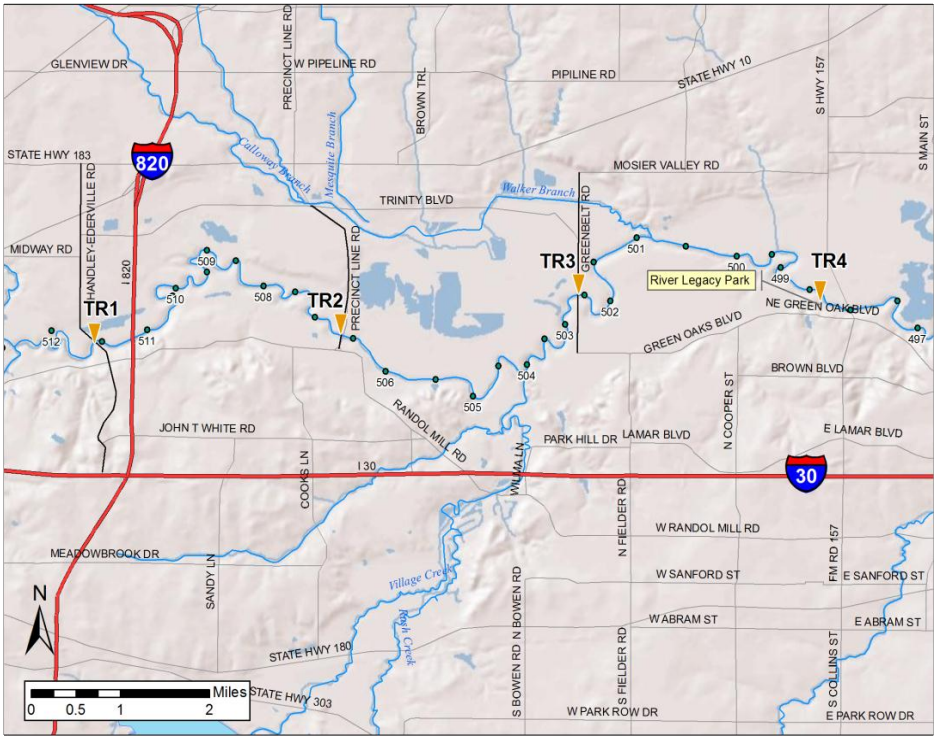

Trinity River Authority of Texas

December 2012

Clean Rivers Program
Project # 6012.001.012

Final Report

Upper Trinity River Flow Discrepancy Study

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Upper Trinity River Flow Discrepancy Study

Abstract: Previous studies have shown a possible loss of water during prolonged periods of low flow along 32.9 river miles of the Upper West Fork Trinity River (RM 518.6-RM 485.7) through Tarrant and Dallas Counties, Texas. The Trinity River Authority and USGS partnered to install four sites in order to determine if water losses were real and if sources could be identified. Results suggest that the losses are occurring after extended periods of low flows along a four mile reach between Greenbelt Road in Fort Worth, Texas (RM 502.4) and River Legacy Park in Arlington, Texas (RM 498.5). Additional study is needed to determine the cause/causes for these losses.

Published and distributed by:

Trinity River Authority of Texas
Texas Clean Rivers Program
5300 S. Collins St.
Arlington, TX 76018

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December 2012

The preparation of this report was financed through grants from and in cooperation with the Texas Commission on Environmental Quality under agreement number 582-10-91345.

Additional Cooperator: United States Geological Survey

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1 Background and Objective

Valid and dependable flow data are imperative for river studies, basin planning, emergency response, and resource management. To this end, the United States Geological Survey (USGS), in cooperation with various other state and local entities, maintains and operates a series of stream gages throughout the Dallas/Fort Worth Metroplex.

During low flows, the Upper West Fork Trinity River system is effluent dominated with wastewater discharge making up more than ninety-five percent of the flow; background flows consist of landscape irrigation runoff, small upstream discharges, and minor seeps. The USGS gage at Grand Prairie (GP) (08049500) has been in operation since 1925 and is strategically important because it is located downstream of the first major wastewater discharge, Fort Worth Village Creek (FWVC) Wastewater Treatment Plant (WWTP) (Figure SS-A5.1). Flows at GP should equal:

$$Q_{background} + Q_{FWVC\ WWTP} = Q_{GP\ USGS\ gage}$$

Recent studies (Upper trinity River Water Quality Compact, 2011) have shown that *naturalized summertime low flows*, flows adjusted for the effects of humans, are < 0 cfs at GP (Upper Trinity River Compact, 2011):

$$Q_{background} - Q_{FWVC\ WWTP} = <0\ Q_{GP\ USGS\ gage}$$

Data has been studied in-depth, adjusted for travel time, and quality assured in an attempt to explain the loss of water. No explanation was discovered. Field work and field reconnaissance along this entire reach was completed by boat during summer 2011 and no visual evidence was found to indicate an unpermitted water intake. The objective of this study was to collect discharge data over a range of *low flow* stages at four locations along a reach of the upper West Fork Trinity River to determine if flow discrepancies are measurable and to further pinpoint the source and/or location of the water losses, if possible.

The field portion of the study was executed between September 29, 2011 and November 9, 2011, a period of extreme drought throughout the Dallas/Fort Worth area. 2011 USGS data at the Grand Prairie gage show an extended period of low flow (Figure 1-1). The initial ten days of the study were representative of the conditions in question – extended periods of low flows (Figure 1-2). On the 11th day of the study, a significant pulse (3,550 cfs) passed through the system and conditions never returned to the low flow conditions needed to answer the research question (Figure 1-2).

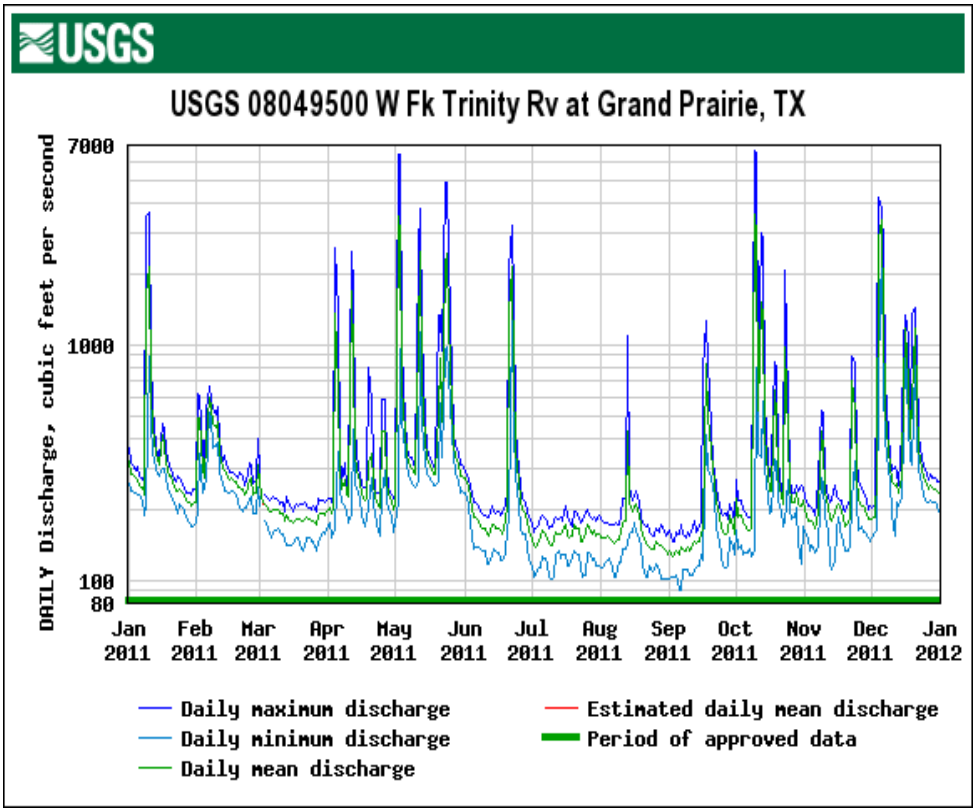


Figure 1-1. Average daily discharges for 2011 at the West Fork Trinity River gage.

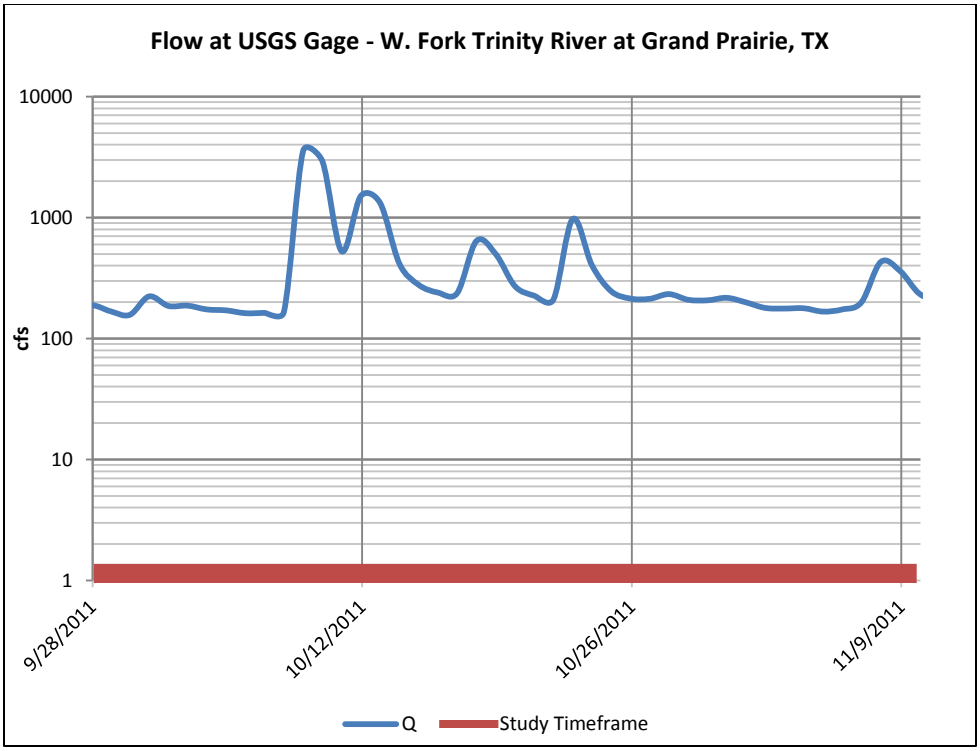


Figure 1-2. Flow at USGS gage - W. Fork Trinity River at Grand Prairie, TX

For this report, USGS staff provided field work, with some TRA assistance, and data analysis. The data are published on the USGS National Water Information System Web Interface (http://waterdata.usgs.gov/nwis).

1.1 Study Area

The study area (Figure 1-1) covers approximately 32.9 river miles (RM 518.6-RM 485.7) through Tarrant and Dallas Counties, Texas. The study boundaries are the USGS gage West Fork Trinity River at Beach St. (08048543) in Fort Worth and the USGS gage West Fork Trinity River at Grand Prairie (08049500) in Grand Prairie. This section of river is nearly 100% urbanized, though there are significant riparian areas associated with much of the reach. To further pinpoint the location/cause of water losses, four study sites were selected along the reach to be as evenly spaced as possible:

1. TR1 - West Fork at Handley Ederville Rd. - RM 511.7
2. TR2 - West Fork at Precinct Line Rd. - RM 506.6
3. TR 3 - West Fork at Greenbelt Rd. - RM 502.5
4. TR4 - West Fork at River Legacy Park - RM 498.4

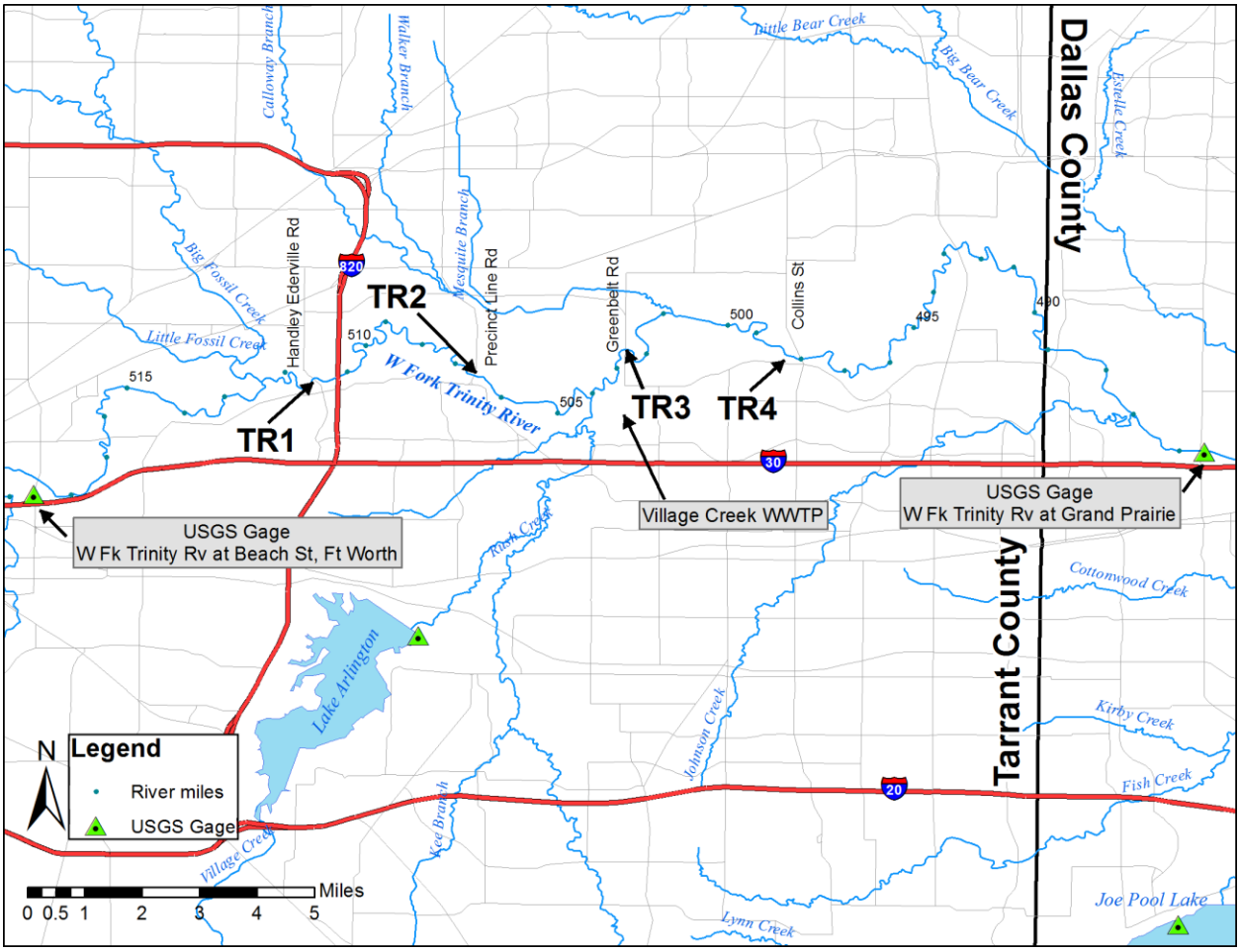


Figure 1-3. Upper Trinity River flow discrepancy study area map

1.2 Study Design and Methods

USGS and TRA field staff installed one unvented pressure transducer (PT) and temporary staff gage at each site listed above in order to measure stage changes at 15 minute intervals. Additionally, an atmospheric barometric pressure instrument was installed at the West Fork Trinity River at Beach St. gage so that PT data could be post-processed and corrected for changes in atmospheric barometric pressure. Two sites (TR1 and TR2) were located above and two sites (TR3 and TR4) were located below the Village Creek WWTP outfall.

USGS staff completed four discharge measurements over the study period. Discharge measurements were made at the time of gage establishment, at the end of the project, and two additional times during the study. Flow measurements were performed with an acoustic Doppler profiler (ADP) or by wading rod by USGS personnel using standard USGS methods (Turnipseed and Sauer, 2010) (Rantz, et al., 1982). The objective of this study was to collect discharge data over a range of stages with a particular focus on low flows. Flow measurements were taken on:

1. October 5, 2011;
2. October 12, 2011;
3. November 3, 2011; and
4. November 10, 2011.

The large gap between measurements two and three are due to a large pulse (>3,500 cfs pulse as measured at the Grand Prairie gage) that passed through the system. USGS staff created stage discharge relationships using standard USGS methodology (Sauer and Turnipseed, 2010).

2 Data Analysis

PTs and staff gages were retrieved from the field and the data were downloaded and corrected for atmospheric barometric pressure. ADP flow measurements (Table 2-1) were quality assured and used to create stage discharge relationships for the PT data using USGS standard methods (Sauer and Turnipseed, 2010). The rating curves were then used to calculate mean, maximum, and minimum daily flows (Figures 2-2, 2-3, & 2-4, respectively).

Table 2-1. Table showing instantaneous discharge (cfs) at gages and PT locations

Measured Discharge in Cubic Feet Per Second							
Date	Station Name Station No.	W Fk Trinity at Beach St (GAGE) 08048543	W Fk Trinity at Handley Ederville Rd (PT) 08048856	W Fk Trinity at Precinct Line Rd (PT) 08048858	W Fk Trinity at Greenbelt Rd. (PT) 08049300	W Fk Trinity at River Legacy Park (PT) 08049340	W Fk Trinity at Grand Prairie (GAGE) 08049500
10/5/2011		27.1	20.6	32	168	142	186
10/12/2011		--	1060	841	1740	2210	--
11/3/2011		--	39.7	32.9	135	122	--
11/10/2011		--	43.6	53.6	194	170	--

Table 2-2. Mean daily flows and differences between sampling sites for September 29, 2011 to November 9, 2011.

Mean Daily Flows (cfs)										
Date (2011)	TR1 W Fk Trinity @ Handley Ederville Rd	TR2 W Fk Trinity @ Precinct Line Rd	TR3 W Fk Trinity @ Greenbelt Rd.	TR4 W Fk Trinity @ River Legacy Park	DS Gage W Fk Trinity @ Grand Prairie	Dif. (TR1-TR2)	Dif. (TR1+TR2)-TR3	Dif. (TR1+TR2+TR3)-TR4	Dif. (TR1+TR2+TR3+TR4)-DS Gage	% Dif. (TR3-TR4)/TR3
Sept. 29	24	26	189	166	168	2	163	-23	2	-12.2%
Sept. 30	98	93	223	194	157	-5	130	-29	-37	-13.0%
Oct. 1	57	86	237	219	223	29	151	-18	4	-7.6%
Oct. 2	47	61	212	187	186	14	151	-25	-1	-11.8%
Oct. 3	42	52	218	192	187	10	166	-26	-5	-11.9%
Oct. 4	39	47	211	183	174	8	164	-28	-9	-13.3%
Oct. 5	22	36	201	166	171	14	165	-35	5	-17.4%
Oct. 6	23	33	189	151	162	10	156	-38	11	-20.1%
Oct. 7	26	40	201	160	163	14	161	-41	3	-20.4%
Oct. 8	31	43	204	161	165	12	161	-43	4	-21.1%
Oct. 9					3550					
Oct. 10					2930					
Oct. 11	127	177	428	514	527	50	251	86	13	20.1%
Oct. 12					1510					
Oct. 13	425		905	1200	1320			295	120	32.6%
Oct. 14	99	147	367	414	417	48	220	47	3	12.8%
Oct. 15	58	87	283	267	280	29	196	-16	13	-5.7%
Oct. 16	42	62	253	218	243	20	191	-35	25	-13.8%
Oct. 17	37	56	232	213	239	19	176	-19	26	-8.2%
Oct. 18	432	346	606	769	644	-86	260	163	-125	26.9%
Oct. 19	112	171	342	432	503	59	171	90	71	26.3%
Oct. 20	45	78	217	229	274	33	139	12	45	5.5%
Oct. 21	33	52	186	191	229	19	134	5	38	2.7%
Oct. 22	26	38	169	174	212	12	131	5	38	3.0%
Oct. 23	87	92	452	803	977	5	360	351	174	77.7%
Oct. 24	53	93	264	350	406	40	171	86	56	32.6%
Oct. 25	31	45	177	206	248	14	132	29	42	16.4%
Oct. 26	31	34	161	186	216	3	127	25	30	15.5%
Oct. 27	33	29	158	186	215	-4	129	28	29	17.7%
Oct. 28	36	30	162	194	236	-6	132	32	42	19.8%
Oct. 29	44	44	151	183	212	0	107	32	29	21.2%
Oct. 30	42	47	152	192	210	5	105	40	18	26.3%
Oct. 31	37	38	149	192	220	1	111	43	28	28.9%
Nov. 1	34	31	131	174	201	-3	100	43	27	32.8%
Nov. 2	35	28	130	170	184	-7	102	40	14	30.8%
Nov. 3	37		128	168	182			40	14	31.3%
Nov. 4	27		132	171	183			39	12	29.5%
Nov. 5	29		136	165	171			29	6	21.3%
Nov. 6	35		153	176	178			23	2	15.0%
Nov. 7	51		178	201	205			23	4	12.9%
Nov. 8	272	219	447	560	437	-53	228	113	-123	25.3%
Nov. 9	91	111	303	344	368	20	192	41	24	13.5%

DS - Downstream TR"X" - Station ID # Indicates value <0

Table 2-3. Maximum daily flows and differences between sampling sites for September 29, 2011 to November 9, 2011.

Maximum Daily Flows (cfs)										
Date (2011)	TR1 W Fk Trinity @ Handley Ederville Rd	TR2 W Fk Trinity @ Precinct Line Rd	TR3 W Fk Trinity @ Green belt Rd.	TR4 W Fk Trinity @ River Legacy Park	DS Gage W Fk Trinity @ Grand Prairie	Dif. (TR1-TR2)	Dif (TR1+TR2) -TR3	Diif. (TR1+TR2 +TR3)-TR4	Dif. (TR1+TR2+TR3+ TR4)-DS Gage	% Dif (TR3-TR4)/ TR3
Sept. 29	31	34	225	197	192	3	191	-28	-5	-12.4%
Sept. 30	155	165	312	305	176	10	147	-7	-129	-2.2%
Oct. 1	79	132	290	287	266	53	158	-3	-21	-1.0%
Oct. 2	51	69	256	228	219	18	187	-28	-9	-10.9%
Oct. 3	49	58	254	228	217	9	196	-26	-11	-10.2%
Oct. 4	49	58	254	217	200	9	196	-37	-17	-14.6%
Oct. 5				204	197				-7	
Oct. 6	29	40	212	174	186	11	172	-38	12	-17.9%
Oct. 7	31	45	235	187	184	14	190	-48	-3	-20.4%
Oct. 8	46	52	267	212	186	6	215	-55	-26	-20.6%
Oct. 9					6640					
Oct. 10					6550					
Oct. 11	225	273	615	823	800	48	342	208	-23	33.8%
Oct. 12					2960					
Oct. 13	1160		2090	2570	2790	-1160	2090	480	220	23.0%
Oct. 14	151	206	484	603	579	55	278	119	-24	24.6%
Oct. 15	73	107	326	332	319	34	219	6	-13	1.8%
Oct. 16	49	71	303	282	279	22	232	-21	-3	-6.9%
Oct. 17	89	67	298	435	328	-22	231	137	-107	46.0%
Oct. 18	757	581	821	1050	840	-176	240	229	-210	27.9%
Oct. 19	214	280	527	762	800	66	247	235	38	44.6%
Oct. 20	61	112	270	282	322	51	158	12	40	4.4%
Oct. 21	39	59	217	217	243	20	158	0	26	0.0%
Oct. 22	29	45	205	217	234	16	160	12	17	5.9%
Oct. 23	155	175	647	1630	2060	20	472	983	430	151.9%
Oct. 24	99	158	399	573	560	59	241	174	-13	43.6%
Oct. 25	37	55	220	254	279	18	165	34	25	15.5%
Oct. 26	37	41	193	212	231	4	152	19	19	9.8%
Oct. 27	39	32	195	225	236	-7	163	30	11	15.4%
Oct. 28	42	34	176	212	256	-8	142	36	44	20.5%
Oct. 29	51	52	193	236	241	1	141	43	5	22.3%
Oct. 30	46	50	217	257	256	4	167	40	-1	18.4%
Oct. 31	42	43	188	246	251	1	145	58	5	30.9%
Nov. 1	37	34	156	207	224	-3	122	51	17	32.7%
Nov. 2	49	35	154	197	210	-14	119	43	13	27.9%
Nov. 3	44		152	199	210			47	11	30.9%
Nov. 4	31		154	194	208			40	14	26.0%
Nov. 5	39		176	209	194			33	-15	18.8%
Nov. 6	42		200	222	215			22	-7	11.0%
Nov. 7	151		281	323	277			42	-46	14.9%
Nov. 8	392	290	508	662	535	-102	218	154	-127	30.3%
Nov. 9	147	167	405	528	513	20	238	123	-15	30.4%

DS - Downstream TR"X" - Station ID # Indicates value <0

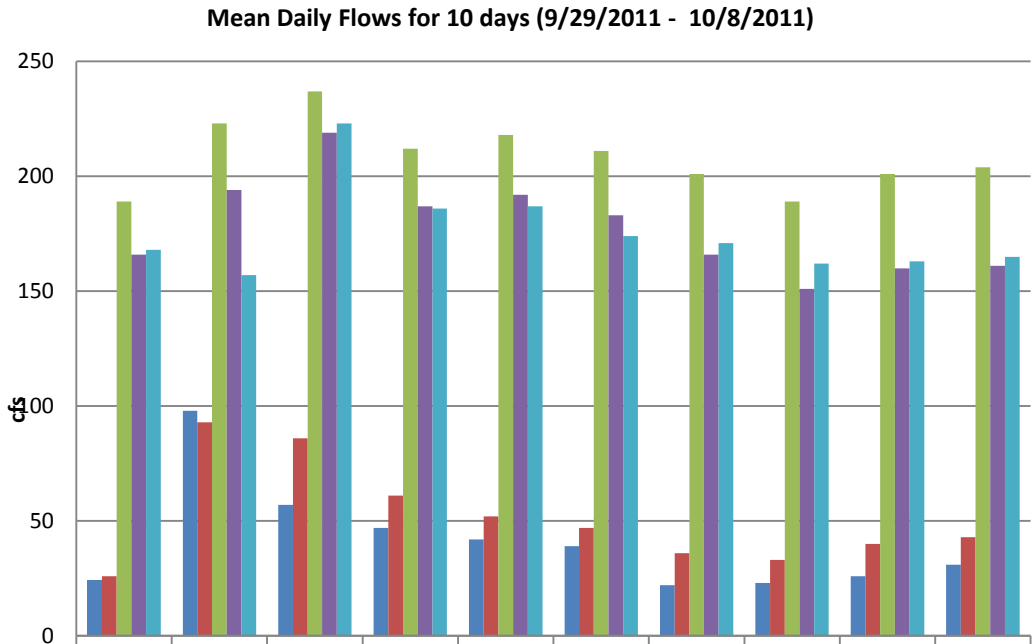
Table 2-4. Minimum daily flows and differences between sampling sites for September 29, 2011 to November 9, 2011.

Minimum Daily Flows (cfs)										
Date (2011)	TR1 W Fk Trinity @ Handley Ederville Rd	TR2 W Fk Trinity @ Precinct Line Rd	TR3 W Fk Trinity @ Greenbelt Rd.	TR4 W Fk Trinity @ River Legacy Park	DS Gage W Fk Trinity @ Grand Prairie	Difference (TR1-TR2)	Difference (TR1+TR2)-TR3	Difference (TR1+TR2+TR3)-TR4	Difference (TR1+TR2+TR3+TR4)-DS Gage	% Dif. (TR3-TR4)/ TR3
Sept. 29	17	20	152	135	139	3	132	-17	4	-11.2%
Sept. 30	25	20	138	121	128	-5	118	-17	7	-12.3%
Oct. 1	44	64	185	163	164	20	121	-22	1	-11.9%
Oct. 2	44	56	156	137	136	12	100	-19	-1	-12.2%
Oct. 3	35	45	176	155	141	10	131	-21	-14	-11.9%
Oct. 4	29	32	122	114	128	3	90	-8	14	-6.6%
Oct. 5				121	130				9	
Oct. 6	18	28	148	120	130	10	120	-28	10	-18.9%
Oct. 7	22	37	156	128	136	15	119	-28	8	-17.9%
Oct. 8	25	38	146	118	126	13	108	-28	8	-19.2%
Oct. 9					132					
Oct. 10					800					
Oct. 11	76	119	343	369	344	43	224	26	-25	7.6%
Oct. 12					334					
Oct. 13	151		477	603	579		477	126	-24	26.4%
Oct. 14	67	107	309	317	302	40	202	8	-15	2.6%
Oct. 15	49	71	233	207	226	22	162	-26	19	-11.2%
Oct. 16	37	58	193	159	194	21	135	-34	35	-17.6%
Oct. 17	29	45	181	155	200	16	136	-26	45	-14.4%
Oct. 18	89	61	262	425	328	-28	201	163	-97	62.2%
Oct. 19	61	110	238	265	313	49	128	27	48	11.3%
Oct. 20	37	58	172	180	222	21	114	8	42	4.7%
Oct. 21	27	43	146	157	197	16	103	11	40	7.5%
Oct. 22	22	32	122	132	171	10	90	10	39	8.2%
Oct. 23	17	27	185	202	179	10	158	17	-23	9.2%
Oct. 24	35	55	202	246	266	20	147	44	20	21.8%
Oct. 25	25	41	138	163	197	16	97	25	34	18.1%
Oct. 26	27	31	128	153	184	4	97	25	31	19.5%
Oct. 27	15	24	117	145	189	9	93	28	44	23.9%
Oct. 28	31	25	136	165	205	-6	111	29	40	21.3%
Oct. 29	37	32			145	-5				
Oct. 30	37	41			120	4				
Oct. 31	33	32	106	144	171	-1	74	38	27	35.8%
Nov. 1	31	27		140	164	-4			24	
Nov. 2	29	24		135	157	-5			22	
Nov. 3	29			121	139				18	
Nov. 4	23			137	145				8	
Nov. 5	23			125	134				9	
Nov. 6	29		102	130	136			28	6	27.5%
Nov. 7	35		126	142	145			16	3	12.7%
Nov. 8	147	59	281	311	277	-88	222	30	-34	10.7%
Nov. 9	54	74	251	262	264	20	177	11	2	4.4%

DS - Downstream TR"X" - Station ID # Indicates value <0

3 Discussion and Conclusion

During the initial ten days of the study, after a consistent period of low flows, data showed a significant, consistent loss of water between TR3 and TR4. This phenomenon was apparent in mean daily flow, maximum daily flow, and minimum daily flow. Water losses between TR3 and TR4 range between -7.6% (-18 cfs) and -21.1% (-43 cfs) for mean daily volumes. After a pulse on day 11, extended low flow conditions never returned before removal of the PTs and staff gages. Data for days 11 - 42 showed some sporadic losses in water between TR3 and TR4, but did not display consistent, measureable losses in water. Though there are some measureable water losses between the other stations, the volumes were very small, most within the 5% margin of error for flow measurements, and the occurrences were sporadic (Figures 2-2, 2-3, 2-4).



	Sept. 29	Sept. 30	Oct. 1	Oct. 2	Oct. 3	Oct. 4	Oct. 5	Oct. 6	Oct. 7	Oct. 8
TR1	24	98	57	47	42	39	22	23	26	31
TR2	26	93	86	61	52	47	36	33	40	43
TR3	189	223	237	212	218	211	201	189	201	204
TR4	166	194	219	187	192	183	166	151	160	161
Grand Prairie Gage	168	157	223	186	187	174	171	162	163	165

Note: Data are listed left to right per day in stream order. Note how flow increases, as expected, between TR1, TR2, and TR3, then decreases significantly between TR3 and TR4.

Figure 3-1. Chart showing the West Fork Trinity River with increasing flows between TR1, TR2, and TR3, then decreasing flows between TR3 and TR4.

Causes for the water loses are unknown. It is possible that interactions with natural geologic formations or anthropogenic factors (Figure 3-2) are causing river water to infiltrate through the bed and banks. Additional studies are needed to further narrow the location of water losses within this approximate 4-mile reach.

Figure 3-2. Aerial photograph showing anthropogenic activities along the reach shown to be losing water.

4 References

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