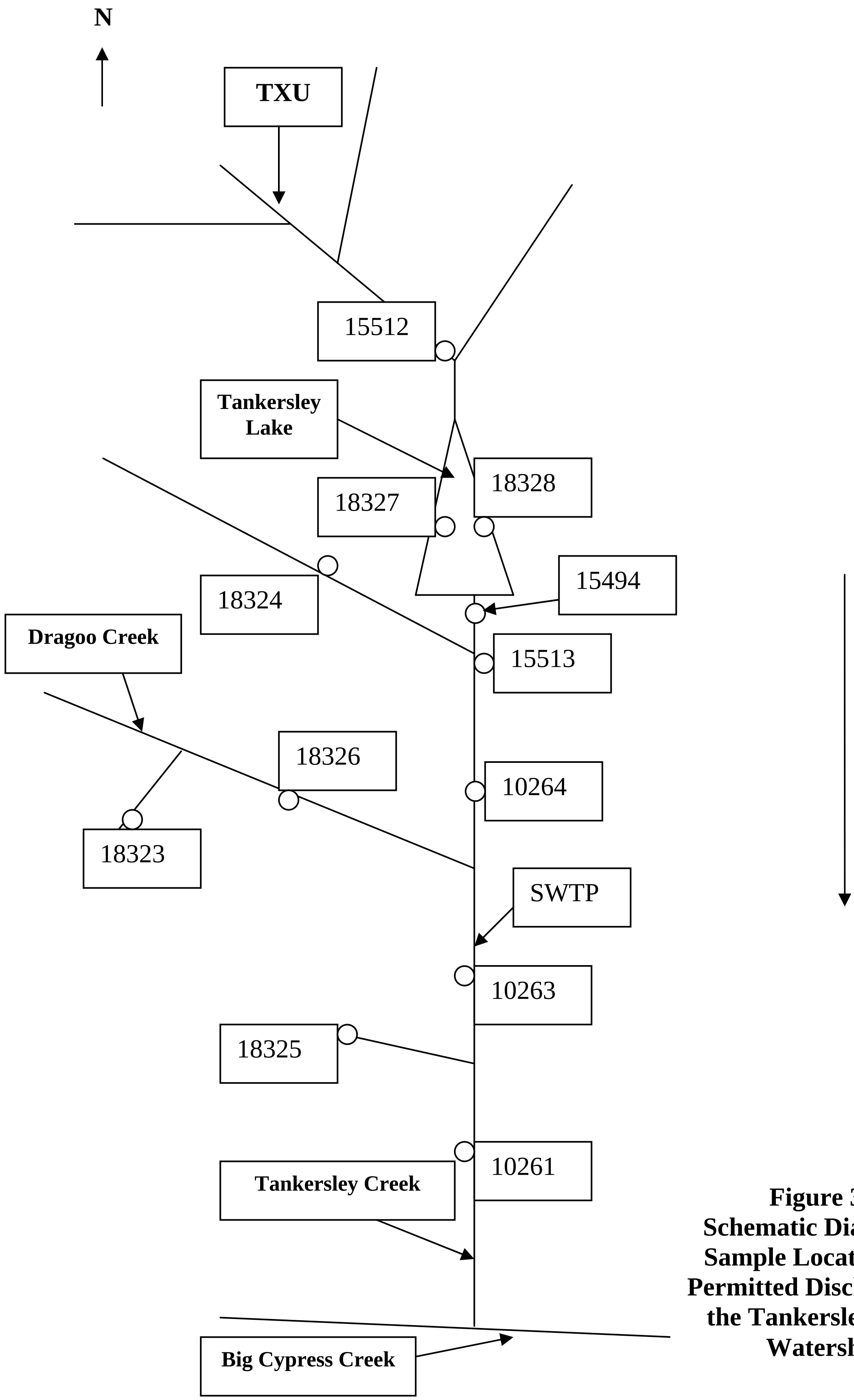

Figure 3-1
Schematic Diagram of Sample Locations and Permitted Dischargers in the Tankersley Creek Watershed

the reservoir where photosynthetic consumption of carbon dioxide and production of oxygen tends to raise the pH..

Comparison of the *E. coli* and fecal coliform results from the long-term sampling stations is summarized in Table 3-2 for a data set in which data pairs with a missing value were eliminated and censored values were entered as the detection limit. The *E. coli* results exhibit a wider range of numerical values and a correspondingly larger standard deviation reflecting the greater variability of that data. The differences in bacterial abundances observed between paired sample sets is both large (in Table 3-2 the geometric mean fecal coliform abundance is only 47% of the comparable *E. coli* value) and significant ($P< 0.001$, paired sample t-test). Figure 3-2 is a graph of this data set, showing the results to be moderately well correlated (Pearson Correlation coefficient 0.849). The results presented in the December, 2003 Tankersley Creek Study were similar; the fecal coliform geometric mean was 55% of the *E. coli* value and a similar level of correlation between the two measures was observed.

Table 3-3 shows the *E. coli* results from samples collected from the 12 stations employed in this study. Table entries in bold type are instances where the single value criterion for *E. coli* abundance (394/100 ml) was not met. Substantial differences in abundance are evident among both stations and sampling period. There is a strong tendency for bacterial abundance to increase in the downstream direction, and all stations except the two Tankersley Lake stations (18327 and 18328) and the uppermost stream station (15512) exhibited geometric mean *E. coli* abundances that exceed the long-term average criterion for protection of contact recreation. The Friedman Nonparametric Two-way analysis of variance (AOV) indicated significant ($P<0.05$) differences among both stations and sampling periods, but no pairwise comparison methods are available to follow this method. Application of the Kruskal-Wallace One-Way AOV provides the same result, and the associated pairwise comparison of means (a nonparametric analog of the Bonferroni Test) showed that *E. coli* abundance was significantly ($P<0.01$) less at Stations 18327 and 18328 in Tankersley Lake than at most of the remaining stations. Of the stream sampling locations, Station 15512, which receives runoff water from TXU mine areas north of IH30, is least contaminated and *E. coli* abundances there are not significantly different than either Tankersley Lake Station. Additionally, *E. coli* results from Stations 10264, 15494 and 15513 are not significantly different from those of Station 18327. Much of watershed above Station 15512 is mined land in some stage of reclamation, and may be used for pasture, but this portion of the watershed does not include significant areas of intensive agriculture or residential land use. Relative to streams, lake environments typically exhibit elevated levels of coliform organisms only briefly following runoff events, and decline rapidly as they settle out of the water column with other particulate material. Viable populations of these bacteria generally do persist, and may reproduce, in association with sediments and aquatic vegetation where they may be resuspended by streamflow or by disturbance during sampling.

Since the number of days since the last rainfall prior to sampling was the same for all stations on each of the 12 sampling dates, the prevalence of high or low values during certain sample periods could be a result of recent rainfall and surface runoff, or be a seasonal effect. Statistically significant ($P<0.05$) differences in *E. coli* abundance are present among sample periods and among “days since last rainfall” (Kruskal-Wallace One-Way AOV). Pairwise comparisons of all station means indicates that *E. coli* sampled zero “days since last rain” was significantly different from abundances on days 2, 3,5,7,9 and 10. The same test showed that neither measured streamflow nor flow severity were significantly ($P>0.05$) related to *E. coli*

Table 3-2
Comparative Bacterial Sampling Summary Statistics

	E. coli	**Fecal Coliform**
N	59	59
Average	490	178
Geometric Mean*	168	79
Median	163	85
Minimum	4	3
Maximum	4838	2222
Standard Deviation	925	315

*Used to evaluate recreation standard

Figure 3-2
Paired Fecal coliform - E. coli Samples

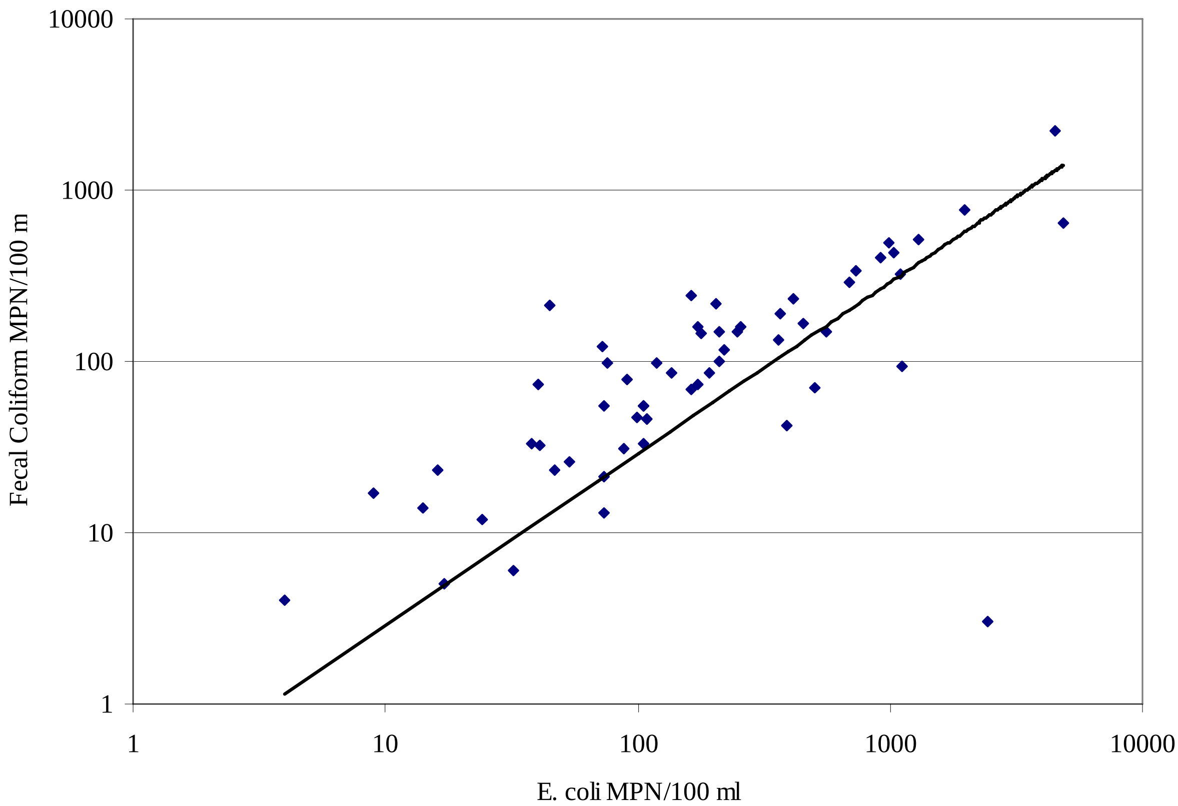

Table 3-3

Abundance (MPN/100 ml) of *E. coli* Collected from the Tankersley Creek Watershed during FY2004-2005*

Stations Date Collected	**10261**	**18325**	**10263**	**18326**	**18323**	**10264**	**15513**	**18324**	**15494**	**18327**	**18328**	**15512**
05/26/04	255	**953**	106	**782**	**717**	137	362	**484**	**690**	4	4	4
06/21/04	163	91	**504**	74	**870**	91	72	109	76	29	12.6	17
07/19-20/04	166	249	73	111	56	22	33	276	112	2	1	11
08/25/04	205	17	**1120**	**958**	43	41	387	9	45	3	1.5	54
09/21/04	365	67	162	53	79	106	38	**613**	172	2	1	16
10/27/04	250	**629**	**984**	261	**2419**	106	9	21	172	1	1	40
11/30/04	**2419**	**2419**	**1986**	**748**	**1414**	**4538**	**922**	190	**555**	10	10.4	47
12/20/04	88	280	73	358	215	74	99	60	108	1	4.1	24
01/20/05	**415**	325	**451**	132	20	192	73	152	108	15	24	32
02/22/05	219	**1226**	118	324	26	209	179	**690**	209	6	6	14
03/29/05	**3539**	**1298**	**821**	115	156	**1226**	**977**	**2713**	**1095**	126	54	**560**
04/26/05	**1034**	**4838**	**4838**	**4838**	**4838**	**4834**	**1298**	**4838**	**731**	**411**	14	**1095**
Geometric Mean (126/100mL)	380	415	408	301	239	216	154	234	212	8	5	38
#>394 (single grab)	4	6	7	4	5	3	3	5	4	1	0	2

↑ unnamed tributary ↑ Dragoo Creek ↑ unnamed tributary ↑ Tankersley Lake

downstream ⟶ upstream

* The mainstream Tankersley Creek station results are those found in the gray shaded columns

Bold numbers exceed the single grab criterion of 394 MPN/100ml abundance. Although an unweighted “Least Significant Difference” regression of the number of days since last rainfall on *E. coli* abundance was significant ($P<0.001$), it was a relatively poor predictor of bacterial abundance ($R^2=0.1507$). *E. coli* abundance is better predicted by the “number of days since last rainfall” parameter ($P<0.05$, adjusted R^2 of 0.2579) when *E. coli* abundances were averaged over all stations for each sample period and those statistics used in the same regression analysis. This result suggests that much of the variation among stations is random, since consistent differences among stations should tend to obscure the “number of days since last rainfall”-*E. coli* abundance relationship.

Figure 3-3 is a plot of *E. coli* results against the number of days since last rainfall during the current study period. These are similar to the results presented in the December 2003 study of Tankersley and Hart Creeks, shown in Figure 3-4, illustrating that the highest E coli abundances occur during and immediately after rainfall when surface runoff delivers accumulated fecal material to the waterways. However, the figures also show substantial bacterial levels to be present at some locations when there was no recent surface runoff. Regional streams, up to and including Big Cypress Creek, tend to be intermittent, and following a rainfall/runoff will experience a “baseflow” period during which streamflow more or less slowly declines, maintained by groundwater seepage, followed by periods in which the stream is reduced to a series of isolated pools. Since bacteria are no longer being delivered to the stream in surface runoff, their persistence in the water indicates that there must be other sources.

Table 3-4 lists *E. coli* abundance in samples collected five or more days following rainfall, presumably during baseflow periods or pooled conditions. Even without surface runoff, half of the sample stations still exhibit geometric means exceeding the *E. coli* long term average criterion. The Kruskal-Wallace One-Way AOV applied to this portion of the data set also indicated significant ($P<0.05$) differences in station means, while the pairwise comparisons showed that the stream stations 10261, 18325 and 18324 had significantly higher *E. coli* numbers than did the two Tankersley Lake stations. Below Tankersley Lake, only Stations 15513 and 10264 had neither geometric mean *E. coli* greater than the 126/100 ml average criterion nor any instance of *E. coli* numbers exceeding the single sample criterion of 394/100 ml.

Figure 3-3

Decline of *E. coli* Abundance Following Rainfall-Runoff Events in the Tankersley Creek Watershed, FY2004-2005

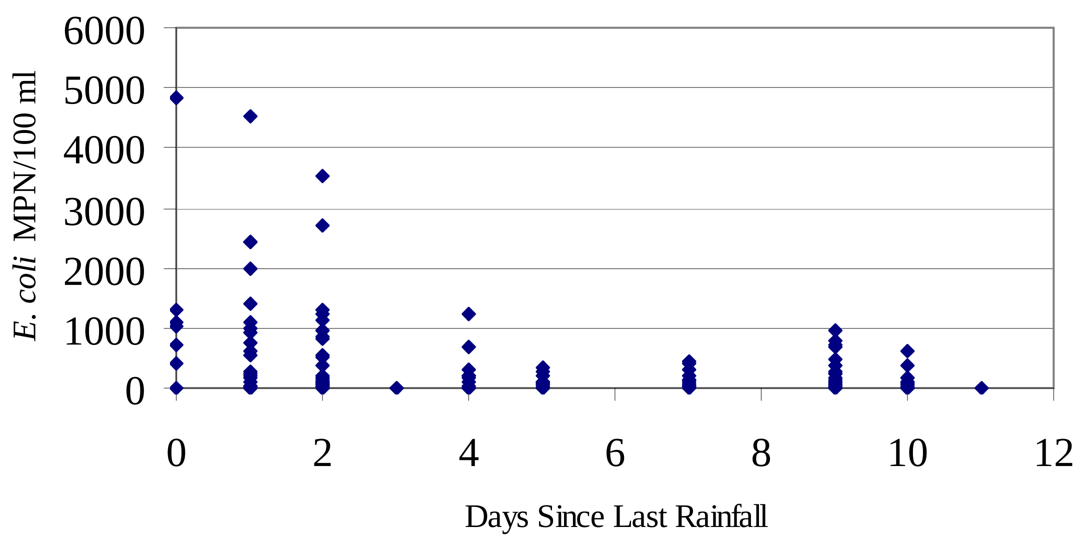

Figure 3-4

Decline of *E. coli* Abundance Following Rainfall-Runoff Events in the Big Cypress Creek Watershed in 2002-2003

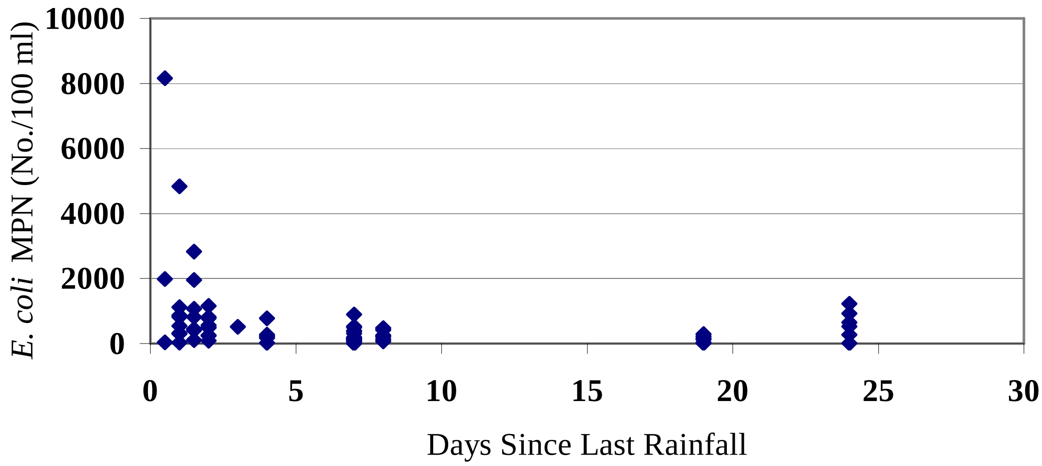

Table 3-4

Abundance (MPN/100 ml) of *E. coli* Collected from the Tankersley Creek Watershed at Least Five Days Following Rainfall*

Date	10261	18325	10263	18326	18323	10264	15513	18324	15494	18327	18328	15512
05/26/04	255	**953**	106	**782**	**717**	137	362	**484**	**690**	4	1	4
07/19-20/04	166	249	73	111	56	22	33	276	112	2	1	11
09/21/04	365	67	162	53	79	106	38	**613**	172	2	1	16
12/20/04	88	280	73	358	215	74	99	60	108	1	4	24
01/20/05	**415**	325	**451**	132	20	192	73	152	108	15	24	32
Geometric Mean (126/100 ml)	224	270	133	185	106	85	80	237	173	3	3	14

*The mainstream Tankersley Creek station results are those found in the gray shaded columns
Bold numbers exceed the single grab criterion of 394 MPN/100ml

4.0 DISCUSSION AND CONCLUSIONS

Except for Tankersley Lake and the short stream reach sampled above it, high levels of *E. coli* are present throughout the watershed. The extensive shoreline development fringing Tankersley Lake has had little apparent impact on bacterial water quality there. Below Tankersley Lake, all stations exhibited geometric mean *E. coli* numbers in excess of the criterion for protection of contact recreation (126 MPN/100 ml), while the single grab criterion was exceeded from three to seven times (Table 3-3). Station 10263, located just below the SWTP outfall, exhibited the largest proportion (7 of 12 samples) of single sample criterion exceedences. Station 18325, located on an unnamed tributary draining a small watershed west of Tankersley Creek, had the highest geometric mean concentration of *E. coli*, followed closely by stations 10263 and 10261, the lowermost station on Tankersley Creek (Figure 3-1). Stations exhibiting the next highest geometric means and the next highest proportions of single grab exceedences were located on the other two western tributary streams, Dragoo Creek (18326 and 18323) and the unnamed tributary joining Tankersley Creek just below Tankersley Lake.

Consistent with the results of the previous study, highest bacterial numbers were present during and immediately following rainfall. Although neither measured streamflow nor the more subjective “flow severity” was significantly related to *E. coli* abundance, we assume that “days following rainfall” represents the more reliable indicator of the presence of surface runoff. When only samples collected during dry weather are considered (Table 3-4), geometric mean concentrations of *E. coli* exceeded the 126 MPN/100 ml criterion in the three western tributaries and in the upper (15494) and lower-most Tankersley Creek stations (10263 and 10261). Dry weather exceedences of the single grab criterion were recorded only at the four western tributary stations and 15494 on Tankersley Creek in the May 2004 sample, at Station 18324 during September 2004, and at the two lowermost stations of Tankersley Creek (10261 and 10263) in January, 2005.

The widespread and common exceedence of the criteria for protection of contact recreation throughout the lower reach Tankersley Creek and its western tributaries represents at least a potential impairment of that use. The degree to which the contact recreation use is actually impaired depends on the suitability of the streams for contact recreation and their accessibility. These streams are too small for water skiing, boating and swimming, the channels tend to be deeply and sharply incised into the landscape, with large amounts of woody debris and turbid water; not attractive recreational qualities. While they are generally isolated in that they flow, for the most part, through private, rural property, they are nevertheless accessible at road crossings.

Figure 4-1 is a land use/cover map of the Tankersley Creek watershed, showing the overwhelming dominance of the landscape by pastureland and the rural residential areas along US 67 and FM 899**.** Those areas are drained by Dragoo Creek and the two unnamed western tributaries, and may be important sources of bacterial contamination from the high densities of livestock (e.g., horses, goats, fowl) observed there, and from on-site treatment facilities. Station 15494 occupies a reach of Tankersley Creek between Tankersley Lake dam and the confluence of the unnamed western tributary just below IH 30. North of IH 30 this stream segment lies on a landscaped property with a large house that is, or has been, used for large private events (i.e.,

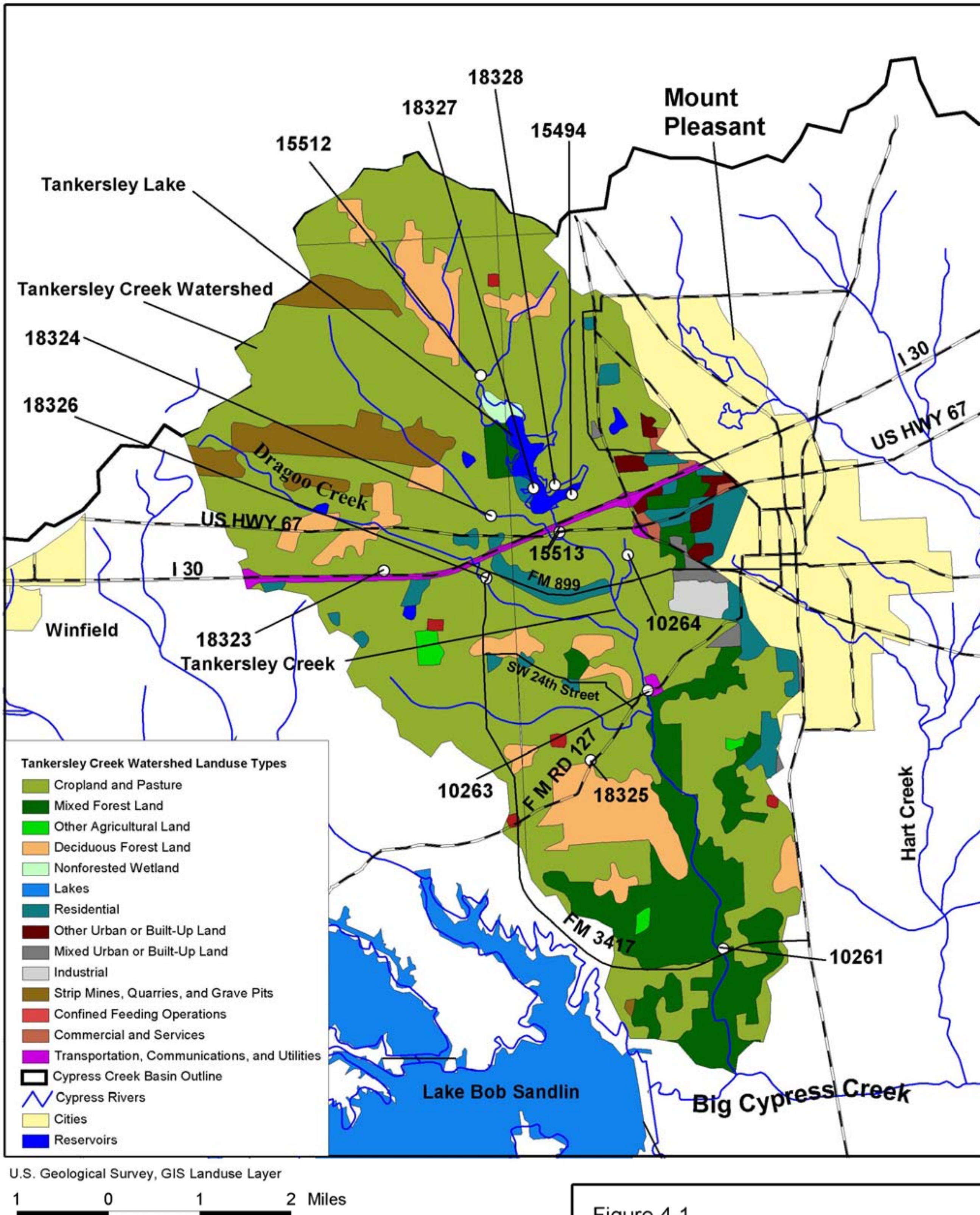

Figure 4-1
Tankersley Creek Watershed Landuse

weddings). Waterfowl have been maintained on the ponds and stream reach on this property, suggesting a potential source of *E. coli* at Station 15494.

Potential sources of enteric bacteria include wildlife, livestock (including household pets and waterfowl concentrations), improperly functioning on-site wastewater treatment systems and leaking wastewater collection lines. Treated, disinfected wastewater effluent is not a likely source of these bacteria unless overflows or bypasses occur, and high *E. coli* abundances during dry weather periods in the western tributaries and at Station 15494, locations remote from central wastewater collection and treatment facilities, suggests that wastewater line leaks are not a substantial source. The relatively low *E. coli* abundance except during some of the wet weather sample periods at Tankersley Creek Stations 15513 and 10264 seems to indicate that while urban runoff from Mount Pleasant may be a source of *E. coli*, it is not as important as the rural sources that result in contamination of the tributary streams. The most obvious potential watershed-wide source of fecal material is livestock (cattle) which we have observed to have access to the streams unlimited by anything except precipitous banks. While wildlife sources of fecal material are certainly present (raccoon tracks are ubiquitous at our sampling locations in the Cypress Creek Basin), cattle are much more abundant.

Maintenance of high bacterial abundances during periods when no surface runoff is present requires either a continuing source of fecal material, or the continuing viability of those bacteria in the stream environment. Although one reason for the preference of *E. coli* as an indicator over Fecal Coliform is that they are less likely to grow and reproduce in surface waters, they are known to persist in those environments in a viable state, usually associated with substrate particles or the biofilms present on aquatic vegetation (Rheinheimer 1991). It is possible that inclusion of particulate material in samples collected from these small, shallow streams may be inflating bacterial numbers in the dry weather samples. However, as noted above, cattle pasturage is widespread here, and we have observed numerous instances of extensive riparian use by cattle, including breakdown and erosion of stream banks and direct deposition of feces in the streams. This behavior is particularly prevalent during the hot, low flow periods that characterize summer conditions.

The higher individual values and the higher average (geometric and arithmetic) values for *E. coli* relative to Fecal Coliform results from the same collections in this and the previous special study should be compared with the results from other labs to evaluate the possibility of a systematic error in the analytic process. The large differences in the abundances of Fecal Coliform and *E. coli* observed in paired samples means that bacterial levels will be judged to exceed the criteria for the protection of contact recreation more often when the *E. coli* results are used for the evaluation than when Fecal Coliform results from the same station are used.

Further characterization of enteric bacterial sources will require the use of specific source tracking methodologies. A *Bacteroides-Prevotella*, or other assay that distinguishes between human and other animal sources would be useful in this case where there appears to be interspersion of rural and urban uses. Where human sources are not the primary problem, maintenance of riparian buffers that exclude livestock from the stream channel may offer an effective method of control. Additional identification of non-human sources is possible through the use of DNA typing, but this method is expensive in terms of both field time and lab cost and seems to be of limited utility for control of bacterial contamination. Where human sources are indicated to be the primary problem, fluorometric testing for the presence of optical brighteners may be useful in identifying leakage from on-site treatment systems and wastewater collection lines.

5.0 REFERENCES

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APPENDIX A

TANKERSLEY CREEK INDICATOR BACTERIA SPECIAL STUDY
Field and Laboratory Results by Date

TABLE 2-1

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 10261 Tankersley Creek at FM 3417											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	11:36	25.1	7.70	1789	7.30	0.53	8.51	9	255	160	Normal
6-21-04	15:45	28.28	8.41	572	7.10	0.59	39.79	2	163	68	High
7-19/20-04	07:05	26.46	5.99	1306	6.68	0.49	6.58	9	166	*	Normal
8-25-04	07:10	27.53	8.54	1740	6.55	0.51	9.26	2	205	218	Normal
9-21-04	08:00	22.6	7.29	1445	6.54	0.32	7.66	10	365	190	Normal
10-27-04	07:50	23.66	10.88	1395	7.17	0.61	8.60	1	250	149	Normal
11-30-04	07:50	13.44	10.77	810	6.47	0.24	Too deep	<1	2419	<3	High
12-20-04	08:10	7.05	12.28	890	6.87	0.62	4.59	5	88	31	Normal
1-20-05	07:50	9.88	9.94	785	7.50	0.59	14.46	7	415	230	Normal
2-22-05	08:04	17.27	8.92	1110	7.37	0.76	6.48	4	219	118	Normal
3-29-05	07:38	14.58	11.56	440	6.55	0.32	Too deep	2	3539	TNTC**	High
4-26-05	08:08	17.94	11.01	1583	6.59	0.35	18.21	0	1034	427	High
Adjacent Land Use: Pasture on both sides											
Comments: Perennial stream; *Samples collected but not analyzed due to bad media; **Too Numerous To Count											

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 10263 Tankersley Creek at FM 127

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	10:42	27.2	8.90	1764	7.10	0.99	7.81	9	106	33	Normal
6-21-04	14:37	27.9	10.46	591	6.48	0.49	12.69	2	504	70	Normal
7-19/20-04	08:04	25.21	7.87	2111	6.85	0.27	6.28	9	73	*	Normal
8-25-04	07:54	29.41	8.23	18.6	6.71	1.30	8.23	2	1120	93	Normal
9-21-04	08:50	25.26	8.54	1582	6.98	0.72	6.64	10	162	240	Normal
10-27-04	08:50	26.52	7.26	1274	7.15	1.22	10.01	1	984	493	Normal
11-30-04	08:37	14.54	11.29	836	7.00	0.24	16.74	<1	1986	760	High
12-20-04	08:50	10.77	13.18	1618	7.46	1.40	7.16	5	73	13	Normal
1-20-05	08:25	10.90	10.49	856	7.43	0.92	13.85	7	451	167	Normal
2-22-05	08:22	17.16	9.03	1157	7.42	0.95	8.78	4	118	97.5	Normal
3-29-05	08:00	15.03	12.79	415	6.64	0.33	49.66	2	821	TNTC**	High
4-26-05	08:38	16.70	9.42	504	6.63	0.05	28.33	0	>4838	637	High

Adjacent Land Use: Pasture, road right-of-way, downstream of WWTP

Comments: Perennial Stream; *Samples collected but not analyzed due to bad media; **Too Numerous To Count

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 10264 Tankersley Creek at FM 899											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	08:05	23.1	7.67	607	6.52	0.40	0.09	9	137	85	Low Flow
6-21-04	12:33	27.6	8.80	223	6.38	0.65	11.31	2	91	78	High
7-19/20-04	09:47	25.55	4.94	501	6.46	0.24	0.09	9	22	*	Low Flow
8-25-04	09:43	25.71	6.09	644	6.34	1.30	0.10	2	41	32	Low
9-21-04	10:44	22.92	6.39	340	6.40	0.5	0.32	10	106	55	Normal
10-27-04	10:08	22.41	12.30	417	6.12	0.36	0.14	1	106	55	Low Flow
11-30-04	09:45	10.72	11.83	147	5.92	0.28	6.59	<1	4538	2220	High
12-20-04	10:24	6.57	11.49	457	6.06	0.80	0.34	5	74	21	Normal
1-20-05	09:56	8.77	10.91	303	6.95	0.55	5.73	7	192	85	High
2-22-05	10:35	14.89	9.75	383	6.70	0.42	1.82	4	209	100	Normal
3-29-05	10:10	14.88	12.98	262	7.24	0.53	35.75	2	1226	TNTC**	Low Flow
4-26-05	09:34	15.48	9.05	370	6.27	0.12	5.11	0	>4834	TNTC**	Normal
Adjacent Land Use: Agriculture, Pasture with cattle on both sides; road right-of-way											
Comments: Intermittent with perennial pools; *Samples collected but not analyzed due to bad media; **Too Numerous To Count											

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 15512 Tankersley Creek at FM 1734											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	08:45	25.4	9.90	254	6.54	0.90	^	9	4	4	Normal
6-21-04	09:11	25.7	6.31	228	6.20	0.61	^	2	17	5	Normal
7-19/20-04	06:45	29.24	4.97	195	6.17	0.49	^	10	11	*	Normal
8-25-04	10:35	28.68	6.29	205	6.19	0.70	^	2	54	26	Normal
9-21-04	11:55	25.87	7.04	197	5.98	0.74	^	10	16	23	Normal
10-27-04	11:15	24.17	9.39	212	6.23	0.76	^	1	40	73	Normal
11-30-04	11:50	11.99	7.67	260	5.97	0.67	^	<1	47	23	High
12-20-04	11:44	7.72	10.35	266	6.27	0.90	^	5	24	12	Normal
1-20-05	11:28	8.84	10.94	252	6.92	0.82	^	7	32	6	Normal
2-22-05	11:47	14.96	7.16	316	6.77	1.5	^	4	14	14	Normal
3-29-05	11:42	15.40	9.13	332	6.80	0.42	^	2	560	TNTC**	Normal
4-26-05	11:22	19.17	8.21	291	6.20	0.48	^	0	1095	320	Normal
Adjacent Land Use: Undeveloped, Forested upstream, pasture											
Comments: Segment of creek that enters Tankersley Lake from the north, non-wadeable conditions prevented attainment of flow measurements; ^Non-wadeable stream; *Samples collected but not analyzed due to bad media; **Too Numerous To Count											

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 15513 Tankersley Creek at U.S. Hwy 67

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	09:48	23.3	8.24	566	6.95	0.48	0.08	9	362	132	Low Flow
6-21-04	11:54	28.3	9.70	220	6.10	0.52	11.96	2	72	122	High
7-19/20-04	10:12	25.72	6.34	409	6.59	0.34	1.41	9	33	*	Normal
8-25-04	10:00	26.03	6.67	661	6.29	0.80	0.14	2	387	42	Low Flow
9-21-04	11:15	23.70	8.62	342	6.42	0.54	0.23	10	38	33	Low Flow
10-27-04	10:44	23.01	12.52	482	6.25	0.71	0.08	1	9	17	Low Flow
11-30-04	11:15	11.44	11.37	325	6.13	0.37	2.39	<1	922	400	Normal
12-20-04	11:10	7.23	13.0	433	6.40	0.33	0.12	5	99	47	Normal
1-20-05	10:40	9.12	9.70	276	6.72	0.60	4.13	7	73	55	Normal
2-22-05	10:55	15.27	9.24	316	6.89	0.29	1.87	4	179	147	Normal
3-29-05	10:37	15.44	12.57	299	6.82	0.51	27.26	2	977	TNTC**	High
4-26-05	10:43	16.43	9.52	530	6.25	0.25	1.59	0	1298	513	Normal

Adjacent Land Use: pasture, road right-of-way

Comments: Perennial stream; *Samples collected but not analyzed due to bad media; **Too Numerous To Count

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 15494 Tankersley Creek at Tankersley Road											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	09:20	23.9	8.40	733	6.70	0.48	0	9	690	290	No Flow
6-21-04	10:23	27.68	7.96	219	6.68	0.69	17.85	2	76	98	High
7-19/20-04	09:08	26.12	4.63	510	6.37	0.37	3.68	10	112	*	Normal
8-25-04	10:50	27.50	6.38	651	6.35	0.30	0	2	45	210	No Flow
9-21-04	12:15	24.54	6.11	347	6.79	0.21	0.93	10	172	160	Low Flow
10-27-04	12:30	24.06	7.47	484	6.47	0.46	0.39	1	172	73	Low Flow
11-30-04	12:13	11.89	10.22	342	6.13	0.52	2.05	<1	555	148	Normal
12-20-04	12:59	7.66	10.59	455	6.49	0.53	0	5	108	46	No Flow
1-20-05	10:56	8.98	10.61	277	6.93	NT	3.79	7	108	46	Normal
2-22-05	11:08	15.17	9.53	377	6.38	0.25	1.30	4	209	148	Normal
3-29-05	10:58	15.41	12.72	300	6.78	0.54	25.46	1	1095	TNTC**	High
4-26-05	10:58	17.18	8.15	724	6.87	0.20	0.42	0	731	340	Low Flow
Adjacent Land Use: Network of bridge structures, some pasture											
Comments: Stream bed concrete lined, intermittent with perennial pools; *Samples collected but not analyzed due to bad media; **Too Numerous To Count											

*Too Numerous To Count
NT = Not Taken

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18323 Tributary of Dragoo Creek on the IH-30 north frontage road

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	09:59	23.2	8.00	1098	6.80	0.45	0	9	717	--	No Flow
6-21-04	11:11	24.03	5.76	808	6.01	0.49	0.03	2	870	--	Low Flow
7-19/20-04	10:50	25.0	6.25	1183	6.08	0.43	0	9	56	--	No Flow
8-25-04	09:21	25.41	7.42	684	6.05	0.83	0	2	43	--	No Flow
9-21-04	10:02	22.3	6.01	691	6.18	--	0	10	79	--	No Flow
10-27-04	09:26	22.79	13.29	460	6.10	0.76	0	1	>2419	--	No Flow
11-30-04	09:50	11.76	10.99	--	6.39	0.20	0.65	1	1414	--	Normal
12-20-04	10:52	9.62	8.33	913	6.09	0.55	0	5	215	--	No Flow
1-20-05	10:27	9.48	10.4	836	6.70	0.77	0.03	7	20	--	Low Flow
2-22-05	09:18	14.51	10.31	1557	6.29	0.55	0.00	4	26	--	No Flow
3-29-05	09:04	13.66	8.79	487	6.66	0.58	0.03	2	156	--	Low Flow
4-26-05	09:18	15.72	10.55	254	5.52	0.29	0.01	0	>4838	--	Low Flow

Adjacent Land Use: Road right-of-way, pasture

Comments: Intermittent stream with perennial pools, water present in May but no flow was recorded by the Marsh-McBirney Flo-Mate 2000

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18324 Tributary of Tankersley Creek on Titus County Road 1030

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	09:02	22.5	8.94	1296	6.62	0.65	0.02	9	484	--	Low Flow
6-21-04	09:29	24.47	9.01	300	6.24	0.42	3.37	2	109	--	High
7-19/20-04	10:12	25.17	7.21	913	6.75	0.37	0.25	9	276	--	Normal
8-25-04	10:18	25.48	9.71	1262	6.25	0.73	0.001	2	9	--	Low Flow
9-21-04	11:37	22.74	7.21	358	6.63	0.98	0.11	10	613	--	Low Flow
10-27-04	11:02	22.91	7.66	549	6.79	0.46	0.03	1	21	--	Low Flow
11-30-04	11:34	10.48	11.77	300	6.16	0.69	2.85	<1	190	--	High
12-20-04	11:26	6.47	13.70	470	6.44	0.80	0.11	5	60	--	Normal
1-20-05	11:17	8.60	10.87	435	7.44	0.13	1.03	7	152	--	Normal
2-22-05	11:31	15.34	10.01	585	6.80	0.90	0.39	4	690	--	Normal
3-29-05	11:15	16.50	10.19	476	7.85	0.47	2.52	2	2713	--	High
4-26-05	11:12	15.56	9.89	857	6.21	0.10	0.51	0	>4838	--	Normal

Adjacent Land Use: Pasture, mobile home northwest side of creek,

Comments: Perennial stream

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18325 Tributary of Tankersley Creek on FM 127											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	11:11	24.5	9.30	594	7.30	0.33	0.10	9	953	--	Low Flow
6-21-04	15:14	28.57	15.19	266	6.28	0.23	2.40	2	91	--	High
7-19/20-04	09:52	24.91	7.59	250	6.70	0.21	1.27	9	249	--	Normal
8-25-04	08:30	27.21	9.96	491	5.97	0.85	0	2	17	--	No Flow
9-21-04	09:30	22.3	7.20	360	5.67	0.49	0	10	67	--	No Flow
10-27-04	08:59	22.90	??	484	6.09	1.07	0.04	1	629	--	Low Flow
11-30-04	09:00	10.70	11.41	483	5.89	0.24	2.33	<	>2419	--	High
12-20-04	09:06	3.43	12.41	653	6.46	0.45	0.07	5	280	--	Low Flow
1-20-05	08:45	7.31	11.14	527	7.02	0.42	0.92	7	325	--	Normal
2-22-05	08:45	12.07	11.37	879	6.36	0.36	0.29	4	1226	--	Normal
3-29-05	08:35	13.54	12.09	458	7.40	0.36	2.31	2	1298	--	High
4-26-05	08:45	16.47	9.56	856	6.23	0.18	1.79	0	>4838	--	Normal
Adjacent Land Use: Pasture with cattle on both sides; road right-of-way											
Comments: Intermittent with perennial pools											

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18326 Dragoo Creek at Titus County Road 2400

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	10:21	22.9	6.80	593	7.10	0.22	0.02	9	782	--	Low Flow
6-21-04	13:56	29.99	11.13	311	7.11	0.57	11.72	2	74	--	High
7-19/20-04	09:25	24.28	4.91	446	6.54	0.21	0.97	9	111	--	Low Flow
8-25-04	08:53	24.47	6.29	517	5.95	0.53	0	2	958	--	No Flow
9-21-04	09:45	20.56	4.48	367	6.16	0.27	0	10	53	--	No Flow
10-27-04	09:16	21.43	8.28	404	6.05	0.61	0	1	261	--	No Flow
11-30-04	08:36	12.02	10.06	311	6.65	0.06	2.67	<1	748	--	Normal
12-20-04	09:24	7.66	14.67	350	6.67	1.4	0.80	5	358	--	Normal
1-20-05	09:05	8.94	11.41	353	7.69	0.11	5.03	7	132	--	Normal
2-22-05	09:07	13.35	9.91	421	7.28	0.40	0.20	4	324	--	Low Flow
3-29-05	08:50	15.16	11.12	382	7.67	1.00	8.10	2	115	--	High
4-26-05	09:11	16.81	9.26	388	6.71	0.28	0.96	0	>4838	--	Normal

Adjacent Land Use: Near residential community and railroad track, pasture, neighborhood trash dump

Comments: Intermittent with perennial pools

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18327 Tankersley Lake 0.9 mile east of Titus County Road 1030

Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	14:10	+	+	+	+	0.71	N/A	9	4	--	N/A
6-21-04	08:28	28.3	7.86	181	7.12	0.86	N/A	2	29	--	N/A
7-19/20-04	08:40	30.46	8.47	181	8.12	0.61	N/A	10	2	--	N/A
8-25-04	08:15	+	+	+	+	0.61	N/A	3	3	--	N/A
9-21-04	09:58	26.71	6.82	202	7.14	0.50	N/A	11	2	--	N/A
10-27-04	13:13	24.44	9.16	204	7.83	0.70	N/A	1	1	--	N/A
11-30-04	14:10	13.62	10.69	202	6.87	0.61	N/A	<1	10	--	N/A
12-20-04	13:30	9.62	12.84	205	7.34	0.64	N/A	5	<1	--	N/A
1-20-05	12:54	10.47	10.93	208	7.61	0.70	N/A	7	15	--	N/A
2-22-05	13:12	18.10	10.01	224	7.47	0.70	N/A	4	6	--	N/A
3-29-05	13:19	15.50	9.20	237	7.33	0.58	N/A	2	126	--	N/A
4-26-05	13:07	21.17	9.62	252	7.16	0.47	N/A	0	411	--	N/A

Adjacent Land Use: Residential community nearby
Observed Reservoir Use: Recreation, water supply

Comments: Open water in reservoir; While water column measurements were taken, only the surface water measurements are reported; Area received rainfall around 04:00; +Equipment malfunction

TABLE 2-1 (cont'd)

TCEQ - NETMWD
Tankersley Creek Bacterial Source Tracking Special Study
FY2004-2005

Station: 18328 Tankersley Lake 1.2 miles west of U.S. Highway 271											
Date	Time	Temp (C°)	DO (mg/L)	Cond (µS/cm)	pH s.u.	Secchi (m)	Flow (cfs)	Days Since Last Rainfall	*E. coli* MPN/100ml	Fecal coliform #/100ml	Flow Severity
5-26-04	13:54	+	+	+	+	0.71	N/A	9	<4	--	N/A
6-21-04	08:15	28.2	8.00	180	6.68	0.84	N/A	2	12.6	--	N/A
7-19/20-04	08:45	30.47	8.55	180	8.25	0.73	N/A	10	<1	--	N/A
8-25-04	08:11	+	+	+	+	0.37	N/A	3	<1.5	--	N/A
9-21-04	09:36	26.47	6.98	202	7.02	0.50	N/A	10	<1	--	N/A
10-27-04	12:58	24.81	9.65	205	7.67	0.70	N/A	1	1	--	N/A
11-30-04	13:59	13.60	11.18	202	6.67	0.67	N/A	<1	10.4	--	N/A
12-20-04	13:20	10.07	12.60	205	7.08	0.54	N/A	5	4.1	--	N/A
1-20-05	12:45	10.33	10.84	209	7.50	0.37	N/A	7	24	--	N/A
2-22-05	13:04	16.55	9.85	222	7.25	0.60	N/A	4	6	--	N/A
3-29-05	13:12	16.37	9.92	237	7.24	0.49	N/A	2	54	--	N/A
4-26-05	13:00	21.80	10.52	251	6.93	0.42	N/A	0	14	--	N/A
Adjacent Land Use: Residential community nearby											
Comments: Open water in reservoir; While water column measurements were taken, only the surface water measurements are reported; Area received rainfall around 04:00; +Equipment malfunction											