FY-00 319 (C9-996100-08) Task 900 – Priority UWA Watershed Monitoring to Support WRAS and TMDL Development

OKLAHOMA CONSERVATION COMMISSION
DECEMBER 2005

INTRODUCTION

The Turkey Creek watershed is listed as a priority-two watershed under section 303(d) of the Clean Water Act and is one of the top five watersheds in Oklahoma slated for the establishment of a TMDL (ODEQ 2002). Its beneficial uses, as described in *Oklahoma's Water Quality Standards, Subchapter 15: Use Support Assessment Protocols* (OWRB 2002) and in *Continuing Planning Process, Integrated Water Quality Report Listing Methodology* (ODEQ 2002), are Public and Private Water Supply (PPWS), Warm Water Aquatic Community (WWAC), Agriculture (Ag), Industrial and Municipal Process and Cooling Water (Ind), Primary Body Contact Recreation (PBCR), and Aesthetics (Aes) (OWRB 2004). Streams throughout this wheat and cattle producing area are nearly universally threatened by nutrients, siltation, suspended solids, and fecal bacteria. Some of these parameters have been identified at alarmingly high levels.

The Oklahoma Department of Environmental Quality (ODEQ), Oklahoma Conservation Commission (OCC), and U. S. Geological Survey (USGS) have collaborated for several years in order to attempt to correlate the causes of pollution with specific or diffuse sources. Monitoring efforts to confirm or refute the contribution of pollutants from likely sources such as pastures, row crop farming, dairies, waste water lagoons, and animal feeding operations were implemented to aid in the establishment of a TMDL and a watershed restoration action strategy (WRAS) for Turkey Creek.

Following a review of the data available that had been collected by the USGS and OCC, ODEQ determined that the main piece of information missing for development of a TMDL was flow data that could be used to characterize the hydrologic regime of the stream. Although a USGS gaging station is present farther downstream, none existed on the mainstem of Turkey Creek. Therefore, OCC installed an automated datalogger and a pressure transducer in 2003 in order to collect enough flow data (from various highflow, baseflow, and lowflow conditions) to calibrate the TMDL model to Turkey Creek.

Project Location

The Turkey Creek watershed is located in the Central Great Plains Ecoregion in north central Oklahoma (Figure 1). The watershed is 417 square miles and includes parts of 4 counties. Turkey Creek is roughly 55 miles long from the headwaters near Helena (Alfalfa County) to the confluence with the Cimarron River near the town of Dover (Kingfisher County). The watershed is a highly productive agricultural area where wheat, grain sorghum, and other row crops are intensively grown. Animal agriculture is also a predominant landuse (dairies, cattle pasturing, and wheat grazing) (Figure 2). Streams in this area are frequently plowed to the stream bank, and the smallest watercourses are plowed over. The datalogger was installed on Turkey Creek (Lower), located in Kingfisher County, legal description NW 2-T17N-R7W.

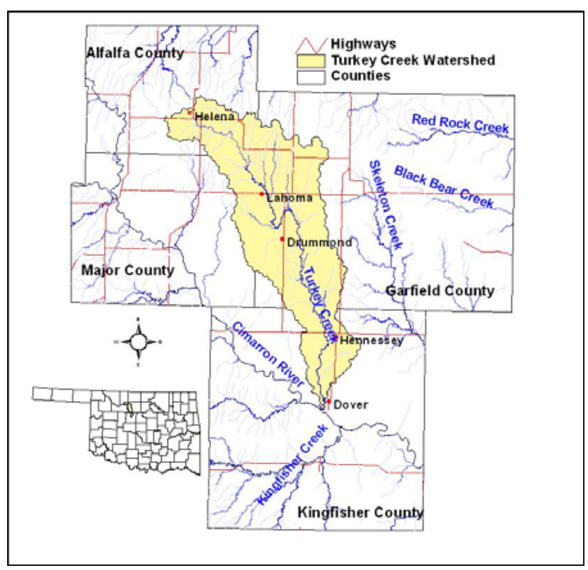


Figure 1. Turkey Creek Watershed Location.

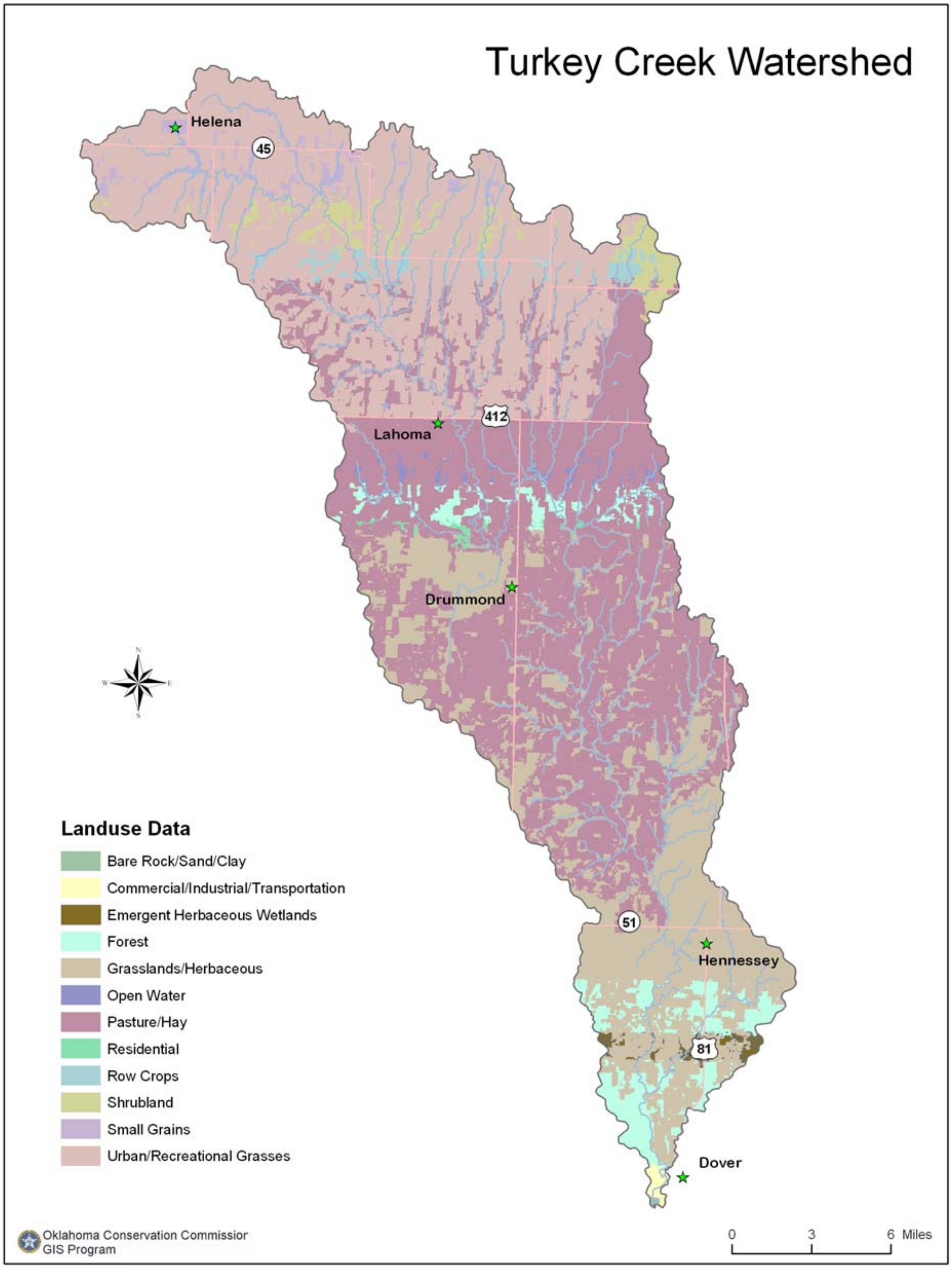


Figure 2. Land Use in Turkey Creek Watershed.

Problem Statement

The Nonpoint Source Assessment Report (OCC 2000) identified 81 miles in Water Quality Management Segment 620910, which includes Turkey Creek, as threatened by agricultural sources. The report noted elevated suspended solids and phosphorus under high flow conditions. The report also noted nutrients, suspended solids, and siltation as problems caused largely by excessive erosion from cropland. Most of these pollutants are likely associated with soil particles. Elevated levels of suspended solids and total phosphorus disturb bottom habitat and encourage excess algal growth, which could lead to undesirable fluctuations in dissolved oxygen and impact the fishery. Current assessments of Turkey Creek and three streams in its watershed have resulted in nonattainment status for Warm Water Aquatic Community and Primary Body Contact Recreation, as detailed in the Oklahoma 2002 Integrated Report (ODEQ 2002) and Table 1. The establishment of a TMDL should help to address the NPS pollution in the Turkey Creek watershed.

Table 1. Turkey Creek Watershed Impairments as presented on the 2002 303(d) List (ODEQ 2002).

OKWBID	Stream Name	Segment Size	Impairment
OK620910060010_00	Turkey Creek (Lower)	83 miles	Pathogens, turbidity
OK620910060020_00	Little Turkey Creek	11 miles	Low DO, pathogens, turbidity
OK620910060030_00	Buffalo Creek	14 miles	Low DO, pathogens, turbidity
OK620910060110_00	Clear Creek	5 miles	Pathogens, turbidity

MATERIALS & METHODS

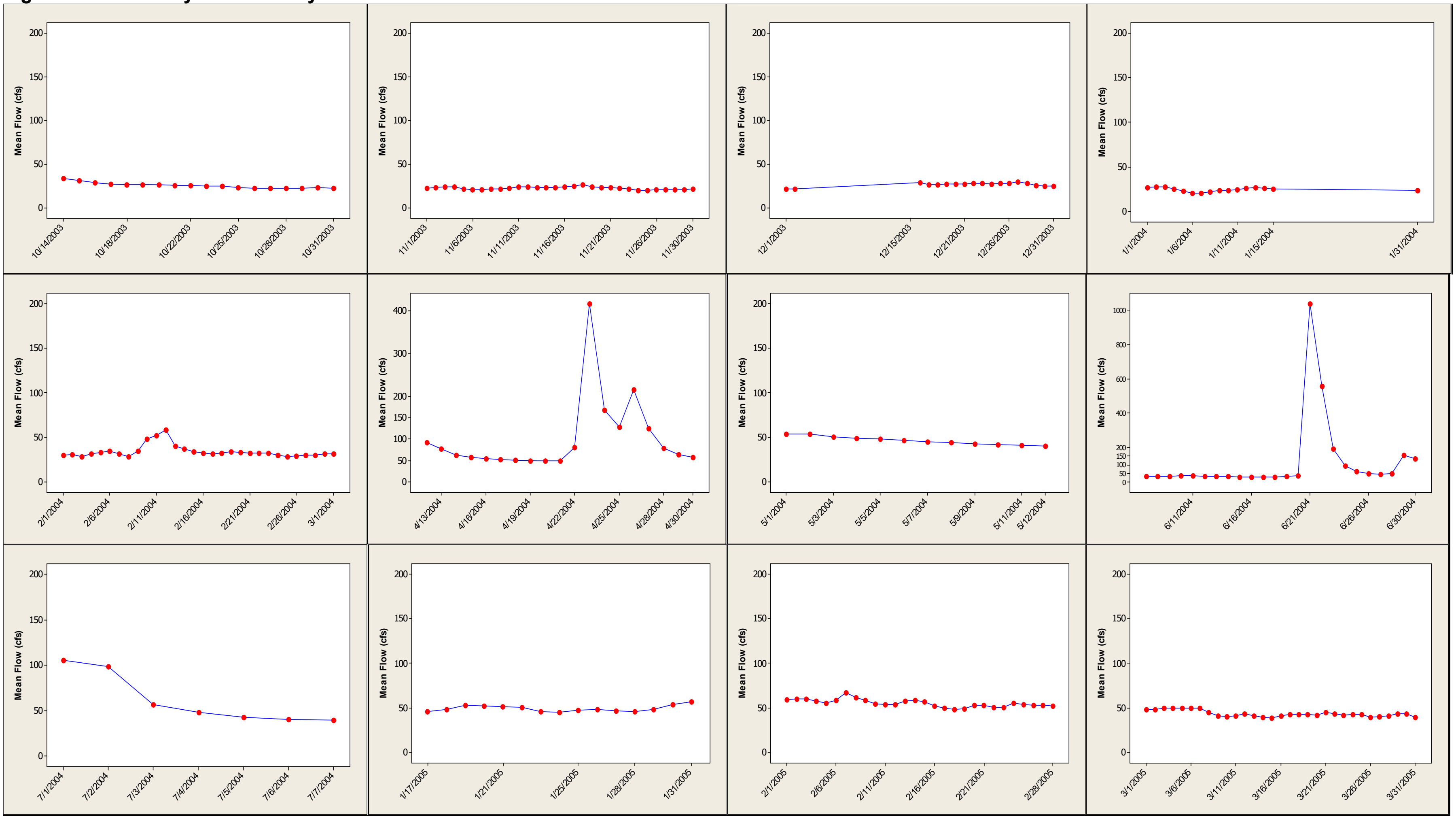
Flow measurement began with installation of an automated datalogger and a pressure transducer in March 2003 on Turkey Creek (OK620910060010_00). Initially, data was examined to test the equipment and the stability of the channel morphometry and to develop a stage/discharge relationship. By October 2003, the datalogger was considered calibrated and stable.

Readings were taken following the OCC SOPs (OCC 2001) and associated procedures outlined in the project's QAPP (OCC 2000). Stage was continuously monitored and downloaded at least monthly for the project period. Instantaneous discharge was measured with a flow meter at the time of download or at least monthly. The site was visited during and following storm events to insure that the measurement device was not dislodged or otherwise harmed by highflow. Any gaps in data are due to malfunctioning of the datalogger. The project was extended until October of 2005 in order to account for missing data in earlier months.

RESULTS

Figure 3 presents mean daily flow rates for each month of data collection. Especially high flow events are evident in April 2004, June 2004, June 2005, and August 2005. Flow was consistently low from October 2004 through January 2005. Average daily flow rates are given in Table 2. Raw datalogger results are presented in Appendix A.

Figure 3. Mean daily flow rates by month.



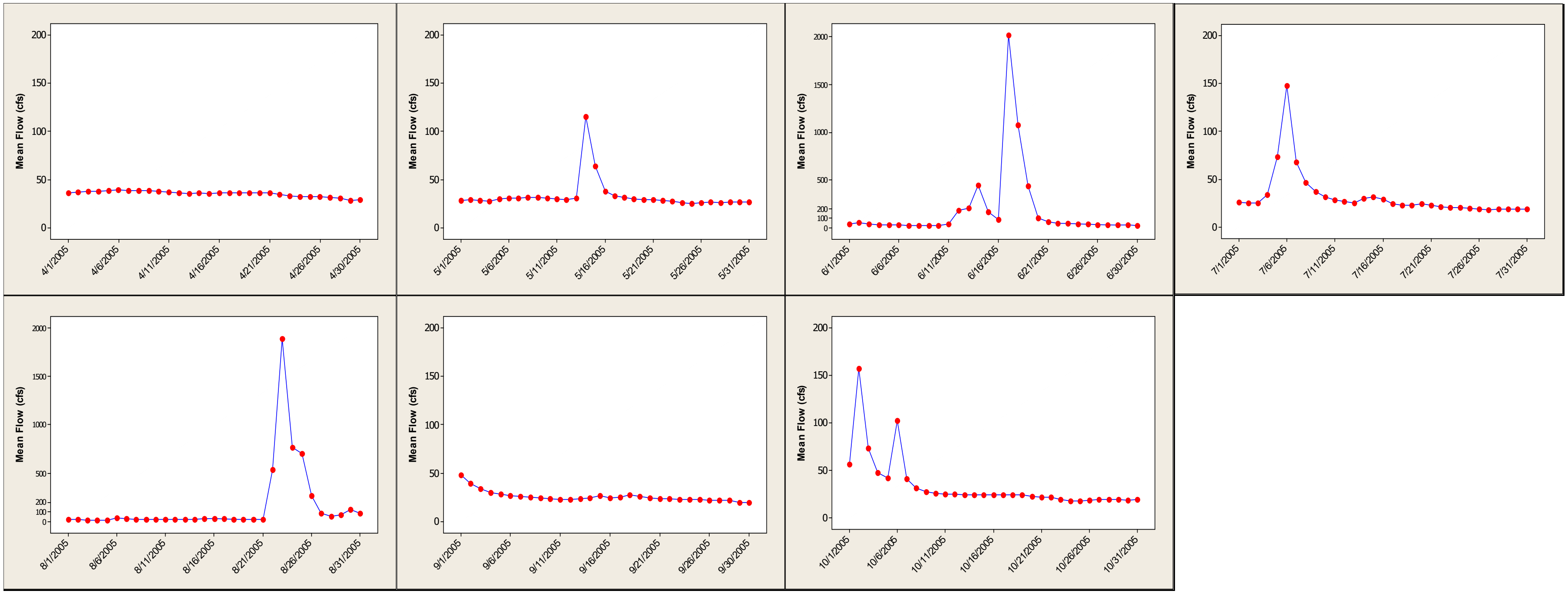

Mean Flow (cfs)
0 50 100 150 200
4/1/2005 4/6/2005 4/11/2005 4/16/2005 4/21/2005 4/26/2005 4/30/2005
5/1/2005 5/6/2005 5/11/2005 5/16/2005 5/21/2005 5/26/2005 5/31/2005
0 100 200 500 1000 1500 2000
6/1/2005 6/6/2005 6/11/2005 6/16/2005 6/21/2005 6/26/2005 6/30/2005
7/1/2005 7/6/2005 7/11/2005 7/16/2005 7/21/2005 7/26/2005 7/31/2005
8/1/2005 8/6/2005 8/11/2005 8/16/2005 8/21/2005 8/26/2005 8/31/2005
9/1/2005 9/6/2005 9/11/2005 9/16/2005 9/21/2005 9/26/2005 9/30/2005
10/1/2005 10/6/2005 10/11/2005 10/16/2005 10/21/2005 10/26/2005 10/31/2005

Table 2. Mean daily flow rates.

Year	Day of the Month	Mean of daily flow values (cfs)											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003	1											22.266	21.813
	2											23.278	21.935
	3											24.418	
	4											24.195	
	5											22.024	
	6											20.847	
	7											20.699	
	8											21.468	
	9											22.117	
	10											22.946	
	11											23.967	
	12											23.973	
	13											23.057	
	14										34.116	23.1	
	15										31.231	23.53	
	16										29.144	24.006	28.751
	17										27.84	25.085	27.05
	18										26.883	26.437	26.493
	19										26.92	24.128	27.642
	20										26.595	23.844	27.309
	21										26.054	23.118	27.468
	22										25.9	22.638	28.393
	23										25.427	21.482	27.944
	24										24.991	20.41	27.839
	25										23.599	20.509	28.153
	26										22.693	21.013	28.227
	27										22.883	20.957	29.946
	28										22.989	20.644	28.049
	29										22.759	20.951	26.043
	30										23.555	21.616	25.118
	31										22.669		25.45

Year	Day of the Month	Mean of daily flow values (cfs)											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2004	1	27.097	29.714	31.748		53.325		105.34					
	2	27.957	30.552			53.923		98.77					
	3	27.372	28.146			50.832		56.644					
	4	25.371	31.706			49.338		47.852					
	5	23.069	33.441			47.854		42.776					
	6	20.378	34.723			46.815		40.098					
	7	20.614	31.453			45.341	30.967	39.405					
	8	21.649	28.096			44.162	30.234						
	9	23.61	35.001			42.969	31.27						
	10	23.444	48.018			41.681	38.253						
	11	24.672	52.005			41.183	35.188						
	12	26.093	58.47		91.981	40.461	34.181						
	13	26.456	40.041		77.023		32.881						
	14	26.036	36.968		62.178		30.41						
	15	25.433	33.723		56.995		28.584						
	16		32.151		54.978		27.84						
	17		31.923		52.947		27.254						
	18		32.255		50.924		29.638						
	19		33.682		49.387		31.798						
	20		33.193		49.504		36.803						
	21		32.126		48.914		1038						
	22		32.151		80.52		558.1						
	23		32.08		417.02		190.35						
	24		29.816		168.48		93.92						
	25		28.467		128.27		60.315						
	26		28.863		215.6		48.686						
	27		29.774		125.63		43.287						
	28		29.713		79.003		46.74						
	29		31.899		64.413		154.48						
	30				57.662		135.45						
	31	23.275											

Year	Day of the Month	Mean of daily flow values (cfs)											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2005	1		59.196	48.241	36.334	28.701	40.18	26.214	18.833	48.228	56.76		
	2		60.309	48.062	37.166	28.788	53.899	25.439	18.686	39.59	157.43		
	3		60.185	49.376	37.85	28.627	35.229	25.243	18.36	33.521	73.67		
	4		57.958	50.079	38.164	27.708	30.682	33.692	18.305	30.04	47.414		
	5		55.393	49.839	38.888	29.571	28.319	73.09	18.453	28.166	42.329		
	6		58.713	49.871	39.11	30.915	27.037	148.25	36.883	26.759	102.42		
	7		67.249	49.455	38.362	30.886	26.654	68.27	29.016	25.814	40.838		
	8		61.699	44.979	38.579	31.157	25.02	46.847	25.104	25.321	31.225		
	9		58.55	41.065	38.61	31.156	23.659	37.401	22.196	24.371	27.752		
	10		54.177	40.023	38.161	30.923	23.401	31.576	22.242	23.444	25.71		
	11		53.671	41.239	37.258	30.153	37.32	28.461	21.597	23.131	25.185		
	12		53.837	43.312	36.112	29.217	184.84	26.492	20.89	23.204	24.808		
	13		57.736	40.899	35.784	30.724	203.75	25.47	21.161	23.784	24.278		
	14		58.514	39.691	36.154	115.58	445	30.101	24.093	24.394	23.983		
	15		57.019	38.98	35.809	63.84	162.45	31.595	31.224	27.073	24.056		
	16		52.375	41.066	36.087	38.049	84.55	29.417	26.741	24.315	24.166		
	17	45.733	49.641	42.496	36.308	33.268	2017	24.604	29.582	25.216	24.179		
	18	48.463	47.785	42.768	35.933	31.384	1073.5	23.02	25.827	27.464	24.192		
	19	53.269	48.562	42.27	35.964	30.308	441.5	22.447	23.438	25.648	24.481		
	20	51.979	52.856	41.868	36.124	29.37	102.26	24.475	22.166	24.426	22.653		
	21	51.455	52.509	45.151	35.89	28.829	63.338	22.791	22.883	23.985	21.74		
	22	50.615	50.707	43.369	34.519	28.258	50.356	21.369	540.2	23.358	21.665		
	23	45.569	50.22	41.949	32.909	27.662	42.856	20.767	1892.5	22.877	19.526		
	24	44.688	55.201	42.764	32.133	26.178	37.845	20.564	763.8	22.897	18.09		
	25	47.056	53.621	42.899	32.545	25.138	34.941	19.968	707.1	22.883	18.145		
	26	48.518	52.758	39.621	32.083	25.765	32.824	18.884	269.6	22.272	18.467		
	27	46.952	52.892	39.894	31.643	26.439	30.201	17.979	85.91	21.778	19.484		
	28	45.59	52.134	41.381	30.565	25.642	28.94	18.557	54.515	21.689	19.806		
	29	48.463		43.335	28.614	26.581	27.754	18.859	70.99	19.473	19.516		
	30	53.639		43.521	28.813	27.109	26.651	18.753	128.49	19.454	19.009		
	31	56.626		39.833		26.585		18.815	86.61		19.606		

Figures 4 and 5 show the monthly flow averages, with the mean represented by a solid line within each box and outliers represented by asterisks. Figure 4 is based on all flow data, while Figure 5 presents average monthly flow with extremely high flow omitted (>200 cfs). Table 3 gives the monthly flow statistics.

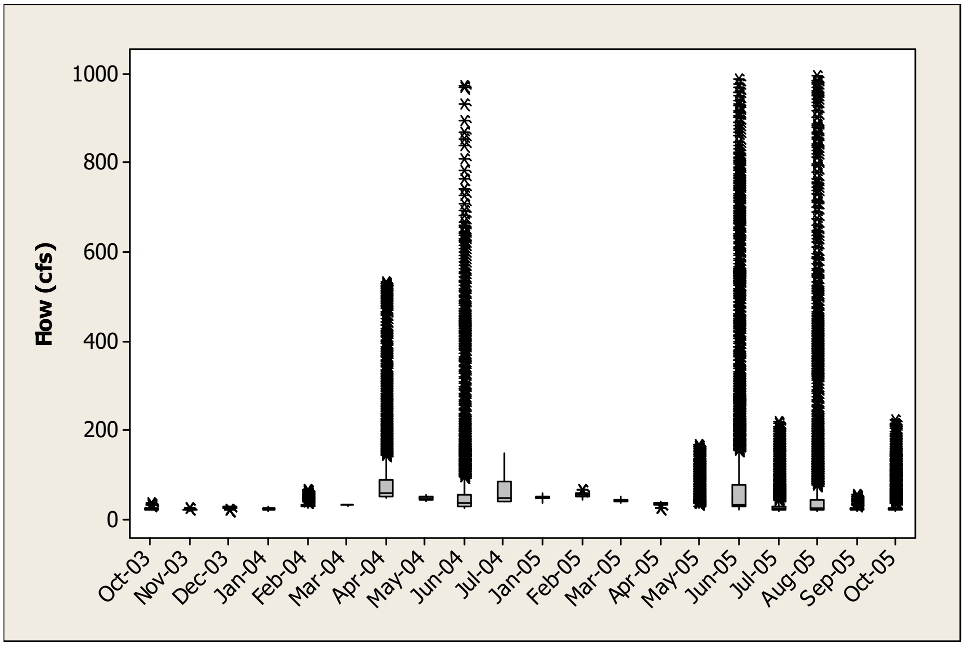


Figure 4. Average monthly flow, all data.

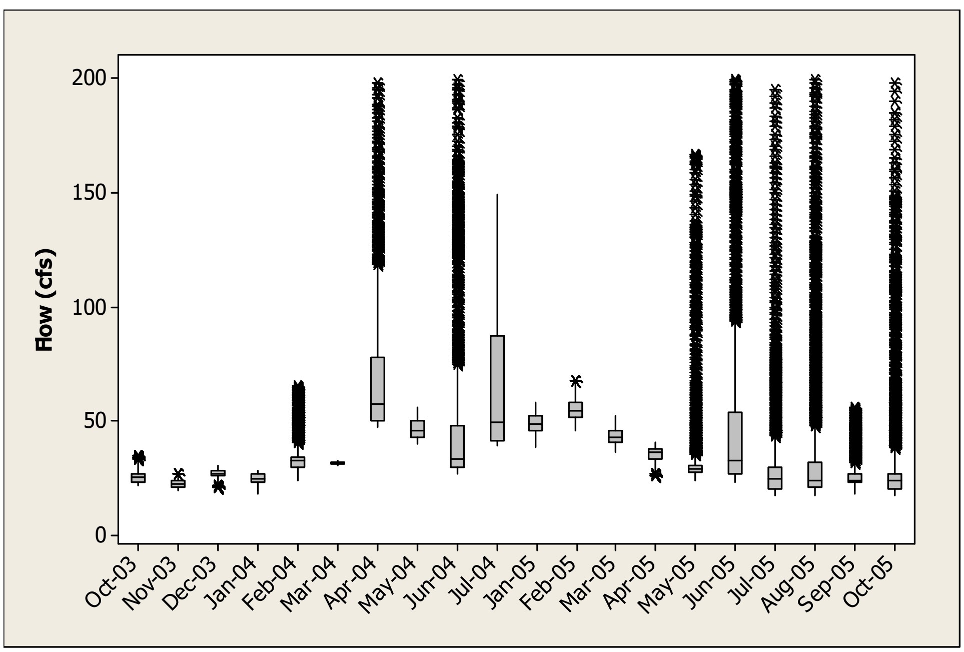


Figure 5. Average monthly flow, extremely high flow (>200 cfs) omitted.

Table 3. Monthly flow statistics.

Year	Month	N	Mean flow (cfs)	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
2003	Oct	1667	25.602	0.0675	2.757	21.91	23.1	25.47	27.25	34.95
2003	Nov	2880	22.624	0.0298	1.598	19.55	21.32	22.51	23.69	27.25
2003	Dec	1665	26.993	0.0503	2.053	21.32	26.06	27.25	28.43	30.8
2004	Jan	1470	24.52	0.0657	2.521	18.36	23.1	24.88	26.65	28.43
2004	Feb	2784	34.143	0.137	7.247	24.28	30.21	32.58	34.35	65.74
2004	Mar	53	31.748	0.0626	0.456	30.8	31.39	31.98	31.98	32.58
2004	Apr	1654	94.28	2.25	91.43	47.38	50.94	59.53	87.81	531.29
2004	May	1105	46.747	0.133	4.426	40.28	42.65	46.2	50.34	56.27
2004	Jun	2218	117.63	6.62	311.88	26.65	30.21	34.95	59.82	2629.79
2004	Jul	621	63.37	1.15	28.58	39.09	41.46	49.75	87.07	149.26
2005	Jan	1418	49.295	0.106	3.993	38.5	46.2	49.16	52.12	58.64
2005	Feb	2688	55.195	0.0887	4.599	45.61	51.53	54.49	58.04	68.11
2005	Mar	2978	43.527	0.0698	3.81	36.13	40.87	42.65	45.61	52.71
2005	Apr	2880	35.416	0.0571	3.065	26.06	33.76	36.13	37.91	40.87
2005	May	2976	33.049	0.33	18.01	24.28	27.84	29.02	30.8	167.03
2005	Jun	2846	181.35	9.44	503.81	23.1	27.84	34.95	87.66	4214.17
2005	Jul	2917	30.331	0.396	21.366	17.18	20.73	24.88	30.21	217.96
2005	Aug	2923	165.08	8.01	433.21	17.77	21.32	25.47	56.86	3120.21
2005	Sep	2880	25.819	0.108	5.799	18.36	23.1	24.28	26.65	56.27
2005	Oct	2803	31.522	0.472	24.99	17.18	20.14	24.28	27.25	221.52

Table 4 shows the instaneous discharge measures. There was good correlation between the datalogger and flow meter once the datalogger was properly calibrated (after October 2003). Two high flow events were compared. For the first high flow event (26-Apr-04), there were Quality Assurance concerns with the flow meter, so the data collected at that time can not be validated, and the datalogger is probably more accurate. The data collected during the other high flow event (21-Jun-04) corresponded very closely with the datalogger readings at the time of collection.

Table 4. Comparison of instantaneous discharge with datalogger values.

Date	Instantaneous Discharge (Flow Meter)	Daily Average Discharge (Datalogger)	Daily Maximum (Datalogger)	Daily Minimum (Datalogger)	Comment
23-Oct-03	12.57	25.43	25.47	24.88	Still calibrating datalogger.
27-Oct-03	12.32	22.88	23.69	21.91	Still calibrating datalogger.
03-Nov-03	21.75	24.42	24.88	24.28	
12-Jan-04	21.02	26.09	27.84	24.88	
17-Feb-04	37.68	31.92	33.76	30.21	
01-Mar-04	37.7	31.75	32.58	30.8	
26-Apr-04	915.67	215.60	217.96	213.23	QA concerns with flow meter data; logger more likely to be accurate.
12-May-04	36.41	40.46	40.87	40.28	
07-Jun-04	17.65	30.97	31.39	30.21	
21-Jun-04	1926.08	1038	2630	54	Within range--corresponds with flow from datalogger at collection time.

CONCLUSIONS

Evaluation of available data from the Turkey Creek Watershed, considered under the context of TMDL development, revealed that the primary “missing piece” was a record of daily flow values for the main stream. Therefore, OCC installed a datalogger at a site agreed to by ODEQ as representative and, after a period of calibration and equipment adjustment, began recording data and sending it to DEQ for use in the TMDL model development.

ODEQ now has a record of discharge patterns within the basin that it can correlate to climatic data. This relationship can then be compared to the existing water quality and climatic data to develop a SWAT model for the watershed.

Literature Cited

OCC. 2000. *Nonpoint Source Management Program and Nonpoint Source Assessment Report*. Oklahoma Conservation Commission, Oklahoma City, OK.

OCC. 2001. *Standard Operating Procedures (SOPs)*. Oklahoma Conservation Commission, Oklahoma City, OK.

OCC. 2000. *Quality Assurance Project Plan (QAPP) for Priority UWA Watershed Monitoring to Support WRAS and TMDL Development (FY 2000 319(h)).* Oklahoma Conservation Commission, Oklahoma City, OK.

ODEQ. 2002. *Integrated Water Quality Assessment Report*, Appendix C: Category 5 Waterbodies (303(d) list). Oklahoma Department of Environmental Quality, Oklahoma City, OK.

ODEQ. 2002. *Continuing Planning Process*. Oklahoma Department of Environmental Quality, Oklahoma City, OK.

OWRB. 2002. *Oklahoma Water Quality Standards*, OAC 785:45. Oklahoma Water Resources Board, Oklahoma City, OK.