

## **APPENDIX**

## **2.0 PROGRAM OUTLINE**

The TMDL program is divided into four major work areas, each of which subsumes one or more of the Tasks included in the Workplan. The four work areas, and their respective workplan tasks are: Administration (Tasks 1, 2, 3, and 4), Data Collection (Tasks 6, 7, 8, 9, and 10) Data Management (Tasks 5 and 11), and Modeling, Analysis, and Reporting (Tasks 12, 13, 14, and 15). Collection of the data necessary for the development of the Lake O' the Pines TMDL was organized into five monitoring programs: Task 6, Baseflow Monitoring, Task 7, Stream flow Monitoring, Task 8, Wet Weather Monitoring, Task 9, Intensive Monitoring, and Task 10, Toxicity Screening/Metals in Sediments and Tissues. The workplan for the TMDL program was fitted into a standard TCEQ shell, provided during the development of the project. The majority of the work involved in the TMDL process involved Data Collection (Tasks 6, 7, 8, 9, and 10) Data Management (Tasks 5 and 11), and Modeling, Analysis, and Reporting (Tasks 12, 13, and 14).

### **Development of a Quality Assurance Project Plan**

A Quality Assurance Project Plan (QAPP) was developed for the Lake O' the Pines Watershed TMDL to ensure the reliability of the monitoring data collected under each task description. The monitoring plans developed as a result of the work plan activities outlined in Section 2 were formatted and incorporated into the QAPP as provided by the TCEQ for the TMDL program. Each monitoring plan was submitted to the TCEQ in their approved format with details of the monitoring schedule, parameters, and sampling locations (with GPS verified latitude and longitude coordinates) within the study area. Monitoring plans were coordinated with the TCEQ regional offices and other watershed monitoring entities to minimize duplication of effort. The QAPP addressed the elements described in the EPA's QA/R-5 document including: Project Management, Measurement/Data Acquisition, Assessment/Oversight, and Data Validation and Usability. Laboratory analysis of all water and sediment samples were done in accordance with the EPA approved methodologies as reported in 40 CFR Part 136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants. Acceptable levels for accuracy and precision for samples are presented in Table A7-1 of the Lake O' the Pines QAPP. The QAPP was reviewed and approved by the TCEQ prior to the onset of data collection activities, and amended in May 2002. Quality Assurance Management Protocols were consistent with TCEQ policies as specified in the TCEQ Quality Management Plan (QMP). The QAPP was updated (specifically Tasks 6 and 10) as modifications or alterations to a specific monitoring plan of the Lake O' the Pines Watershed TMDL Project were implemented.

### **Task 6: Baseflow Monitoring and Hydrographic Characteristics**

Baseflow monitoring was intended to focus on determination of low flow background and point source loadings, assist our evaluation of the dissolved oxygen regime in the shallow, vegetated portion of Lake O' the Pines, provide water quality data needed for water quality model calibration and verification, assist in linkage and allocation analysis, and furnish information on which to base recommendations for continuing to monitor water quality trends.

Baseflow conditions were defined, prior to the initiation of sampling, to occur when the day-to-day variation in stream discharge at USGS Gage 07344500 (Big Cypress Creek at Highway 11)

has been less than 15% for a period of at least 6 consecutive days, and no significant rainfall has occurred in the Lake O' the Pines watershed during that period. During 4 of the 12 scheduled sampling events, field parameter measurements included diurnal dissolved oxygen and temperature profiles collected at a minimum of six hour intervals over 24-hr periods at all stations. Baseflow monitoring parameters are listed in Table 2-1 and Baseflow monitoring station locations are shown in Table 2-2.

Due to the delay of final approval for the Lake O' the Pines Watershed Total Maximum Daily Load Quality Assurance Project Plan (QAPP), baseflow sampling was initiated during the months of July and August during the fiscal year 2000. The baseflow monitoring plan was not revised for the fiscal year 2001; therefore the program initiated in July 2000 was simply continued. During FY 2001, the criteria for baseflow conditions as specified in the QAPP were met during only a few months due to unusually wet climatic conditions. Baseflow sampling requires a period of at least six consecutive days of less than 15% stream flow variation at Big Cypress Creek at Highway 11, and no significant rainfall within the Lake O' the Pines watershed during that period. Baseflow conditions did not occur between 1 November 2000 and 30 June 2001. Consequently, baseflow water quality monitoring occurred only during the months of September and October 2000 and February and July 2001. The February sampling was interrupted by high flows and did not meet the baseflow criteria for reporting purposes.

This lack of data mandated a revision of the original Task 6 monitoring plan to show collection of water quality samples for an additional 8 months during fiscal year 2002, beginning in September 2001. Water quality parameters, including field and conventional parameters and diurnal dissolved oxygen data was continued in accordance with Amendment 1 of the LOP TMDL QAPP. Baseflow sampling in FY2002 occurred in July, October, November 2001 and January 2002. Baseflow monitoring originally scheduled for March, April, and May 2002 was not conducted due to a determination that the combination of the existing baseflow dataset and the Intensive Survey results for 1999 and 2000 was sufficient to characterize baseflow loading conditions in the Lake O' the Pines watershed and its impact on water quality in the reservoir.

A modification of the Task 6 primary objective necessitated a change in specific details through the development of Amendment 3 in May 2002. Instead of the continuation of baseflow sample collection as outlined in Amendment 1 to the Lake O' the Pines TMDL QAPP, a total of two additional sets of nutrient, profile, and diurnal data was collected under summer low flow conditions at ten Lake O' the Pines stations on Segment 0403, at one station above the reservoir that serves as an inflow station during baseflow conditions, and at one station below the reservoir dam. Additionally, synoptic data sets were obtained in the characterization of the dissolved oxygen (DO) regime within the upper, shallow, densely vegetated lake environment to help comprehend the existing oxygen dynamics in this portion of the lake. Sample parameters and stations for the original baseflow monitoring program are presented in Tables 2-1 and 2-2, respectively, while stations and parameters employed for the sampling conducted in Lake O' the Pines during the summer of 2002 are shown in Tables 2-3 and 2-4. Station locations where baseflow and Lake O' the Pines monitoring was conducted are depicted in Figure 2-1.

**Table 2-1  
TMDL Baseflow Sample Parameters**

<b>Field Parameters</b>	<b>Storet Code</b>	<b>Metals in Water</b>	<b>Storet Code</b>	<b>Sediment Samples</b>	<b>Storet Code</b>
Dissolved Oxygen (mg/l)	00300	<b>Dissolved Metals</b>		Aluminum, Total	01108
Diurnal Dissolved Oxygen (mg/l)	89857	Aluminum	01106	Arsenic, Total	01003
Temperature (°c)	00010	Arsenic	01000	Barium, Total	01008
Secchi Depth (m)	00078	Barium	01005	Cadmium, Total	01028
pH (s.u.)	00400	Cadmium	01025	Chromium, Total	01029
Conductivity ( <i>umhos</i> )	00094	Chromium	01030	Copper, Total	01043
Flow (cf/s)	00061	Copper	01040	Lead, Total	01052
Days Since Last Rainfall	72053	Lead	01049	Manganese, Total	01053
Flow Severity	01351	Manganese	01056	Mercury, Total	71921
		Molybdenum	01060	Molybdenum, Total	01063
<b>CNP Parameters</b>		Nickel	01065	Nickel, Total	01068
Ammonia	00610	Silver	01075	Selenium, Total	01148
Nitrate/Nitrite	00630	Zinc	01090	Silver, Total	01078
Total Kjeldahl Nitrogen	00625			Zinc, Total	01093
Total Phosphorus	00665	<b>Total Metals</b>		TOC	81951
Dissolved ortho-Phosphorus	00671	Calcium	00916	Oil and Grease	00557
Chlorophyll-a	32211	Iron	01045	Total Kjeldahl Nitrogen	00603
TOC	00680	Mercury, Total	71900	Total Phosphorus	00668
BOD <sub>5</sub>	00310	Selenium, Total	01147	% Clay	82009
BOD Carbonaceous	80082			% Gravel	80256
TSS	00530			% Sand	89991
Pheophytin a	32218			% Silt	82008
				Acid Volatile Sulfide (AVS)	50088
				Total Solids (% WT)	81373

**Table 2-2  
Baseflow Monitoring Stations for TMDL Development**

Segment	TNRCC Station	Location	Field Data	D.O. Diurnal	CNP	Metals in Water	Metals in Sediment	Biology
	(temp)		Frequency	Frequency	Frequency	Frequency	Frequency	Frequency
0402	13630	Below Lake O' the Pines dam	12/yr	4/yr	12/yr	--	--	--
0404	10311	Below Lake Bob Sandlin dam	12/yr	4/yr	12/yr	2/yr	1/yr	--
0404	16457	Big Cypress below Walker Cr.	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	15257	Big Cypress above FM 997	12/yr	4/yr	12/yr	2/yr	1/yr	--
0404	16016	Greasy Creek at FM 557	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	15894	Boggy Creek at FM 144	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	15836	Prairie Creek at FM 557	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	16454	Walkers Creek at US 271	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	15738	Swanano Creek at SH 11	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	10275	Dry Creek at CR 4230	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	10308	Big Cypress Creek at HWY 11	12/yr	4/yr	12/yr	2/yr	1/yr	--
0404	10261	Tankersley Creek at FM 3417	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0404	10266	Hart Creek at SE 12	12/yr	4/yr	12/yr	2/yr	1/yr	1/yr
0403	10296	Lake O' the Pines at dam	12/yr	4/yr	12/yr			
0403	13631	Lake O' the Pines at US 259	12/yr	4/yr	12/yr			
0403	10297	Mid Lake 1	12/yr	4/yr	12/yr			
0403	13977	Mid Lake 2	12/yr	4/yr	12/yr			
0403	16452	NE cove	12/yr	4/yr				
0403	16450	NW cove	12/yr	4/yr				
0403	16448	SE cove	12/yr	4/yr				
0403	16449	SW cove	12/yr	4/yr				

**Table 2-3  
Dissolved Oxygen Climate Characterization Program Monitoring Stations**

Seg.	TCEQ Station	Location	Field Data	D.O. Diurnal	CNP
			Frequency	Frequency	Frequency
0402	15135	Below Lake O' the Pines dam	2 times	2 times	2 times
0403	10296	Lake O' the Pines at dam	2 times	2 times	2 times
0403	13631	Lake O' the Pines at US 259	2 times	2 times	2 times
0403	10297	Lake O' the Pines at NETMWD Intake	2 times	2 times	2 times
0403	16156	Lake O' the Pines at Longview Intake	2 times	2 times	2 times
0403	16452	Lake O' the Pines NE cove	2 times	2 times	2 times
0403	16450	Lake O' the Pines NW cove	2 times	2 times	2 times
0403	16448	Lake O' the Pines SE cove	2 times	2 times	2 times
0403	16449	Lake O' the Pines SW cove	2 times	2 times	2 times
0403	10300	Lake O' the Pines at Lone Star	2 times	2 times	2 times
0403	17087	Lake O' the Pines 1 mi Above SH 155	2 times	2 times	2 times
0403	16868	Lake O' the Pines 2 mi Above SH 155	2 times	2 times	2 times
0403	Station A	Yet to be determined	2 times	2 times	--
0403	Station B	Yet to be determined	2 times	2 times	--
0403	Station C	Yet to be determined	2 times	2 times	--

**Table 2-4**  
**TMDL Field and CNP Sample Parameters**  
**Dissolved Oxygen Climate Characterization Program**

<b>Field Parameters</b>	<b>Storet Code</b>
Dissolved Oxygen (D.O.)	00300
24-Hr D.O. Average	89857
Temperature (°C)	00010
Temperature (°C) 24-Hr Average	00209
pH (s.u.) - Field	00400
Conductivity (uS/cm)	00094
Conductivity (uS/cm) 24-Hr Average	00212
Secchi Depth (m)	00078
Flow (cfs)	00061
Flow Estimate (cfs)	74069
Flow Measurement Method	89835
Flow Severity	01351
Days Since Last Rainfall	72053
Total Water Depth	82903
<b>CNP Parameters</b>	
Ammonia-Nitrogen	00610
Nitrate/Nitrite	00630
Total Kjeldahl Nitrogen	00625
Total Phosphorus	00665
Dissolved Ortho-Phosphorus	00671
Chlorophyll-a	32211
TOC	00680
BOD <sub>5</sub>	00310
Dissolved CBOD <sub>5</sub>	80082
TSS	00530
Pheophytin a	32218



## **Field Physicochemical Measurements**

Instantaneous and diel (24-hr) field measurements of water temperature, dissolved oxygen (D.O.), conductivity, and pH readings were obtained with a Yellow Springs Instrument (YSI) 610 DM/600 XLM Minilogger. Measurements of the aforementioned standard field parameters were taken from all stations at the start and finish of each diurnal field effort, during each water collection survey, and concurrent with all habitat/biological assessment efforts conducted in the late summer of 2000 and 2001. During each 24-hour measurement water quality survey, the multi-probe instrument was placed securely in streams whose depth was greater than 1.5 feet at 1 ft. within the water zone, and at a point between a depth of 1 foot and a depth of one-half the mixed surface layer in the reservoir, programmed and left unattended, automatically recording at 15-minute intervals over a minimum of a 24-hour period. The instrument was retrieved the following day, and the collected data was downloaded and checked for accuracy. Instantaneous readings of standard parameters were also recorded from that portion of the stream that exhibited 50% of the flow at the time of datalogger setup and retrieval. Each datasonde was calibrated according to the manufacturer's recommendations prior to installation and post-calibrated upon return to the office. Light penetration at each station measured utilized a 20-cm diameter black-and-white Secchi disc.

## **Water Sample Collection**

The day to day variation in stream discharge was monitored at USGS Gage 07344500 (Big Cypress Creek at Highway 11) to determine if the criteria for baseflow conditions (less than 15% for a period of at least 6 consecutive days, and no significant rainfall has occurred in the Lake O' the Pines watershed) during that period were met prior to sample collection. Water column nutrient parameters (carbon, nitrogen, phosphorous) were collected from the surface mixed layer, by directly immersing the container beneath the water surface to a depth of one (1) foot, or near surface and near bottom using a Van Dorn horizontal water sampler following fall overturn. Sample containers, provided by Ana-Lab Corporation of Kilgore, Texas, were labeled in the field with the field collector initials, station number, and date and time of collection, and immediately stored in an ice chest filled with ice. A log of all types of samples collected was maintained during the survey. A chain-of custody (COC) inventory form was submitted along with each sample collection set transported to Ana-Lab to ensure precise laboratory sample tracking.

## **Rapid Bioassessment (RBA) Collection**

The biological collection and physical habitat evaluation occurred on 25, 29, 31 August/1 September 2000 and 6-8 August 2001. The methods and materials for the work performed followed the guidelines of the Texas Natural Resource Conservation Commission (TNRCC) *Receiving Water Assessment Procedures Manual* issued in June 1999 and as described in the 1999 *TNRCC Surface Water Quality Monitoring Procedures Manual*.

A Habitat Quality Index (HQI) was prepared from riparian vegetation and physical habitat characteristics observed at five transect lines. Analysis of a minimum of 200+ benthic macroinvertebrates sampled from all available microhabitats, and fisheries data collected by backpack electrofishing and seine was integrated through the use of comparative statistical

parameters and available benthic and fish community trophic structure data to provide an aquatic life use rating for each stream investigated.

The riparian vegetation and physical characteristics were documented during each of the RBA sampling efforts with a series of cross sections and associated habitat evaluations. Transect placement at most sites began either upstream or downstream of a bridge crossing and was measured at four evenly spaced distances for a total of five cross-sections. The riparian vegetation and physical habitat characteristics at each of the five transect locations were characterized by a series of attributes and associated aquatic habitat measurements as outlined in TNRCC (1999) and recorded on TNRCC's Part I-Stream Physical Characteristics Worksheet.

Instream channel measurements included habitat type, number of riffles, dominant substrate type, percent of substrate composed of gravel, presence or absence of algae and aquatic macrophytes, and instream cover types and the percentage of each. Stream morphological parameters include channel sinuosity, channel obstructions/modifications, channel flow status, stream width and depth. Features that describe the riparian environment include width of natural vegetative buffer, aesthetics, percentage of riparian vegetation types, bank slope, bank stability, canopy cover and dominant types of riparian vegetation. The percentage of tree canopy cover was determined with a concave spherical densiometer. The percentage of the dominant riparian vegetation types along the left and right banks at each transect station was made by visual estimation. A Suunto clinometer was used to determine creek bank slope in degrees. A summary of the physical characteristics of the stream was obtained from information noted on the field worksheet and recorded on the Part II summary worksheet.

Field measurements of water temperature, dissolved oxygen (DO), conductivity, and pH readings were taken concurrent with RBA efforts. Each datasonde was calibrated according to the TCEQ and manufacturer's recommendations prior to installation and post-calibrated upon return to the office. Light penetration was measured with a 20-cm diameter black-and-white Secchi disc. When feasible, 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 (cfs) was calculated by multiplying the section width by the section depth (ft<sup>2</sup>) by the velocity (ft/s).

Macroinvertebrate sampling using a 10.5" x 18.5" rectangular frame dip net (500 x 500 micron mesh) was conducted at each stream. Sweeps were made through all available microhabitats within each transect area along with hand-picking from stable substrates located in areas exposed to current (e.g., logs, woody snags, etc.) Processing of the dip net samples was accomplished in the field by thoroughly washing the sample in the dip net then placing appropriate sample aliquots in a shallow white pan. The sample was stirred in the pan to disperse the contents as evenly as possible, repeating the process until a total of 200 individuals were picked. Samples were preserved with 70% ethanol and returned to the lab for taxonomic identification, enumeration, and metric calculations.

Seine and backpack electroshock sampling was conducted in accessible areas throughout the entire sample zone bounded by the first and fifth transect line. The fish fauna was sampled with a 15-ft x 5.0-ft x 1/4-inch common sense minnow seine and a variable voltage Smith-Root Model 15-B Programmable Output Waveform (POW) generator-powered backpack electrofisher. A minimum of six seine hauls were taken at representative locations along each RBA reach. The

length towed, in meters, was recorded for each haul along with the type of habitat sampled. The backpack electrofisher was used as a check on the efficiency of seining in the various habitat types encountered and in areas where the creek channel was cluttered with enough snags and brush in or over the water that seining was difficult or impractical. The collector carrying this type of gear proceeded in a downstream to upstream direction, in an attempt to eliminate the effects of turbidity caused by disturbing bottom sediment, with a 6-ft long fiberglass handle dip net with 3/8 in mesh while accompanied by a second and third person equipped with nets to capture all fish stunned by the electrode. Each electrofishing sample consisted of a minimum of 15 minutes of actual shock time or continued sampling until there were no new species captured after 15 minutes, thereby sufficiently covering the accessible areas of the sample reach. The control box of the electrofisher was set at various modes and output voltage range settings. The concentration of effort focused upon brushy areas, small shallow backwater areas, woody debris piles, and depressional areas associated with undercut banks, along with occasional sweeps through open water areas. Most of the fish were placed into bottles containing 10% formalin when seine hauls or electrofishing at their respective stations/reaches were completed. All fish collected from each seine haul and electroshock sample were visually examined for obvious diseases, parasites, and other abnormalities. A minimum of one specimen of each fish species was preserved in 70% ethanol and kept as a voucher collection.

### **Lake O' the Pines Dissolved Oxygen Characterization Study**

The dissolved oxygen dynamics in the shallow vegetated upper portion of Lake O' the Pines was monitored twice during the Summer of 2002 (27-30 June and 19-23 August) at three stations by recording 24-hour measurements of water temperature, dissolved oxygen (D.O.), conductivity, and pH. YSI 600 XLM Miniloggers were calibrated according to the TCEQ and manufacturer's recommendations deployed and left unattended over a 24-hour period in Plexiglas box enclosures having volumes of about 250 liters (0.250 m<sup>3</sup>) and areas of 0.372 m<sup>2</sup>. The actual box dimensions measured 24"x24"x30" deep, so the total volume was 283 liters, however, the boxes are designed to limit sediment penetration to 4", which would result in a volume of 245.4 liters. Gentle circulation within each box enclosure was provided with a battery-powered submersible pump with a pumping rate of 1.6 liters/minute. Additional data sondes were deployed freely at various depths in the water column for diel measurement near the Plexiglas metabolism boxes. The results of the datalogger deployments within the metabolism boxes and the open water column were transferred to a PC computer, and the dataloggers were post-calibrated upon return to the office.

Phytoplankton grab samples were taken from near the Ferrell's Bridge Dam, the Longview Intake, the NETMWD Intake, the U.S. 59 Bridge crossing, and above the SH 155 Bridge on 22-23 August 2002. At each location, a single sample was collected from the surface mixed layer, by directly immersing the container beneath the water surface to a depth of one (1) foot. Each sample was preserved in the field by the addition of 60 mL of M3 fixative, an algal preservative composed of 5g potassium iodide, 10g iodine, 50ml glacial acetic acid, and 250ml formalin dissolved in one liter of distilled water. Upon receipt at the laboratory, the samples were checked against the chain-of-custody field inventory record. A data sheet for each sample was initiated which included all information present on the sample label.

The optical equipment, counting chambers and quantitative techniques used in the laboratory followed the instrument calibration, collection, enumeration and calculation procedures outlined in Sections 1002 and 1003 in *Standard Methods for the Examination of Water and Wastewater*. Calibration of ocular reticules, counting chamber dimensions, and microscope field diameters was accomplished with a stage micrometer, and dimensions are recorded on instrument labels, or in the Lab Record Book keyed to codes on the counting chamber. The samples were mixed thoroughly to ensure a homogeneous solution. The total sample volume was measured and recorded on the data sheet. One liter (1000 ml) of sample solution was placed into a clean graduated cylinder, labeled and covered with Parafilm®. The sample was allowed a minimum sedimentation time of 3 hr/cm or approximately 4.5 days. After the required settling time was attained, the supernatant was siphoned from just under the liquid surface, taking care to not disturb the accumulated bottom sediment layer material, until <50 ml remains in the cylinder. The remaining "concentrate" volume was measured and recorded.

The concentrated sample was enumerated at 400x magnification in a Palmer-Malony counting chamber with a high dry (40x) lens. The code number on the counting chamber was recorded as "Cell Code" on the data sheet. The unit area (field) used for enumeration was recorded as "Grid" on the data sheet. A constant number of fields were examined for all samples in a given collection. All organisms encountered in these water mounts was enumerated and identified to the lowest practical taxonomic level.

Density was expressed as a number of cells/ml where possible. Unicellular species were enumerated individually, colonial forms with consistent cell numbers were recorded as a single unit, and large colonies with variable cell numbers were recorded in terms of cell groups. Filamentous forms were enumerated in standard length units of 100 µ. Phytoplankton density was calculated using the formulas as follows: Concentration (No./ml)={No. counted/counted vol. (ml)} x {concentrate vol. (ml)/1000 ml} x 1- {preservative vol. (ml)/sample vol. (ml)}.

### **Task 7 & 8: Streamflow Monitoring, Wet Weather and Rainfall Monitoring**

The wet weather sampling and stream flow monitoring program was initiated with the construction and installation of stream gages, automatic samplers, and rain gages at 15 locations in the Lake O' the Pines watershed during the summer of 2000. Most of these installations included conventional telephone connections to provide alerts when water level rises occurred, and allowed real time monitoring of the progress of the storm hydrograph to coordinate sample collection across the watershed. The wet weather monitoring locations are the same as the stream flow monitoring stations, and have the same equipment and sampling capabilities as described below. The rain gages internally recorded precipitation and this information was downloaded on a regular basis. Stream and rain gauging equipment was quality checked in the lab prior to installation, and was function tested after installation following manufacturers instructions. Repetitive measurements of stream discharge at each monitoring location was conducted to establish the stage-discharge curves necessary to convert recorded water level readings to stream discharges. Stream flow and rainfall gages were routinely visited for data retrieval and general maintenance consistent with the manufacturers recommendations.

An automated, battery operated sampling system, consisting of a bubbler-type flowmeter, automatic sampler, modem and necessary appurtenances, were installed in secure enclosures at the locations given in Table 2-5. Rating curves based on manual stream flow measurements and, where applicable, standard culvert formulations, were developed for each sample location. Equipment was quality checked in the lab prior to installation, and function tested following field installation.

Durations of stream flow records at each sample station are presented in Section 4. Data Collection, and stream flow station locations are shown on Figure 2-2. Rating curves and stream flow data is included in the input files for the SWAT model.

**Table 2-5  
Streamflow Monitoring Stations**

Segment	Station ID	Location	Start/End Date	Sampling Entity	Stream Discharge
0404	15894	Boggy Creek at FM 144	5-00/8-01	TMDL	*
0404	15836	Prairie Creek at FM 557	5-00/8-01	TMDL	*
0404	10266	Hart Creek at SE 12	5-00/8-01	TMDL	*
0403	17027	Meddlin Creek at Snapdragon Road	5-00/8-01	TMDL	*
0404	16455	Alley Creek at SH 155	5-00/8-01	TMDL	*
0404	10263	Tankersley Creek at FM 127	5-00/8-01	TMDL	*
0404	17035	Hart Creek Tributary at Arizona Street	5-00/8-01	TMDL	*
0404	17034	Hart Creek Tributary at First Street	5-00/8-01	TMDL	*
0404	17033	Boggy Creek at FM 144 near Omaha	5-00/8-01	TMDL	*
0404	17057	Boggy Creek Tributary at CR3301	5-00/8-01	TMDL	*
0404	17032	Kitchen Creek at CR2254	5-00/8-01	TMDL	*
0404	17031	Prairie Creek at CR 1140	5-00/8-01	TMDL	*
0404	17028	Prairie Creek Tributary at FM 993-East	5-00/8-01	TMDL	*
0404	17029	Prairie Creek Tributary at FM 993-West	5-00/8-01	TMDL	*
0404	17030	Prairie Creek at 1264	5-00/8-01	TMDL	*

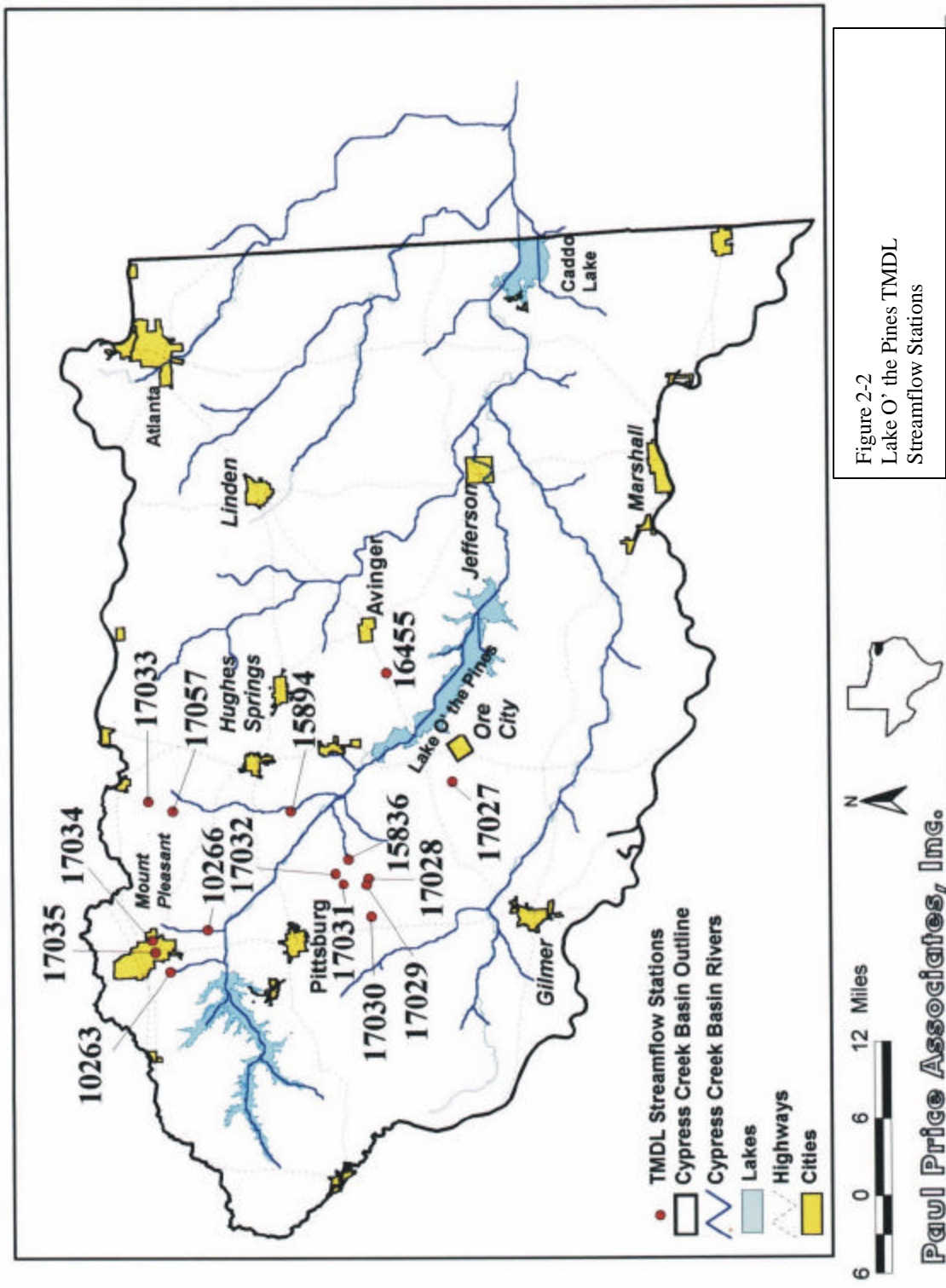


Figure 2-2  
Lake O' the Pines TMDL  
Streamflow Stations

**Paul Price Associates, Inc.**  
 ECOLOGY, WATER QUALITY, CULTURAL RESOURCES, PLANNING

## **Task 7: Stream Flow Monitoring**

Fifteen stream gauging stations were established on major tributaries to Lake O' the Pines to provide continuous stream flow data to support wet weather monitoring. Stream flow measurements are necessary to calculate loadings of oxygen demanding materials and nutrients from point and non point sources, characterize transport processes, locate depositional areas, and evaluate impacts on dissolved oxygen regimes, human uses and biological integrity throughout the Lake O' the Pines watershed.

The automated sampler stations were installed in early 2000 and were monitored on a regular basis to assure the instruments operated in proper working order. Hydrologic data was collected continuously throughout the entire sampling program.

Flow measurements were conducted at each creek location and used for the development of rating curves. Stream flow was measured at the 15 wet weather stations during rain events and in periods of more stable flow by the Texas Institute for Applied Environmental Research (TIAER), Tarleton State University, Stephenville, Texas.

A field training session was arranged with TAIER to go through the basics of setting up, maintenance, and sample collection of the ISCO auto samplers and flow gages with the Paul Price Associates, Inc. field staff.

### **Calculation of Stream Flow and Development of Rating Curves**

The cross-sectional data obtained by the survey team was used to determine the area versus depth data points. The stream gage bubble level was averaged for the span of time that flow was being measured. Stream flow was graphed against the average bubbler level to make an x-y scatter graph for each station. A trend line with the y-intercept set to "0" was inserted into the graphs, along with an equation for the line and an equation for the fit of the line ( $R^2$ ). Using best professional judgment and the examination of the amount and range of stream flow data spanning March 2000 to December 2001 and the fit of the line ( $R^2$ ), station graphs were divided into three categories: good, average, and poor. The stations that were placed into the average and poor groupings required additional instream flow measurements over a wider range of flows and/or alternative interpretation of the existing data.

### **Flow meter Initialization**

The ISCO 4230 Flow meter is an instrument designed to monitor the level of water in a stream, pipe or other system. The bubbler system, used by this particular flow meter to measure level, detects changes in the level of the flow stream by measuring the amount of air pressure required to force an air bubble from the end of a submerged tube. As the liquid level in the flow stream increases, the amount of air pressure required to force the bubble from the tube also increases.

When establishing each new site, the flow meter was programmed to enable the sampler, based on the level of the stream. In order to monitor the rise and fall of the stream, the flow meter was also programmed to record and store the stream level in a partition of the internal memory. In

addition, records of rainfall and collected samples were also recorded and stored in the unit. Three separate partitions were set up in the internal memory of each flow meter. Each partition was identified with the site ID number and the type of partition it represents: level, sampler, and rainfall. In order to partition the flow meter, a laptop computer with a connecting cable was needed. Instructions for the initialization phase are as follows:

Once the flow meter is programmed using the external keyboard, the flow meter is ready to be partitioned. Using a laptop computer, connect to the flow meter using the Flow Link 4.0 software provided by ISCO. Attach one end of the computer cable to the interrogator outlet of the flow meter and the other end of the cable to the serial port of the computer.

Once a communication line has been established, go to the setup icon and make sure that the internal clock is set to the appropriate Central Standard Time. Once the time has established, it is time to partition the flow meter. Go to the memory icon and see if any partitions already exist. If partitions exist, remove each partition using the remove icon. Once all the existing partitions are deleted, use the create icon and go through each step to establish the first partition. Establish the name of the partition, type of partition, interval frequency, length of time, and finally rollover mode. These steps will be done for each of the three partitions to be created. The first partition will be the level partition, five-minute intervals, for 31 days using the rollover mode. The second partition will be the sampler partition, 15-minute intervals, for 1 day using the rollover mode. The third and final partition will be the rainfall partition, 15-minute intervals, for 31 days using the rollover mode. After creating the three partitions, select the hang up icon and terminate communication with the flow meter. At this point, turn off the computer and disconnect the cable from the flow meter and computer. The flow meter is now programmed and partitioned. On a two-week basis, the flow meter needs to be downloaded and data reviewed for accuracy.

The rainfall and level partitions will store data for approximately 30 days before an overlap begins. If an overlap occurs, the oldest data will be overwritten with the latest collected data. The sampler partition will continue to collect data for an unknown period of time. The length of time this partition will store data before an overlap occurs depends on the frequency of samples collected. If rainfall events occur often and samples are collected frequently, the partition may only last one or two months. If rainfall events are rare and samples are not collected frequently, the partition may last for approximately six to eight months. Once the flow meter is correctly partitioned, be sure to complete the general maintenance sheet with all relevant information.

### **Programming Flow Meter Equipment**

The following procedures applied to all ISCO 4230 flow meters used in field applications based upon the written documentation of the methods implemented by TIAER to program all ISCO flow meters used to monitor the stream levels at the 15 automated sampling locations. The ISCO 4230 flow meter with plotter has nine program steps and each step may have one or a series of options to choose from. In addition, there is also a set-up step, which needs to be programmed before going through the nine individual steps. The option that is flashing in a given step indicates the current or default setting. Pushing 'Enter' will accept a flashing option. The instrument was then set up according to the *Instruction Manual for Model 4230 Flow Meter*.

## **Task 8: Wet Weather/Rainfall Monitoring**

Quantification of non point source inputs of nutrient and oxygen-demanding materials to the Lake O' the Pines watershed with the SWAT model (Task 12) required information concerning rainfall-runoff relationships in subwatersheds throughout the basin. The stream gauging stations previously discussed (Table 2-5), were equipped to collect samples to characterize the water quality of the runoff accompanying rainfall events. Stations monitored under this task are shown on Figure 2-3, and listed in Table 2-6. Rain gage locations are summarized in Table 2-7 and Figure 2-4.

Data collection in 2001 occurred at 11 sites on 10-12 January, 2 sites on 5 October, 14 sites on 11-18 October, 11 sites on 28 November – 5 December and in 2002 from one site on 22 January and one site on 24 January. A total of 15 gauging stations were fully operational up to early November 2001. The automated sampler and flow meter installed at the Prairie Creek tributary at Camp CR 1264 near the Camp/Upshur County Line south of Pittsburg was vandalized. Instrumentation from the sampler box located on Boggy Creek (North) on FM 144 near Omaha was transferred to the 1264 site. On 12 March, the Texas Department of Transportation (TxDOT) in Mount Pleasant began right-of-way clearing near the wet weather sampler box located on Tankersley Creek (Station ID 10263). Since relocation was not an option, it was decided that this station was no longer valid for sampling purposes due to the extensive disturbance to the nearby floodplain. On 18 March, the wet weather monitoring program was suspended until further notice. The sampler box and its contents were removed from Tankersley Creek on 19 March 2002, and the flow meter and auto sampler were taken to outfit the North Boggy Creek site. After further discussions, it was decided to terminate the wet weather monitoring program. All sampler boxes were dismantled by NETMWD and transported and stored at their facility in Hughes Springs, Texas.

### **Wet Weather Monitoring**

Quantification of non-point source inputs of nutrient and oxygen-demanding materials to the Lake O' the Pines watershed required information concerning rainfall-runoff relationships in sub-watersheds throughout the basin, and information about the water quality characteristics of runoff accompanying rainfall events onto major vegetational cover and land use types in the watershed.

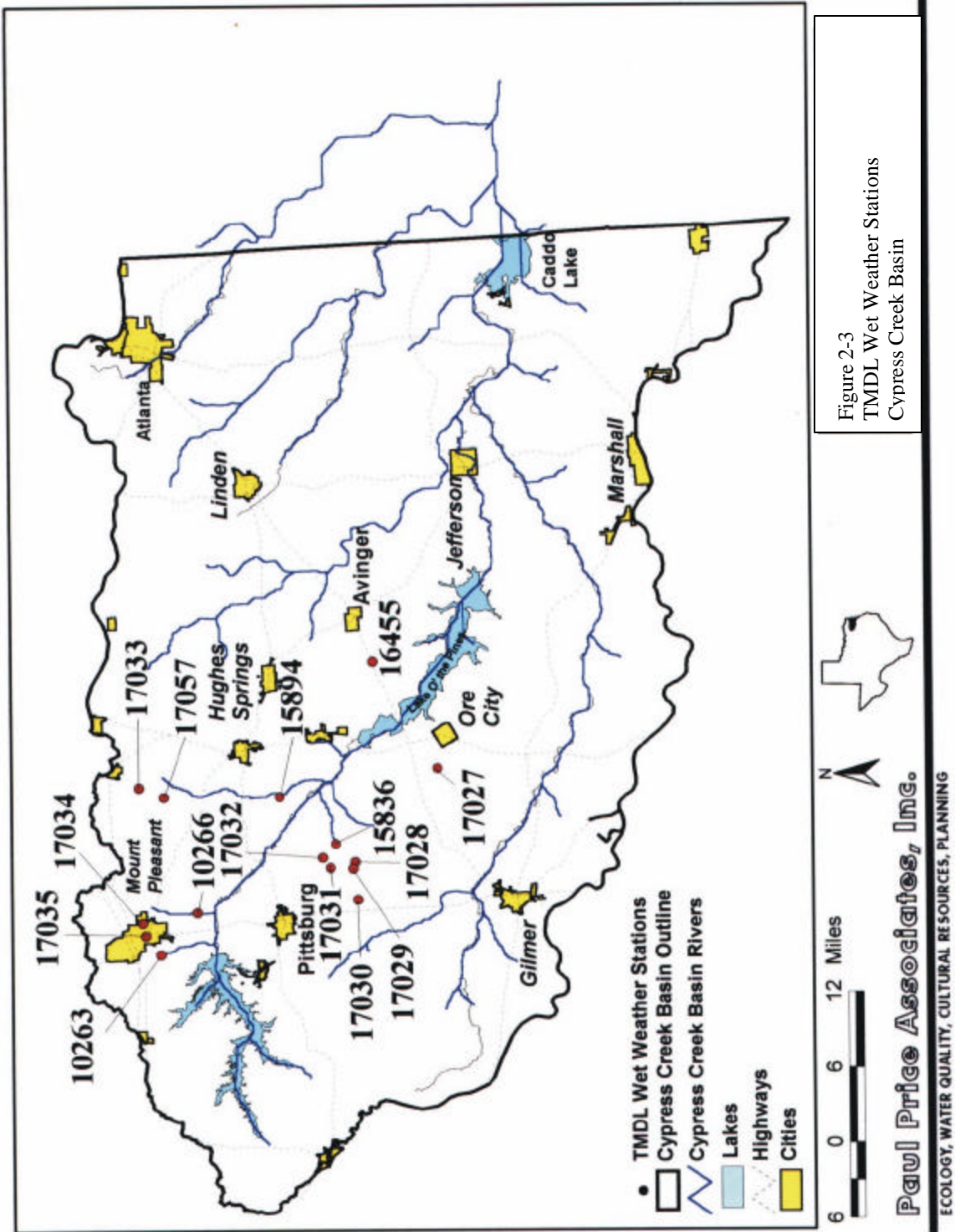


Figure 2-3  
 TMDL Wet Weather Stations  
 Cypress Creek Basin

**Table 2-6  
Wet Weather Monitoring Stations**

Segment	Station ID	Location	Start/End Date	Sampling Entity	Watershed Landuse Type
0404	15894	Boggy Creek at FM 144	5-00/8-01	TMDL	Crop and Pasture
0404	15836	Prairie Creek at FM 557	5-00/8-01	TMDL	Mixed Urban/Rural
0404	10266	Hart Creek at SE 12	5-00/8-01	TMDL	Mixed Urban/Rural
0403	17027	Meddlin Creek at Snapdragon Road	5-00/8-01	TMDL	Mixed Woodland
0404	16455	Alley Creek at SH 155	5-00/8-01	TMDL	Mixed Woodland
0404	10263	Tankersley Creek at FM 127	5-00/8-01	TMDL	Mixed Urban/Rural
0404	17035	Hart Creek Tributary at Arizona Street	5-00/8-01	TMDL	Residential/Urban
0404	17034	Hart Creek Tributary at First Street	5-00/8-01	TMDL	Residential/Urban
0404	17033	Boggy Creek at FM 144 near Omaha	5-00/8-01	TMDL	Crop and Pasture
0404	17057	Boggy Creek Tributary at CR3301	5-00/8-01	TMDL	Mixed Woodland
0404	17032	Kitchen Creek at CR2254	5-00/8-01	TMDL	Crop and Pasture
0404	17031	Prairie Creek at CR 1140	5-00/8-01	TMDL	Poultry Production and litter disposal
0404	17028	Prairie Creek Tributary at FM 993-East	5-00/8-01	TMDL	Poultry Production and litter disposal
0404	17029	Prairie Creek Tributary at FM 993-West	5-00/8-01	TMDL	Poultry Production and litter disposal
0404	17030	Prairie Creek at 1264	5-00/8-01	TMDL	Poultry Production and litter disposal

**Table 2-7  
Rain Gage Monitoring Station Locations**

<b>Segment</b>	<b>Station ID</b>	<b>Location</b>
0403	16465	Ore City WWTP
0403	16463	City of Lone Star WWTP
0403	*	Northeast Texas Municipal Water District Mims Water Treatment Plant at HWY 155 and FM 729
0403	*	SWEPCO Wilkes Power Plant on Johnson Creek Reservoir near SH 49
0404	16466	City of Pittsburg Sparks Branch WWTP
0404	16468	Pilgrim's Pride Processing Plant WWTP
0404	16467	City of Mount Pleasant WWTP
0404	16462	City of Omaha WWTP
0404	16713	City of Daingerfield WWTP
0404	*	Bullock Poultry Farm on FM 144 near Cason, Texas
0404	*	Northeast Texas Municipal Water District Water Treatment Plant near Pittsburg, Texas
0404	*	Bi-County Water Supply on FM 2254 near Pittsburg, Texas
0404	*	Pete Wright Property on Camp County Road 1332
0404	*	Richard Quinn Poultry Farm on FM 2796
0404	*	McCollum Poultry Farm on FM 1000 near Cookville, Texas

\* Rain gage station locations off streams with no TCEQ designated station number.

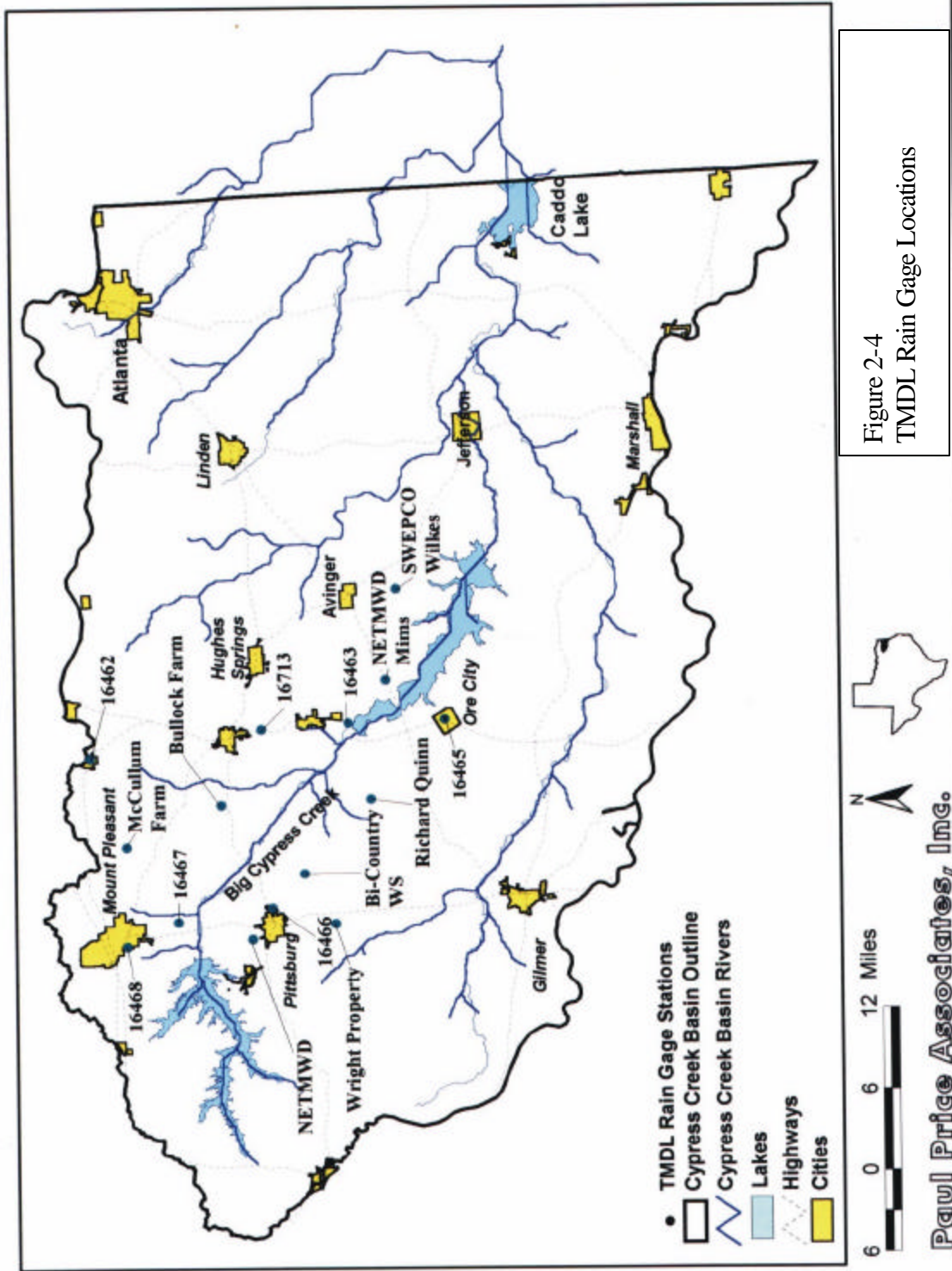


Figure 2-4  
 TMDL Rain Gage Locations

An automated, battery operated sampling system, consisting of a bubbler-type flow meter, automatic sampler, modem and necessary appurtenances, were installed in secure enclosures at each location. Equipment was quality checked in the lab prior to installation, and function tested following installation following manufacturers instructions. Repetitive measurements of stream discharge at each monitoring location were employed to establish the stage-discharge curves necessary to convert water level readings to stream discharges. Samplers were routinely visited for data retrieval and general maintenance.

The collection of five (5) samples over the entire flood event hydrograph was planned. Ultimately this collection effort should include two samples from the rise, one at (or as close to) the peak, and two samples from the fall. The first sample would be obtained at a pre-determined enable/disable level (each station will be different). The second sample would be obtained at a point 1/2 way between the initial enable/disable level and the top of the creek bank (again each station will be different). The third sample would be obtained when the stream level has reached the top of the bank. The last two samples would be obtained when the water has begun to recede and taken at or near the initial two water levels taken during the rise. When the auto samplers notified the field staff and central dispatcher that samples had been taken, the following procedures were conducted upon arrival at each site location. The sampler shelter box was unlocked and the laminated instruction sheet and field book were taken from the sampler shelter and the information such as date, time, weather conditions, sampling personnel and any noteworthy observations were recorded prior to sample retrieval. After viewing the automatic sampler (containing collection bottles) display screen, all information was recorded from the sampler screen into the logbook. All results data was recorded into the field book including bottle information, time, date, etc. The time, current gage level, and enable/disable level from the flow meter display was observed and recorded into the logbook.

### **Programming Automatic Samplers**

The following procedures applied to all ISCO 3700 portable water samplers used in field applications based upon the written documentation of the methods implemented by TIAER to program all ISCO flow meters used to program all automated portable water samplers used in the field. The ISCO Model 3700 Automatic Sampler is used to collect water samples based on time or flow conditions, depending on the program of the instrument. The sampler retrieves samples based on automation, not human actions. The ISCO 3700 Portable Water Sampler has several different program steps and each step may have one or a series of options to choose from. The option that is flashing in a given step indicates the current or default setting. Pushing 'Enter' will accept a flashing option. The pass (code) number needed to change any option of the program in '3700'. Once the sampler has been turned on, the LCD screen should display 'STANDBY' and show the current time and date. Following the *ISCO 3700 Portable Water Sampler Instruction Manual*, the CONFIGURE program step of the sampler is programmed the same way for either flow based sampling or time based sampling. Once the sampler and flow meter are programmed and connected to one another, the sampler should display 'SAMPLER' along with the current time and date. At that time the flow meter and automatic sampler are both ready to collect sequential samples.

## **Sample Retrieval**

The following procedures applied to all samples retrieved from automated sampling sites based upon the written documentation of the methods implemented by TIAER when retrieving water samples following a storm event from automated samplers.

Upon arrival at each sampling location, the following steps were implemented during sample retrieval. The field crew recorded on the field sheet what the LCD screen on the face of the auto sampler read (i.e. Sampler Inhibited). If any samples were collected, i.e. Bottle 1 Source: enable Time: xx:xx Date x-x-xx, then the sampler was downloaded. If no samples were taken, then it was recorded on the field sheet that the sampler was inhibited. The current level and time displayed on the screen of the flow meter was also recorded.

To retrieve the samples, the top cover portion of the sampler was removed and the screw lids on the bottles containing samples were tightened. The center ring of the sampler was removed to access the sample bottles. The appropriate bottles were labeled with the site name and bottle number, removed from the sampler and immediately stored on ice and replaced, with clean bottles. The center ring was repositioned and the sampler top was placed back onto the base and securely fastened.

A chain-of-custody (C-O-C) sheet, protected from the rain in a plastic bag inside of the sampler box, was removed and filled out. Information that included date, time, signature of collection personnel, # of bottles, etc. was recorded on the C-O-C form. After the paperwork had been completely filled out, the C-O-C was kept with the appropriate samples for transportation to the chemistry laboratory.

After all of the bottles were collected and placed on ice, the sampler was reset, and the enable/disable level was reset. The sampler shelter door was then closed and locked and the field collector drove to the next station.

## **Potential Sampling Problems and Troubleshooting**

At times during the retrieval of samples problems associated with the sampling routine may occur that may require a different manner of handling. Different problems experienced include: blown suction lines, loss of plotter power, clogged bubbler lines, fatal error: distributor arm jam, loss of power, excessively large sample volumes, incorrect language display due to lightening, warning: replace pump tubing, sampler display frozen to previous sample, problem occurred press display status or other problems encountered by the field staff.

## **Downloading Automated Sampling Sites**

This procedure applies to the downloading procedures used to collect data from the ISCO 4230 flow meter to retrieve stored data from the ISCO flow meter utilized at all of the LOP TMDL automated water sampling sites. The flow meter has approximately thirty days of memory allocated to each partition. As part of the TMDL QA/QC efforts, each flow meter was

downloaded, and the data reviewed, on a biweekly basis. The biweekly downloading helped eliminate the potential for prolonged periods of missing data.

The procedure for downloading each flow meter involved several steps. The corresponding cable was connected to the interrogator outlet of the flow meter and the serial port of the laptop computer. The computer was turned on and once the C:\ prompt appeared, 'NFL' was typed in and entered. After pressing Enter, the main flow link screen is now in full view. Then, press alt F, select new and press the enter key twice. The computer will then try to connect with the flow meter. The mouse may be used instead of using the keyboard. Once communication with the flow meter has been established, the flow meter is ready to download. Using the tab key, tab over to the interrogation icon and press enter. The computer will now download the flow meter, as a smaller screen will appear showing the percent download completed. Once the computer is finished interrogating the flow meter, a screen will emerge that states that the interrogation phase is complete. Then press enter, tab over to the icon hang-up and press enter. This should close the established communication channel between the flow meter and computer. Select the close box on the main screen and the download will be complete.

### **Equipment Maintenance**

Maintaining equipment in good working order is essential for production of high quality data in the field. Functions or actions required to ensure the proper working order of a piece of equipment include, but are not limited to, cleaning, minor repairs, changes of tubing, lubricants and other consumable parts, checks for damaged or worn components, and protective measures.

### **Rain Gage Monitoring**

As part of the data collection for the TMDL Task 8 (Wet Weather Monitoring), a network of rain gages was placed throughout the Lake O' the Pines (Segment 0403) and Big Cypress Creek (Segment 0404 – between Lake O' the Pines and Lake Bob Sandlin) watersheds in order to collect data from which to correlate rainfall patterns with runoff conditions. This information is currently being used in model development for the TMDL program. Each rain gage consisted of a Campbell Scientific TE 525 Tipping Bucket Rain Gage and an Onset Corporation HOBO Event Logger. All gages and loggers were programmed, set-up, and calibrated according to manufacturers specifications shown in each of the respective instrument user's manuals.

The rain gages were mounted to steel pipes driven into the ground at a depth of 18-24 inches and stand approximately four feet above the surface. The gage dimensions measure approximately six inches in diameter by 12 inches tall and are completely self-contained, requiring no external power source. They were located in open areas so nearby structures or surrounding vegetation would not affect the collection data.

Each rain gage was serviced every two to three weeks by one of the TMDL field staff to offload data and re-launch the unit. All fifteen gages were visited on the same day. All appropriate personnel were notified at least 24-hours in advance of each maintenance trip to assure access to each gage. As part of this inspection, each unit was examined and cleaned of any debris, bugs, etc., and re-leveled as prescribed by each of the user's manuals. A general maintenance

procedure is presented below. This process usually required an average of between 15 to 30 minutes to complete. A maintenance log sheet was filled out for each rain gage during every trip. Data sheets were maintained in a bound notebook kept by the field staff, and photocopies of each sheet were mailed to Paul Price Associates, Inc. following each trip. Major problems were immediately brought to the Project Manager or Technical Coordinator's attention.

### **Supplies Required for Each Trip**

Supplies essential for each rain gage station visit included an Onset Corporation HOBO Data Shuttle, the Rain Gage Maintenance/Calibration Log Book, a laptop computer with Onset Corporation Boxcar software, and a box containing necessary tools, supplies, and spare parts.

### **Offloading Data and Maintenance at Each Rain Gage**

The Onset HOBO Data Shuttle's clock was synchronized with the host computer prior to offloading data from the Onset HOBO Event Loggers. This ensured that the Event Loggers were re-launched with the most accurate time settings. Once on-site, the rain gage was inspected for obvious abnormalities such as leaning mounting posts, missing or broken parts, etc., and the funnel was lifted from the top of the bucket exposing the tipping mechanism and Event Logger. The Event Logger was pulled out making sure not to disturb the tipping mechanism and the wire connecting it to the rain gage was unwound. The top of the Event Logger was opened and the connection cable was inserted into the Data Shuttle. To offload the data, a button on the Data Shuttle was engaged until the testing light began to flash. The button was depressed a second time to reset the Event Logger. When the "successful" light began to flash, the button was pushed a third time to complete download and re-launch of the Event Logger. The Data Shuttle was unplugged from the Event Logger and the case closed on each instrument. The connection wire was then wrapped around the Event Logger and placed securely back inside of the gage bucket. The tipping mechanism was then checked to ensure proper range of motion. The funnel and bucket was examined for bugs and debris and cleaned if needed, and the entire apparatus was checked and adjusted for structural integrity.

### **Uploading Data Shuttle Information to the Computer**

Information was transferred by connecting the Data Shuttle to the computer using a PC interface cable. Using the Onset Corporation Boxcar software, the HOBO Shuttle readout was selected from the logger menu to retrieve the data from each gage and saved to the file specified for that location. This information was transmitted via email to Paul Price Associates, Inc. for database inclusion.

### **Task 9: Intensive Monitoring**

The intensive surveys in the Lake O' the Pines Watershed characterized dissolved oxygen and nutrient concentrations in receiving waters and in point source discharges during summer low flow conditions. The Intensive Monitoring Program was initiated to provide the data used for the calibration and verification of a steady state water quality model to be used for the investigation of linkages among the sources of oxygen-demanding materials and nutrients in receiving waters

and in point source discharges, and dissolved oxygen characteristics of Lake O' the Pines watershed during summer low flow conditions. Intensive surveys in the Lake O' the Pines Watershed were conducted in August 1998 and August/September 1999 in conjunction with the Cypress Creek Basin Clean Rivers Program to provide quantitative water quality and biological data during extreme low flow events. These studies were funded by the Pilgrim's Pride Corporation to facilitate TMDL progress while work plans and the QAPP were being developed. Procedures and documentation utilized during the intensive surveys were consistent with those specified in the QAPP.

The intensive survey sampling was performed under summer low flow conditions in 1998 and 1999. In addition, a hydrologic survey of Big Cypress Creek, tributary streams, and point source discharges was completed. Documentation of baseflow loads of oxygen demanding materials and nutrients in point source discharges and throughout the Lake O' the Pines watershed was accomplished with each survey. Additional aquatic habitat use surveys were completed at four locations on Big Cypress Creek.

Source monitoring encompassed collection and analysis of four effluent water samples over a 24-hour period (approximately 6 hours apart) at each of the major permitted dischargers in the Lake O' the Pines watershed. Source monitoring stations are listed in Table 2-8. The field parameters, (sampling time, flow, dissolved oxygen, temperature, conductivity, pH, and Secchi depth) were measured as appropriate to document outfall conditions at each source location with each water sample. Effluent discharge volumes coincident with sampling were provided by the discharger using the methods employed for self-reporting. Stream Monitoring samples were collected at twenty-two stations located on the major tributaries to Lake O' the Pines for the same parameters being measured at the point sources (Tables 2-9 and 2-10). Station locations are shown for both source and stream stations in Figure 2-5. Water samples were collected twice during a 24-hour period (between 6:00 and 8:00 AM and between 5:00 and 7:00 PM) at each of the stream monitoring stations. Each sample was obtained by standing downstream of the sample bottle and directly immersing the container about one foot below the water surface. The sample bottle label for every sample was marked in permanent ink with the exact information requested. A chain-of-custody form was filled out for each sample taken and transported to the lab where they were composited and analyzed for the CNP parameter specified in the Task 6 water quality collection set.

YSI 600XLM dataloggers were employed (as described in Task 6) at selected locations to measure field parameters (temperature, dissolved oxygen, conductivity, and pH) over a 48-hour period encompassing the sample collection period. At the remaining sample stations, instantaneous field parameters were measured at least four times over a 24-hour period concurrent with water sample collection in accordance with the 1999 TCEQ SWQM Procedures Manual.

Stream flow measurements were made at sample locations lacking stream gauges once during the intensive survey, during periods other than the morning and evening water quality sampling. Variations in stream flow during the survey period were monitored by accessing the gage heights recorded at USGS Gauge No. 07344500 (Big Cypress Creek near Pittsburg) and by reference to temporary staff gages during sample collection visits to stream flow stations.

**Table 2-8.  
Source Monitoring Stations.**

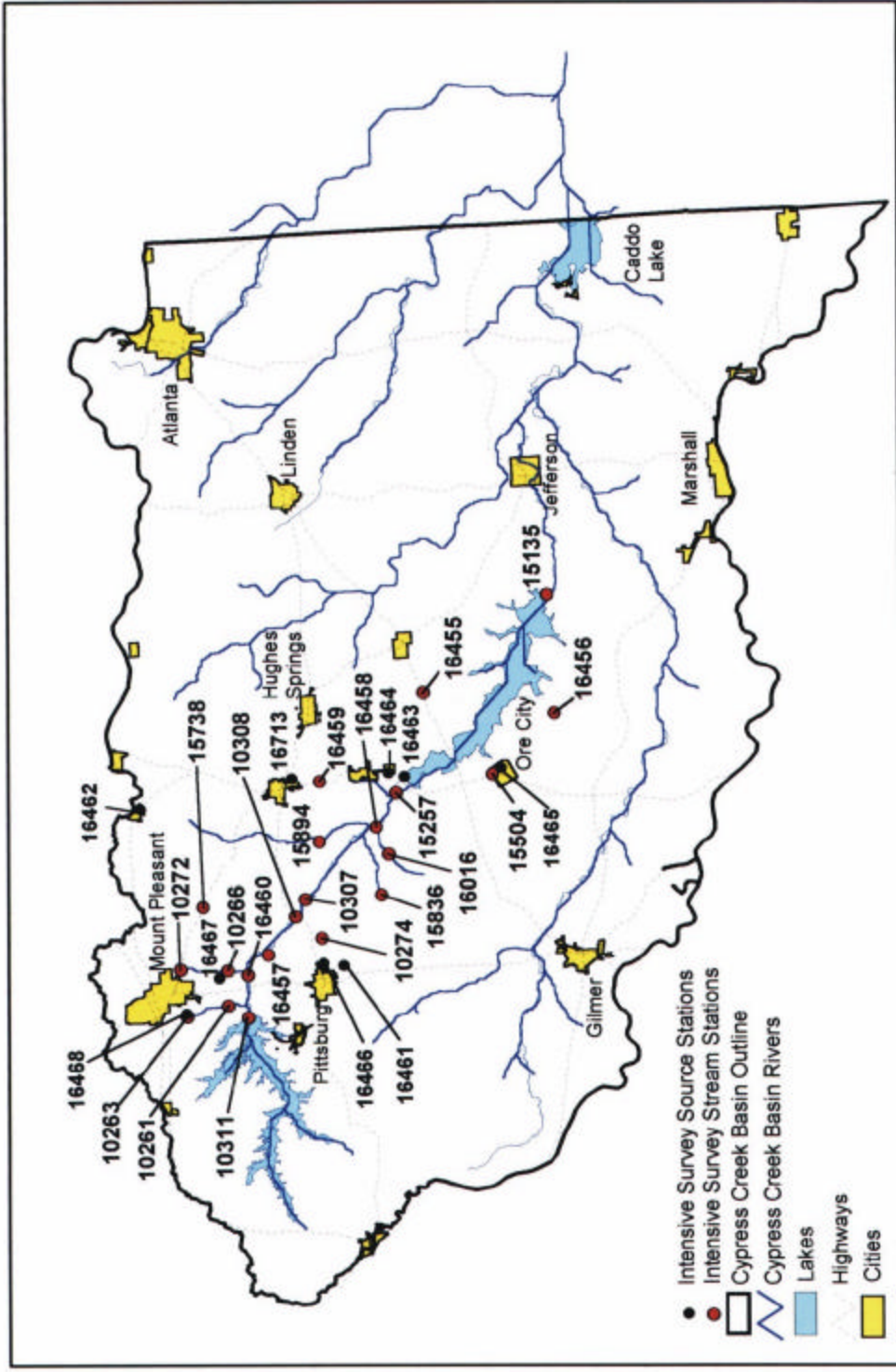
Number	TNRCC Station	Facility
1	16465	Ore City WWTP
2	16463	City of Lone Star WWTP
3	16464	Lone Star Steel WWTP
4	16466	City of Pittsburg Sparks Branch WWTP
5	16461	City of Pittsburg Dry Creek WWTP
6	16468	Pilgrim's Pride Processing Plant WWTP
7	16467	City of Mount Pleasant WWTP
8	16462	City of Omaha WWTP
9	16713	City of Daingerfield WWTP

**Table 2-9  
TMDL Intensive Survey Parameters**

Field Parameters	CNP
Discharge (Flow)	Ammonia
Time	Nitrite-nitrate
Dissolved oxygen	TKN
Temperature	T-P
Conductivity	O-P
PH	Chlorophyll <i>a</i>
Secchi Depth	TOC
	BOD (Total and N-suppressed)
	TSS

**Table 2-10  
Stations and Parameter Sets for Intensive and Aquatic Life Critical Condition Monitoring.**

<b>Segment</b>	<b>TNRCC Station</b>	<b>Location</b>	<b>Field</b>	<b>Data Logger</b>	<b>CNP</b>	<b>Discharge</b>	<b>RBA</b>	<b>Sediment Oxygen Demand</b>
0404	10311	Big Cypress Cr below Lake Bob Sandlin Dam	*	*	*			*
0404	16460	Big Cypress Cr @ Gasline crossing	*	*	*	*	*	*
0404	16457	Big Cypress Cr below Walker Creek	*	*	*	*	*	*
0404	10308	Big Cypress Creek at HWY 11	*	*	*	(USGS Sta)		
0404	10307	Big Cypress Creek at Fish Camp	*	*	*	*	*	*
0404	16458	Big Cypress Creek near Greasy Creek	*	*	*	*	*	*
0404	15257	Big Cypress Creek above FM997	*	*	*			*
0402	15135	Big Cypress Creek below Lake O' the Pines Dam	*	*	*	(USGS Sta)		
0404	10263	Tankersley Creek at FM 127	*	*	*	*		
0404	10261	Tankersley Creek at FM 3417	*	*	*	*		
0404	10272	Hart Creek at SH 49	*	*	*	*		
0404	10266	Hart Creek at SE 12	*		*	*		
0404	16454	Walkers Creek at US 271	*		*	*		
0404	15738	Swanano Creek at SH 11	*		*	*		
0404	10275	Dry Creek at CR 4230	*		*	*		
0404	15836	Prairie Creek at FM 557	*	*	*	*		
0404	16016	Greasy Creek at FM 557	*		*	*		
0404	15894	Boggy Creek at FM 144	*	*	*	*		
0404	16459	Brutons Creek above Ellison Creek Reservoir	*		*	*		
0403	15504	Meddlin (S. shore LOP)	*		*	*		
0403	16456	Arms Creek (S. shore LOP)	*		*	*		
0403	16455	Alley Creek (N. shore LOP)	*		*	*		



TMDL Intensive Survey



6 0 6 12 Miles

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 ECOLOGY, WATER QUALITY, CULTURAL RESOURCES, PLANNING

Biological sampling was conducted on Big Cypress Creek at four stations (Pipeline Crossing, below Walker Creek confluence, Fish Camp, and on Nix Property near Greasy Creek) during the 1998 and 1999 intensive surveys and again in August 2001. Biological sampling and analytical procedures used were outlined in Chapters 2, 7, and 8 of the Final 1999 Surface Water Quality Monitoring Procedures Manual and the 1999 Receiving Waters Assessment Procedures Manual. A detailed description of biological sampling is found in the Task 6 Methodology Section under RBA Collection of this document.

### **Task 10: Toxicity Screening/Metals in Sediment and Tissue**

Two segments in the Cypress Creek Basin appeared on the final EPA 303(d) list on 26 June 1998. This final list indicated that segments 0403 and 0404 were not supporting water quality standards. When the TMDL was initiated in FY1999, the conditions of concern identified in the 1998 303(d) list for Lake O' the Pines included dissolved zinc exceeding aquatic life criteria, low dissolved oxygen concentrations, persistent high selenium concentrations in fish tissues collected from Welsh reservoir, and a Texas Parks and Wildlife Department report that native mussels (*Pelecypoda, Unionidae*) were lacking in the stream due to point source loading in a major tributary, Tankersley Creek. In order to evaluate these problems the following measures were initially planned: 1) Collection and analysis of sediment samples for excessive levels of zinc in the lower portion of Lake O' the Pines to localize potential sources of dissolved zinc in Segment 403, 2) A compilation of existing information on excessive levels of selenium in Welsh Lake with evaluation of the need for remedial action or additional study, and 3) evaluation of the potential ambient toxicity throughout the Lake O' the Pines watershed using a biologically based screening method. Subsequent use of clean sampling techniques has eliminated concern over excessive zinc concentrations, and Segment 0403 was removed from the draft 2000-303(d) list.

### **Welsh Reservoir**

Several electric-generating power plant cooling reservoirs in east Texas, including Welsh Reservoir (Segment 404D), were found to exhibit excessive concentrations of selenium in game fish tissue. These levels in Welsh Reservoir were sufficient to warrant issuance of consumption advisories by the Texas Department of Health, and for Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service to express concerns over the reproductive health of resident fish populations. In 1991, the Texas Natural Resource Conservation Commission required continuing monitoring of selenium concentrations in game fish populations, and the reservoir was placed on the draft 2000 303(d) list (April 28, 2000).

Existing data for fish tissue, water, and sediment sampling in the Big Cypress Creek basin was accessed, assembled, reviewed and used to identify the source of selenium in Welsh Reservoir. Recommendations were made to address the problem in a draft report entitled *Summary of Available Information on Selenium Concentrations in Welsh Reservoir with Recommendations for Necessary Corrective Actions* to the stakeholders and TCEQ dated September 8, 2000. Since this time, TCEQ has been in contact with the reservoir owner and is presumably acting to reduce or eliminate the continuing addition of selenium to the reservoir in the ash pond discharge.

A related concern added to the TMDL by the basin stakeholders included potential impairment of biological uses in the Lake O' the Pines tributary network due to potential toxicity. As part of Task 10, The Screening Survey for Toxic Conditions, RBA techniques were used to prepare screening-level assessments of aquatic life uses in Big Cypress Creek and selected tributaries. RBA sampling to determine habitat, fish and macroinvertebrate community integrity was conducted during August/September 2000 and August 2001 in the lowermost, accessible, flowing reaches of the major tributaries to Big Cypress Creek: Greasy Creek, Boggy Creek, Swauano Creek, Prairie Creek, Dry Creek, Hart Creek, and Tankersley Creek; and at the four Big Cypress Creek stations sampled during the 1998 and 1999 Intensive Surveys. The procedures and analytical protocols used were those outlined in Chapters 2, 7, and 8 of the Final Surface Water Quality Monitoring Procedures Manual (TNRCC, 1999), and are discussed in detail above under Task 6, Baseflow Monitoring..

### **TPWD Mussel Surveys**

The TPWD surveyed only the Big Cypress Creek crossings at highways 271 and 11 for native mussel species. Subsequent non-systematic observations performed at several locations on this stream have indicated that numerous live native bivalves were present, although the abundance and diversity of the assemblage may be less than expected based on the early history of the pearl mussel industry in the region. While the mussel assemblage of Big Cypress Creek was not inventoried in detail to assess its abundance and diversity, this community has evidently not become extirpated as was originally feared.

### **Low Dissolved Oxygen Concentrations**

With respect to dissolved oxygen concentrations, critical conditions are generally associated with high water temperatures and low flow conditions when respiratory demands are greatest, the volume of aquatic habitat is at a minimum, and physical reaeration mechanisms are least effective. Critical conditions were defined with respect to the historical duration and severity of low flow periods and expected return intervals.

The studies necessary to delineate the depressed oxygen levels problem in Segment 0404 will also contribute to and be coordinated with, the TMDL effort to be conducted in Segment 0403. Existing data from the USGS, SWQM, and Cypress Basin CRP, was compiled and systematically examined to identify and locate impairments or water quality characteristics suggestive of potential problems, such as elevated nutrient levels and excessive plant growth, and any additional periodic monitoring stations or activities necessary to characterize these problems.

The diurnal oxygen variation on Big Cypress Creek was monitored during warm, low flow periods to delineate the spatial extent, frequency, and magnitude of low DO episodes, evaluate the extent to which segment standards are not achieved, and assist in the determination of factors responsible for observed DO regimes.

Segment 0404 was subsequently removed from the 303(d) list for low dissolved oxygen concentration as a result of a change in the expected aquatic life use and associated segment standards for dissolved oxygen.

### **Task 11. Development of a GIS-Based Source Inventory for the Lake O' the Pines Watershed**

A comprehensive, GIS-based source inventory of potential sources of pollutants in the Lake O' the Pines watershed to support linkage analysis, allocation, and development of the Watershed Action Plan was developed for this task. The resulting database accounts for all of the permitted point source dischargers in the Lake O' the Pines Watershed, and identifies and delineates potential non-point sources and landuse types for approximately 90% of the watershed.

A landuse layer, including the extent and nature of major potential sources of pollutants, including poultry farms, litter disposal areas, and permitted discharges already exists within a GIS database developed for the Cypress Creek Basin Clean Rivers Program. The portion of this database covering the Lake O' the Pines watershed was expanded to include additional information specific to the watershed area. Existing information on topography and the distribution of soils and vegetation types was acquired and incorporated with existing GIS layers to facilitate interpretation of landscape loading data.

Subwatershed boundaries generated by Digital Elevation Modeling were screened for accuracy by comparison with digital raster graphic (drg) files or paper topographic maps (USGS 7.5 minute quadrangles), as appropriate. Where necessary, subwatershed map layers in the existing GIS database were manually edited to separate merged drainages and to modify subwatershed boundaries.

The positions of possible areas of concern were determined utilizing a Global Positioning System (GPS), which produces latitude and longitude coordinates and whose information is then incorporated into the GIS program. Additional information relating to these positions such as sampling data or discharge information was linked directly to the mapped information. The relationships of the different layers that are mapped and spatially analyzed help to establish potential interrelationships and possible influences on water quality within the watershed. An example of this use could be the relative proximity of point or non-point source contributors to areas with identified water quality concerns. The location data points of monitoring stations and other GPS'd positions, and any associated information was provided to TCEQ in a database format for inclusion in their GIS inventory.

A GIS-based source inventory of potential sources of pollutants in the drainage basin of Segment 0403 and 0404 was developed. The location, extent and nature of major potential sources of pollutants, including poultry farms and litter disposal areas, and permitted discharges were incorporated within our present land use database for the Lake O' the Pines watershed. This database was expanded to include the same information on smaller dischargers and other potential pollutant sources such as industrial sites, areas exhibiting large concentrations of on-site disposal systems, and waste disposal facilities. Current information from Pilgrim's Pride Corporation on poultry litter disposal areas and events was used to update the database. In

addition, a layer representing the total number of fish kills within stream segments 0401-0409 obtained from information provided by Texas Parks and Wildlife Department, and effluent reports on the outfalls of the TXU mines from TNRCC have been added.

## **Task 12. Lake O' the Pines Watershed Water Quality Analysis and Model Development**

Emphasizing critical conditions, a combination of data analysis and modeling was employed to make preliminary determinations of the responses to loadings of oxygen demanding materials and nutrients in Big Cypress Bayou and Lake O' the Pines. Hydrological, water, and sediment quality data collected or compiled during this project were reviewed and analyzed to characterize the factors affecting water quality behavior in the basin. A preliminary analysis of water quality behavior and responses in the watercourses as a function of seasonality, development, and location was completed in a series of technical memoranda that were submitted to TCEQ as they were completed. Using this information, available hydrological and water-quality models were reviewed and those best suited for TMDL determination for the Lake 'O the Pines watershed selected.

For the analysis of the Big Cypress Creek system under conditions of steady flow and equilibrium, water quality was treated as a one-dimensional longitudinally varying stream network. The process and background used to select QUALTX as the appropriate model for depicting low flow regimes in the Lake O' the Pines watershed was explicated in "Rationale for Selection of steady State Stream Model" by Dr. George Ward (2 June, 2000).

Similar analyses were conducted to select a numerical model for Lake O' the Pines. Technical Memoranda summarizing the existing data concerning the lake temperature regime and the importance of stratification, dissolved oxygen conditions and trends, and the light environment of Lake O' the Pines have been submitted at this time. The five Technical Memoranda include:

*"Thermal structure of Lake O' the Pines*

*"Light penetration in Lake O' the Pines*

*"Dissolved oxygen structure and trends in Lake O' the Pines"* (September 2000),

*"Volume budget and hydrological variability of Lake O' the Pines"* (February 2001), and

*"Seasonal and hydrological controls on dissolved oxygen in Lake o' the Pines"* (February, 2001).

The analysis contained in this series of Technical memoranda formed the basis of the report "Rationale for Selection of Lentic Model" by Dr. George Ward (March 2001), which presents the strategy of model development for Lake O' the Pines. A QUALTX model of Lake O' the Pines has been calibrated and verified and was submitted to the TCEQ in August 2002.

Analysis of the hydrologic behavior of the Big Cypress Creek system has included consideration of stream conditions of steady flow and equilibrium water quality in which the stream system is treated as a one-dimensional longitudinally varying stream network ("Rationale for Selection of Steady State Stream Model" Ward, June 2000). Hydrological cross section functions were developed and reported in "Estimation of Hydraulic Properties of Channels in Big Cypress Basin" Ward, May 2001. Network and supporting Kinetics analysis techniques were developed to delineate production, respiration and reaeration in the steady-state model of Big Cypress

Creek as described in “*Calibration and Verification of QUALTX Model of Big Cypress and Tributaries*” Ward, March 2002. These techniques were also employed in implementing the Lake O’ the Pines model, which is described in “*Calibration and Verification of Lake O’ the Pines QUALTX Water-Quality Model*” Ward, August 2002.

The brief travel time from the headwaters to Lake O’ the Pines, and the lack of degraded conditions in Big Cypress Creek, at least during conditions of significant flow led us to conclude that the use of a separate model to depict the dynamic storm response of Big Cypress Creek was not warranted. The analysis leading to this conclusion was presented in “*Rational for Selection of Dynamic Stream Model*” Ward, September 2001. The additional field data collected in the lake during the summer of 2002 was evaluated to better characterize and define the range of variation in the near steady-state “summer conditions” employed in the most current QUALTX analysis of reservoir dissolved oxygen kinetics.

### **Task 13. Development and application of watercourse and watershed models to the Lake O’ the Pines TMDL Determination**

Application of the modeling framework developed in Task 12 to the Lake O’ the Pines watershed was used to develop a determination of assimilative capacities and establish the TMDL. Included were allocation of loads among sources, and evaluation of alternative control strategies.

Suitable models have been developed to quantify the response of water quality to landscape and waste discharge activities, and the combinations of external conditions have been analyzed that are critical for water quality. Following this action, the capacity of the watercourses for assimilation of contaminants was evaluated. Application of the calibrated models with inputs corresponding to critical conditions for maintenance of dissolved oxygen segment standards, and other selected critical parameters, were employed to determine the assimilative capacity of the system.

### **Task 14. TMDL Documentation**

This report describes the watershed data collection, modeling work, and development of the TMDL. This TMDL documentation report was produced in conformance with TCEQ and EPA guidance to describe the Lake O’ the Pines watershed modeling procedures, results and conclusions. The protocol for development of the TMDL and allocation of pollutant loads, including description of the uncertainty analysis and determination of an appropriate margin of safety was described in detail in this report. A draft report was prepared for review and comment, and a final report will be prepared after consideration of the comments.

### **Other Studies Related to the TMDL Monitoring Tasks: 1999 Poultry Operations Water Quality Impact Study**

The development of the Poultry Litter study and selection of the study watersheds was carried out by the TCEQ as an agency-wide project. It included personnel from the Water Quality Standards Team, Field Operations, the Surface Water Quality Monitoring Team, Non-point

Source Pollution, and Modeling. Study design and monitoring site selection criteria were based on the representation of all poultry production activity in the Cypress Creek Basin in an attempt to match poultry (intensive poultry production) and reference sub-watersheds. Sub-watersheds were evaluated with respect to stream order, vegetation, topography, soils, and land uses other than for poultry production to monitor station locations in each sub-watershed as far downstream as practical and select stations consistent with the need to conduct sampling during wet weather conditions.

TNRCC personnel made two field trips to the Cypress Creek Basin during October 1997, to locate and verify the presence of poultry operations and to select the four sub-watersheds for the monitoring study. Using landuse aerial flyover map photography provided by the Farm Service Agency and the Natural Resource Conservation Service, poultry operations were located on topographic and county maps, and poultry and reference sub-watersheds were identified. Two sub-watersheds were selected in areas of concentrated poultry operations (Lilly and Prairie creeks) and two sub-watersheds without significant poultry, or other confined animal feeding facilities, were selected as references (Boggy and Frazier creeks). A total of nine sites were selected for monitoring in the four study sub-watersheds.

All instrument calibration, field measurements, sample collection, preservation and transportation, chemical analysis, data archiving, and quality assurance checking was performed according to procedures outlined in the Quality Assurance Project Plan (QAPP) developed for this program that largely incorporated the 1997 *TNRCC Surface Water Quality Monitoring Procedures Manual* and the 1996 TNRCC QAPP for programs associated with surface water quality routine monitoring, intensive surveys, use attainability surveys, special studies, and receiving water assessments.

Members of the TCEQ Surface Water Quality Monitoring Team (SWQM) began the fieldwork at the four study streams in October 1997 and carried out monthly monitoring until August 1998. Measurement of field parameters and the collection of conventional water samples were carried out on a monthly basis from October 1997 to August 1998. Dissolved metals in water were collected twice (February and April, 1998), and sediment samples were collected once for analysis of metals and associated parameters in April 1998. Habitat and biological surveys were conducted once in May 1998 at the lowermost monitoring site within each of the four sub-watersheds using rapid bioassessment (RBA) techniques that included habitat assessment, fish, and benthic macroinvertebrate assemblages.

The stream physical habitat assessments were made over a one-half mile length of creek at each of the four stations based on the sampling guidelines found in the 1997 SWQM Procedures Manual. Prior to field sampling, the stream gradient (ft/ft) and the drainage area upstream from the sampling site was determined ( $m^2$ ) with the use of United States Geological Survey (USGS) 7.5 minute quadrangle maps. The field habitat assessment at each site was performed using four to eight lateral transects at regular intervals throughout the reach evaluated. One instream flow measurement was taken from one transect and calculated by taking 10-20 velocity measurements and depths across the width of the stream. Stream characteristics as discussed in the aforementioned methodology for RBA collection was measured at points across the stream at each transect.

All available habitats and combinations of habitats were sampled to adequately characterize the fish and benthic macroinvertebrate communities. Biological collections and laboratory identification and enumeration were conducted similarly to that previously discussed in the RBA collection section.

An attempt was made to collect water samples from all flow conditions, however the Poultry Operations Study did not include a wet weather monitoring program to characterize loading from run-off events. Most samples were collected during low to normal flow conditions while a limited number of samples (January and February 1998) were conducted during over bank events. Flow measurements could not be taken during those events because of a lack of suitable stream cross sections to measure.

The TCEQ Houston laboratory was responsible for the analysis of all water and sediment samples collected during this study. Sampling procedures, laboratory methods, and reporting criteria, including MALs (minimum analytical levels to be achieved at the lab) followed the guidelines contained in the 1997 TNRCC Cypress Basin Poultry Operations Study QAPP.

All the data collected by TCEQ during the study was archived in Microsoft Excel 5.0 spreadsheets and used in that format for subsequent analysis. This database was quality assured by comparing the spreadsheet values with the original field sheets and lab reports, and with the warning limits listed in Appendix 13 of the TNRCC Water Quality Monitoring Procedures Manual issued in 1994. The raw data was screened for consistency with the Quality Control Requirements established in Section B5 of the QAPP.

Trip blanks, equipment blanks and field blanks were not employed in this study. In February 1998, field duplicate conventional parameters and duplicate dissolved metals samples were collected from Lilly Creek Station 1.

Stream order was determined by station location on each study stream with reference to the appropriate USGS quadrangle maps. Streams shown as headwater without tributaries were designated as first order.

Data analysis was conducted using Excel spreadsheets for data manipulation, preparation of table, graphs, and correlation analyses. SigmaStat 2.0 was used to perform other statistical analyses on the data. Analysis of the relationships and interactions of water quality parameters was facilitated by construction scatter plots of paired values available over all stations and dates. Time series graphs were also prepared for preliminary evaluations of water quality conditions and seasonal differences among sub-watersheds.

Statistical testing for significant differences in water quality parameters among dates, stations and sub-watersheds were conducted in a stepwise manner as a result of unequal sample sizes and missing data, which precluded the use of a three-way Analysis of Variance (ANOVA). Attempts were made with a variety of transform functions to normalize the field and conventional parameter data, generally without success. Most of the data was tested over individual treatments (date, station, sub-watershed) using a non-parametric analog of a one-way ANOVA,

and the Kruskal-Wallis one-way ANOVA on ranks. The Tukey Test was used to perform multiple comparisons where significant results were obtained in the two way ANOVA, and Dunn's test was employed when Kruskal-Wallis testing indicated significance. Statistical significance was set at  $P < 0.05$  for all testing. To enable statistical testing, non-detects were assigned values equal to one half the tabulated detection limits shown in the 1998 TNRCC *Guidance for Screening and Assessing Texas Surface and Finished Drinking Water Quality Data*.

Mapping of the study areas, and maintenance of the database information was attained with the use of ArcView GIS software. Information concerning location of the poultry farms, and the location and amount of each poultry operation event was obtained from database information provided by Pilgrim's Pride Corporation. The geographic location of each farm and litter event was entered in a database that was sent to TCEQ, and after data manipulation, returned in ArcView format. The formatted databases of information and their associated map layers of information were added to the existing TCEQ Cypress Creek Basin mapping information.

Landuse information for the study area was also provided by TCEQ. Areas designated as sub-watersheds within the study parameters were linked by TCEQ to the database information containing the landuse data. This provided detailed information about landuse within the specific sub-watershed areas. This information was exported in database format to Microsoft Excel and manipulated through grouping and mathematical calculation to obtain the landuse numbers used for the report.

### **1999 Lake O' the Pines Nutrient Study**

Nutrient levels in Lake O' the Pines during 1998-1999 were monitored as part of a special nutrient study. The field study was focused on obtaining the limnological data necessary to understand basic lake processes, data on nutrient levels, and biological activity in the lake over an annual cycle. This information was ultimately to be used to support the development of a nutrient budget of sufficient accuracy to assess the eutrophication risk of Lake O' the Pines relative to other reservoirs within Cypress Creek Basin and the surrounding area. This information was also intended to provide a background on which to assess data collected on nutrient loadings throughout the Lake O' the Pines watershed. Eight stations were established (four within the main lake and four within large coves) and sampled. Sampling of specific stations occurred on a monthly basis during Fiscal Year 1999 for field and water nutrient parameters, and once for sediment parameters.

Transects were established at approximately 1 mile intervals beginning at the dam and moving upstream to approximately 1 mile above State Highway 155. From that point, the lake was impassible due to low lake levels and dense aquatic vegetation. Along each transect, depths and vertical profile data (temperature, conductivity, dissolved oxygen, pH, and depth) were taken at three to six equidistant points. Hydrographic characteristic profiles and depths were measured using an YSI 600-XLM multi-parameter probe calibrated according to the 1997 TNRCC Surface Water Quality Monitoring Procedures Manual, and a 20 cm standard Secchi disk.

A Global Positioning Satellite System was employed in an attempt to develop a bathymetric map of Lake O' the Pines to a resolution at least comparable to that on a USGS 7.5 minute Quadrangle map. GPS coordinates were recorded at each bathymetric mapping point and placed on a map to show where the corresponding depths were recorded. Only four of the 14 transects (1,2,6 and 7) were plotted, however, due to problems with the GPS unit memory. The remaining points were estimated from compass bearings to shoreline features and plotted on a map of the reservoir. These transects were not revisited to obtain GPS coordinates because the Texas Water Development Board was in the process of performing a volumetric survey of the Lake utilizing equipment with a higher level of accuracy and precision.

During bathymetric mapping, data were also collected to map the distribution and abundance of submerged and emergent rooted vegetation. The presence/absence of rooted vegetation was established using direct observation. Relative densities of vegetation stands were established using a line-intercept method following the established bathymetric transects. Vegetation mapping was updated quarterly during regular monitoring field trips by visual inspection.

Hydrographic characteristics of Lake O' the Pines were initially documented along the 14 transects by measuring field parameters (dissolved oxygen, temperature, conductivity, pH, depth, and Secchi depth) in vertical profiles at 1.0 m intervals during the 2-8 August 1998 bathymetric mapping survey. Between September and November 1998, field parameter profiles were taken at the dam and Longview Intake. Profiles were subsequently measured monthly beginning in December 1998 at all eight stations. Field parameter profiles and depths were measured using an YSI 600-XLM multi-parameter probe calibrated according to the 1997 TNRCC Surface Water Quality Monitoring Procedures Manual, and a 20 cm standard Secchi disk.

Water column nutrient parameters (Total phosphorus, ortho-phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate plus nitrite, total organic carbon, chlorophyll *a*, and pheophytin *a*) were collected from the surface and near bottom on a monthly basis from August 1998 to August 1999. The water samples were collected from the two downstream stations located in the main basin of Lake O' the Pines (dam and Longview Intake) using a horizontal closing water bottle and following the procedures outlined in Chapter 5 of the 1997 TNRCC Surface Water Quality Monitoring Procedures Manual for the collection of routine water chemistry.

Diurnal dissolved oxygen/temperature profile measurements were recorded four times at each of the 8 lake stations on 19-20 February, 26-27 May, 12-13 July, and 16-17 August 1999. The four diurnal sampling studies were conducted in conjunction with the routine nutrient sampling and primary productivity studies to allow for the data to be temporally related. In addition, the diurnal studies were conducted during periods of clear, calm weather to maximize the photosynthetic signal. Vertical profiles of field parameters were taken at all eight stations twice during the first collection event but were subsequently collected four times over a 24-hour period during the last three events. Diurnal data was collected in attempt to capture the maximum diurnal variation at each sampled location using an YSI 600-XLM multi-parameter probe calibrated according to the 1997 TNRCC Surface Water Quality Monitoring Procedures Manual.

Sediment nutrient parameters (Total phosphorus, total Kjeldahl nitrogen, total organic carbon) was measured from single core samples collected at each of the eight hydrographic stations on

30-31 August 1999 using an AMS 24" X 1" soil recovery probe and plastic liner. The single core samples collected at each location were frozen on dry ice and transported to the chemistry laboratory for analysis in 2 cm thick sections taken from the surface and from 5 cm, 10 cm, and 20 cm depths.

The original scope of the study was to collect monthly phytoplankton samples using a closing water bottle from the surface mixed layer at each hydrographic station, preserved in the field, and returned to the lab for identification, enumeration and biovolume estimation using a Palmer-Maloney counting chamber. However, collections were made with plankton net having a mesh size too large for phytoplankton. These samples were preserved in a 10% buffered formalin solution and have been stored at the lab. Sample analysis has not been performed.

Net production of periphyton was measured once at three locations (at dam, Longview Intake, and NETMWD Intake) by incubating glass slide substrates *in situ* using 10-slide periphytometers. A total of six periphytometers (two at each station) were set out at the three stations listed above on 30 September 1998. On 6 October 1998 four slides were retrieved from each location. Only one periphytometer was found at each location however. Each sample was preserved in glass jars fixed in a 10% buffered formalin solution and returned to the East Texas Baptist University Lab. By the end of the 25-day period only 2 of the six periphytometers were retrieved with four being lost. The remaining quarterly net production studies were abandoned due to the lack of equipment. The recovered slides have not been processed.

Primary production was measured during four separate studies at two main Lake (at the dam and Longview Intake) and two cove stations (Copeland Creek Cove and Hurricane Creek Cove) concurrent to the diurnal dissolved oxygen/temperature profile measurements taken in February, May, July, and August 1999. An oxygen-based light and dark bottle technique was used based on the procedures outlined in Standard Methods for the Examination of Water and Wastewater Part 1002 I – Plankton Metabolic Rate Measurements (American Public Health Association, 1985). In the oxygen-based light and dark bottle technique, the increase in dissolved oxygen concentration in the light bottle during incubation is a measure of net production while the loss of oxygen in the dark bottle is an estimate of respiration.

### **2001 Special Study of Poultry Operations**

The primary objective of this study was to extend the water quality database for the sub-watersheds that were sampled as part of the 1999 Poultry Operations Study (listed above), of the water quality impacts of the poultry production industry through the continuation of four sampling stations established by TNRCC on Frazier, Lilly, Prairie, and Boggy creeks in 1997. An additional station was established on the lower portion of Walker's Creek downstream of the proposed Pilgrim's Pride Corporation Walker Creek Poultry Processing Facility.

All instrument calibration, field measurements, sample collection, preservation and transportation, chemical analysis, data archiving, and quality assurance checking was performed according to procedures outlined in the Quality Assurance Project Plan (QAPP) developed for this program that largely incorporated the 1999 *TNRCC Surface Water Quality Monitoring*

*Procedures Manual* and the 1996 QAPP for Surface Water Quality Routine Monitoring developed for programs conducted by TNRCC.

Field work was initiated in October 1999 with monthly measurements of field parameters and conventional water collection that continued through June 2001. Sediment samples were collected at the five stations in July 2000 and July 2001. The Ana-Lab Corporation in Kilgore, Texas was responsible for all chemical analysis on all samples collected during this study. Sampling procedures, laboratory methods, and reporting criteria, including MALs (minimum analytical levels to be achieved at the lab) followed the guidelines contained in the 1999 TNRCC Cypress Basin Poultry Operations Study QAPP.

An attempt was made to collect water samples from prevailing flow conditions, however as with the 1999 Poultry Operations Study, this study did not include a wet weather monitoring program to characterize loading from run-off events. Most samples were collected during low to normal flow conditions while several samples were collected during periods when stream flow was too great to allow discharge measurements to be recorded.

Quality assured Special Study data was downloaded from the TNRCC TRACS database, sorted using Microsoft Access and loaded into Excel 2000 spreadsheets for analysis. Statistical testing was identical to the relationship analyses made for the 1999 poultry study.

The habitat and biological surveys were conducted in August 2000 and June 2001 using the same RBA assessment methodology used for the previous poultry study collections.

### **USACE Study of Lake O' the Pines**

Summary of U.S. Army Corps of Engineers and U.S. Geological Survey water quality and biological (phytoplankton, fecal coliform) monitoring at Lake O' the Pines.

### **Task 15: Technical Support for Preparation of Implementation Plans**

Although specific pollutant loads causing water quality problems in Segment 403 have not been quantified and allocated, the general outlines of the problem have been identified; excess nutrient and oxygen demand is transported through surface runoff to Lake O' the Pines where low dissolved oxygen concentrations develop in the surface mixed layer during summer stratified conditions. Any implementation plan developed to address that situation will require continuing monitoring to track trends through time, and will likely need to specify a range of management practices to be applied in some or all the subwatersheds draining into Lake O' the Pines to reduce nutrient loading. Two major activities in support of TMDL development and implementation have been initiated within the Cypress Creek Basin within the last biennium, realization of the Clean Rivers Program monitoring and NETMWD/Pilgrim's Pride Corporation agreement.

The Northeast Texas Municipal Water District (NETMWD) assumed direction of the Clean Rivers Program Water Quality Monitoring in the Cypress Creek Basin during 1998. Under the direction of NETMWD, the program has greatly expanded its activities, focusing on support of

TMDL development, and the identification and delineation of potential impairments. These include commitment to development of long term data sets for additional selected locations in the Lake O' the Pines watershed, studies addressing the elevated bacterial numbers reported from Tankersley Creek and examination of other areas for the same problems, intensive sampling for nutrients and bacteria at Lake Cypress Springs, and sampling in Caddo Lake for organic toxicants.

The second major implementation activity was designed to address both point and non-point source issues within the Cypress Creek Basin. Northeast Texas Municipal Water District (NETMWD) has entered into an agreement with the Pilgrim's Pride Corporation, which allows NETMWD to monitor poultry operations activities within the basin (e.g. Best Management Practices for poultry growers and litter application). This agreement also provides for the active participation in CRP and TMDL monitoring activities by the Pilgrim's Pride Corporation. With respect to non-point source loadings, the NETMWD/Pilgrim's Pride Corporation agreement provides for the implementation of nutrient management plans and best management practices at poultry operation sites. The agreement establishes an inspection program for the following:

- Establish a random inspection program to observe operational and housekeeping practices, and to review plant records at the Tankersley and Walker Creek wastewater treatment facilities, and to monitor progress in facility construction and reductions in nutrient loading.
- Establish a spot inspection program to verify the information in the Litter Management Database and monitor progress in achieving reductions in nutrient runoff from poultry production facilities.
- Establish an inspection protocol for poultry production
- Verify GPS location and other information (No. of houses, size and number of disposal locations)
- Review poultry production/litter application records
- Review soil and litter nutrient analyses
- Review BMP's or Site Specific Nutrient Management Plan in force
- Verify implementation of BMP's or Management Plan
- Document condition of poultry houses, litter and feed storage areas, and disposal fields. Note especially any indication of drainage problems in these areas

In addition to the inspection program, the agreement provides for the implementation of a Complaint Response System. This program will develop investigation protocols and equipment kit for responding to citizen complaints concerning water quality impairments and incidents involving poultry production activities, work with CRP, Citizen Watch, TMDL and other appropriate groups to promote awareness of NETMWD as a basin-wide response agency. Likely complaint categories to be considered in developing protocols and obtaining instruments or materials will include:

- Incidents arising from improper mortality management.
- Litter spills on public roads
- Water quality complaints
- Sludge deposits
- Discoloration, odors, algal blooms

- Identifiable solid materials
- Fish kills
- Reports of operation or maintenance activities out of compliance with BMP's or Management Plan currently in force
- Reports of operation or maintenance activities out of compliance with BMP's or Management Plan currently in force
- Plant upsets at the Tankersley Creek facility, or reports of discharges to Walker Creek

## Problem Definition

Deliverables and Technical Memoranda Submitted to TCEQ During Development of the Lake O' the Pines TMDL	Date of Action
Rational for selection of steady state stream model.	6-02-00 Technical memorandum outlining this rational provided to TCEQ.
Final QAPP	6-23-00 Received final approval and copy of final QAPP from EPA.
Memorandum outlining Watershed Steering Committee consensus concerning desired water quality conditions and project endpoints.	Provided to TCEQ in memorandum dated June 11, 2000 with additional information provided 8-8-00.
Memorandum summarizing selenium concentrations in Welch Lake with recommendations for necessary corrective actions.	8-08-00 Report provided to TCEQ for selenium concentrations in Welch Lake.
Interim Status Reports	10-4-00, 6-8-01, 6-19-02 Interim Status Reports provided to TCEQ.
Rational for selection of lentic model.	3-16-01 Rational for selection of lentic model completed and sent to TCEQ.
Rational for selection of watershed model	10-10-01 Delivered to TCEQ.
Complete input file development for steady state stream model.	7-06-01 Delivered to TCEQ.
Data Management Plan	8-11-00, 7-11-01, 7-10-02 Data Management Plan and updates provided to TCEQ.
Complete calibration for steady state stream model.	3-01-02 <u>Calibration and Verification of QUALTX Model of Big Cypress and Tributaries</u> by Dr. G. Ward provided to TCEQ.
Complete verification of steady state stream model.	3-01-02 Calibration and verification of QUALTX model of Big Cypress and Tributaries by Dr. G. Ward provided to TCEQ.
Recommendations concerning monitoring of water quality trends.	8-30-02 Completed and provided to TCEQ.
Complete input file development for lentic model.	8-30-02 Provided to TCEQ by Dr. George Ward.
Complete calibration and verification of watershed model	12-13-02 Provided to TCEQ by Dr. G. Ward.

Estimation of Hydraulic Properties of Channels in Big Cypress Basin	5-2001
Calibration and Verification of QUALTEX Model of Big Cypress and Tributaries	3-2002
Calibration and Verification of Lake O' the Pines QUALTEX Water-Quality Model	8-2002
Rational for Selection of Dynamic Stream Model	9-2001
Validation of Watershed Loading Model—Technical Memorandum	11-25-2001
Description of Seasonal Effects, Uncertainty Analysis and Margin of Safety	12-05-2002
Complete preliminary Input File Development for Watershed Model	2-2003
Complete Calibration of Lentic Model	8-30-2002
Complete Verification of Lentic Model	8-30-2002
Thermal Structure of Lake O' the Pines Technical Memorandum	9-2000
Light Penetration in Lake O' the Pines Technical Memorandum	9-2000
Dissolved oxygen structure and Trends in Lake O' the Pines Technical Memorandum	9-2000
Volume budget and hydrological variability of Lake O' the Pines Technical Memorandum	2-2001
Seasonal and Hydrological controls on dissolved Oxygen in Lake O' the Pines Technical Memorandum	2-2001