Santa Fe River Studies

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Storm Flow

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This is one of a series of scientifically-based studies designed to provide the technical background information for decision makers and the community in evaluating management options for the Santa Fe River. The series covers the following topics: stream flow, storm flow, reservoir storage, ecosystem watershed yield analysis, stream flow losses, stream-aquifer interaction, and fate of reservoir releases. For more information on the series, please contact Claudia Borchert at 505-955-4203 or ciborchert@santafenm.gov

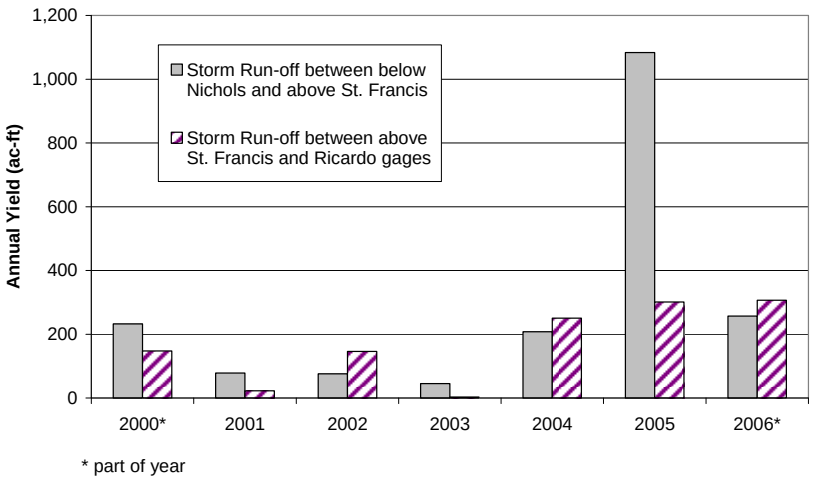
Santa Fe River Studies: Storm Flows

The magnitude and timing of storm events entering the Santa Fe River between Nichols Reservoir and Ricardo Road from 2000 through September 2006 is summarized in this report. Instantaneous stream flow measurements from three stream gages were used to determine storm runoff. This study does not attempt to represent the potential for flood events, only those events that occurred between 2000 and 2006. For information on potential peak storm flows (such as 100-year events) the reader is directed to a study by the US Army Corps of Engineers (USACOE, 2007).

Storm flows entering the Santa Fe River were estimated for two reaches: 1) the *up-town* reach, between the gage below Nichols Reservoir (*below Nichols*) and *above St. Francis Bridge* (*above St. Francis*) gage and 2) the *mid-town* reach between the *above St. Francis* gage and the *Ricardo Road* (*Ricardo*) gage. A storm flow was determined from the 15-minute stream flow data (Williams, 2008) when the flow at the down stream end of the reach was 1 cubic feet per second (cfs) greater than the flow at the upstream gage for any given 15-minute instantaneous reading. Thus a storm flow as considered here, does not include storms that enter into the Santa Fe River above Nichols Reservoir when the reservoir is full and spilling into the reach below Nichols Reservoir. The source of the storm flows is primarily runoff from streets and arroyos in the vicinity of the City of Santa Fe.

The length of time of the storm events for the two reaches was totaled and the average flow rates during these events each year are summarized in Tables 1 and 2. The total annual inflow from storm events in the up-town reach ranges from less than 100 acre-feet per year (ac-ft/yr) to over 1,000 ac-ft/yr and averages 280 ac-ft/yr for the period of record from 2000 through 2006. The total length of time of the storm events entering the up-town reach ranges from about 4 days in 2002 to almost 98 days in 2005. Figure 1 shows the estimated annual storm flows entering each reach.

Figure 1. Estimated annual storm run-off entering the Santa Fe River in two reaches from 2000 through September of 2006



The average amount of storm flows that enter the Santa Fe River between the *below Nichols Reservoir* gage and the *Ricardo* gage is about 450 ac-ft/yr for the period of record from 2000 to 2006, including the partial records available for the year 2000 and 2006.

The storm flows as defined here contribute from 14 percent to over 90 percent of the annual flow at the gage *above St. Francis* and 41 percent of the flow at the *Ricardo* gage for those flows originating between gages. Volumetrically, total storm flows over this period of record account for 20% of the total flow that passed the *above St. Francis* gage from 2000 through September 2006, primarily due to the large flows that occurred in 2005. Figures 2 and 3 show the estimated storm flows entering the up-town and mid-town reaches as compared to the total flow passing the downstream gage in each reach annually.

In a dry year, such as 2003, storm flows amounted to a total of 49 ac-ft, which is a combination of 45 ac-ft at the *above St. Francis* gage and 4 ac-ft at the *Ricardo* gage. In the dry years, the storm flows represent a much greater percentage of the total flow. A portion of the storm flows entering the upper reach infiltrates before reaching the *Ricardo* gage, thus the total flow at the *Ricardo* gage can be less than the combined storm flows.

Figure 2. Storm flows entering the up-town reach as compared to the flow at the above St. Francis gage.

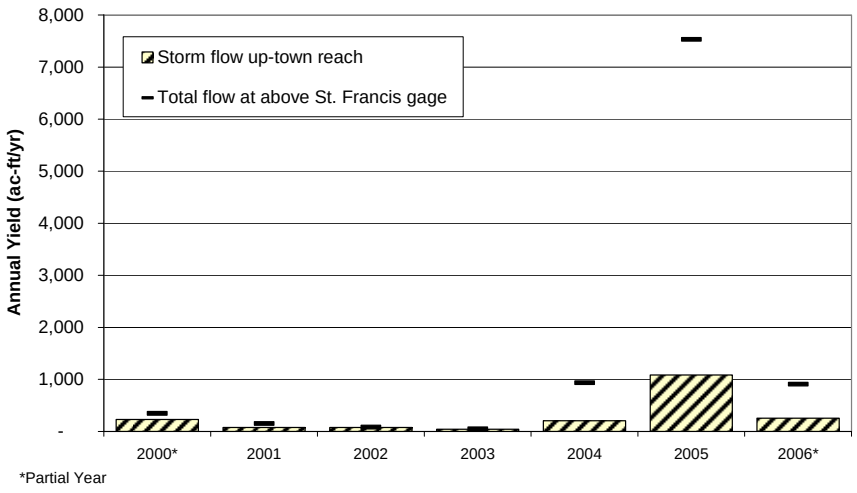
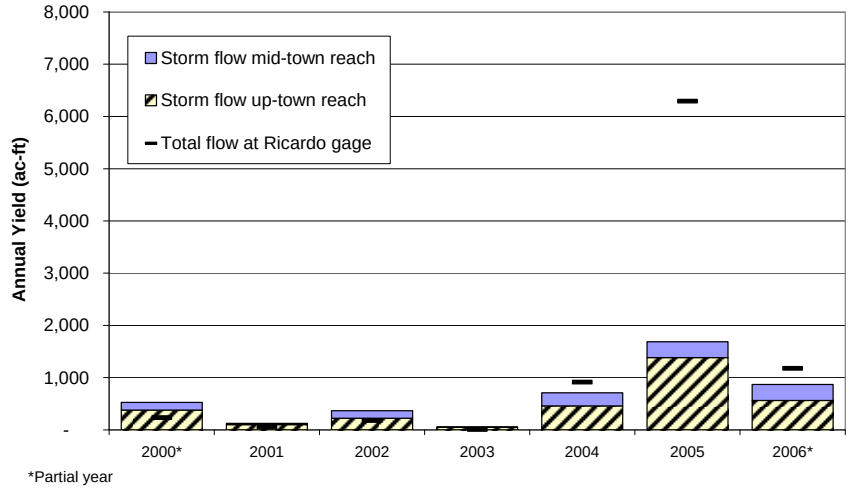


Figure 3. Storm flows entering the mid-town reach as compared to the annual yield at the Ricardo gage



In 2003, storm flows accounted for 88 percent of the flow at *above St. Francis* gage and 44 percent at the *Ricardo* gage. In a wet year, such as 2005, the total storm flows entering both the up-town and mid-town reaches is estimated to be almost 1,400 ac-ft (1,084 and 301 ac-ft at the *above St. Francis* and *Ricardo* gages respectively), yet this volume represents only about 14 percent of the flow at the *above St. Francis* gage and 5 percent at the *Ricardo* gage for that year.

Figures 4 and 5 show the cumulative annual flow by month, showing that the greatest inflow occurs over the summer months, with very little contribution in winter months (with the exception of 2005).

The annual storm inflow on the mid-town reach is summarized in Table 2 and shows a minimum storm input of only 4 ac-ft in 2003 to more than 300 ac-ft in 2006, which only includes January through September of 2006. The average storm inflow is 168 ac-ft per year from 2000 through 2006. The storm totals prior to 2004 may be underestimated due to uncertainties in the stream flow measurements prior to the construction of a control structure at the *Ricardo* gage. While these flow rates may not total to a large amount of water, the intensity of the flow can be very high (almost 1,000 cfs) even in a dry year such as 2002, when only 740 ac-ft of water entered the Santa Fe River watershed.

The intensity of the flow events in the mid-town reach is greater than in the up-town reach even though the local drainage area is smaller (5.9 mi^2 for the mid-town reach as compared to 11.0 mi^2 for the up-town reach). The greater intensity of runoff in the mid-town reach appears to be due to the higher percentage of impervious area.

Impervious cover (pavement and roof tops) was estimated by the USACOE for sub-basins of the Santa Fe Watershed (USACOE 2007) which is shown in Table 3. The weighted average percent impervious for the up-town reach is 9 percent, while the average for the mid-town reach is 29 percent, which results in faster runoff during storm events. While the intensity of the storm flows can be greater in the lower reach, the overall total amount of storm inflow is about 100 ac-ft greater in the upper reach. The precipitation gradient (more precipitation with increase elevation) could possibly contribute to the greater runoff in the up-town reach.

Table 1. Estimated magnitude and duration of storm inflows in the up-town reach (*below Nichols* to *above St. Francis* gages) on the Santa Fe River.

Year	Total time of storm flow events	Average During Storm Events			Total Annual Storm inflow	Maximum storm inflow rate in any 15-minute period
		Below Nichols Flow	*Above St. Francis* Flow	Storm inflow rate		
	days	cfs	cfs	cfs	ac-ft/yr	cfs
2000*	23.8	0.13	5.04	4.9	232	290
2001	8.3	0.01	4.78	4.8	79	113
2002	4.2	0.03	9.24	9.2	76	172
2003	5.0	0.01	4.54	4.5	45	110
2004	20.6	0.45	5.53	5.1	208	84
2005	97.7	19.16	24.75	5.6	1084	221
2006*	21.9	12.2	18.1	5.9	257	86
Time weighted Average	26	12	17	5	283	--

**Partial Year*

Table 2. Estimated magnitude and duration of storm inflows in the mid-town reach (*above St. Francis* to *Ricardo* gages) on the Santa Fe River.

Year	Total time of storm flow events	Average During Storm Events			Total Annual Storm inflow	Maximum storm inflow rate for any 15-minute period
		Above St. Francis flow	*Ricardo* flow	Storm inflow rate		
	days	cfs	cfs	cfs	ac-ft/yr	cfs
2000*	4.0	8.3	26.8	18.5	148	842
2001	0.2	24.4	79.9	55.5	23	282
2002	2.5	4.6	34.5	29.9	146	988
2003	0.1	6.1	23.2	17.1	4	79
2004	12.9	15.2	25.0	9.8	251	102
2005	13.3	18.2	29.7	11.5	301	144
2006*	14.2	24.5	35.3	10.9	307	246
Time weighted Average	7	18	30	13	168	--

**Partial Year*

Figure 4. Cumulative annual inflows by month for the up-town reach 2001-2006.

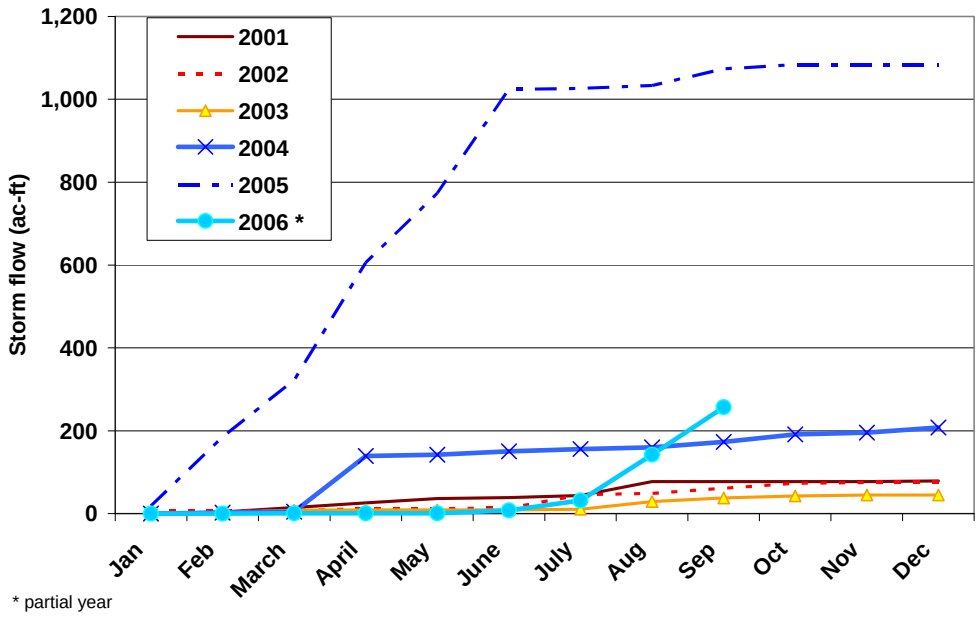


Figure 5. Cumulative storm inflows by month in the mid-town reach 2001-2006.

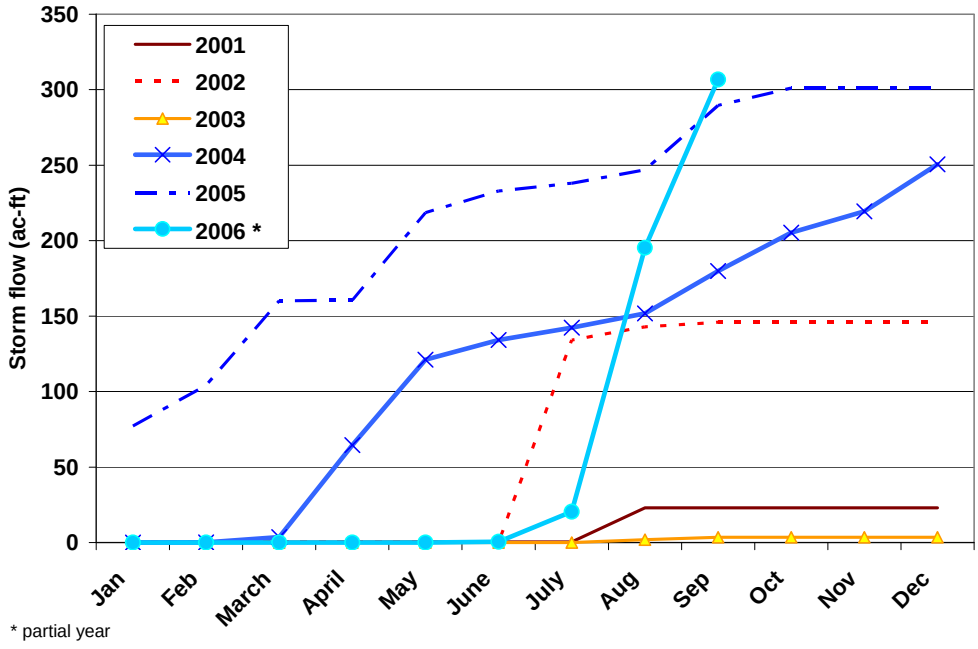


Table 3. Percent impervious area by reach.

USACO Sub-basin	Area of Sub-basin mi^2	Slope ft/ft	Percent impervious 2004-2005 %	Impervious Area mi^2	Location of Sub-basin
Up-town Reach					
W120	2.77	0.04	1%	0.028	Below Nichols Reservoir to Camino Cabra/Canyon Road Bridge
W150	2.95	0.02	1%	0.030	
W200	1.05	0.04	1%	0.011	
W1000	0.36	0.92	13%	0.047	Canyon Road Bridge to St. Francis
W1050	0.14	0.29	11%	0.016	
W1100	0.21	0.53	20%	0.042	
W1110	0.13	0.23	29%	0.038	
W1150	0.09	0.36	30%	0.027	
W1200	0.27	0.54	19%	0.050	
W1210	1.64	1.88	1%	0.016	
W360	0.34	0.9	15%	0.051	
W800	0.57	0.98	70%	0.400	
W850	0.07	0.34	82%	0.057	
W900	0.04	0.17	82%	0.033	
W950	0.41	1.25	48%	0.198	
Total Up-town Reach	**11.04**		**9%**	**1.04**	Weighted average
Mid-town Reach					
W1250	0.17	0.4	54%	0.092	Below St. Francis to Arroyo Mascaras
W1260	0.53	0.73	26%	0.139	
W320	0.19	0.87	25%	0.048	
W450	0.02	0.74	45%	0.009	
W500	0.32	0.81	5%	0.016	
W510	1.67	1.17	12%	0.204	
W550	0.03	0.15	37%	0.011	
W600	0.21	0.38	27%	0.056	
W700	0.24	0.55	64%	0.155	
W710	0.11	0.33	16%	0.018	
W750	0.37	1.14	52%	0.194	
W760	0.28	0.33	34%	0.095	
W340	0.54	0.97	49%	0.265	Arroyo Mascaras to Ricardo Road
W1300	0.44	0.89	1%	0.004	
W1600	0.11	0.57	55%	0.061	
W1750	0.16	0.48	10%	0.016	
W1760	0.48	0.92	61%	0.292	
Total Mid-town reach	**5.87**		**29%**	**1.673**	Weighted Average

USACO Sub-basin	Area of Sub-basin mi^2	Slope ft/ft	Percent impervious 2004-2005 %	Impervious Area mi^2	Location of Sub-basin
West-side reach					
W1400	0.25	0.76	38%	0.096	
W1450	0.17	0.49	18%	0.031	
W1500	0.51	0.88	62%	0.316	
W1550	0.35	0.95	73%	0.256	
W1560	0.67	1.49	73%	0.491	
W1650	0.2	0.72	67%	0.134	
W1660	0.73	1.62	59%	0.429	
W1700	0.5	1.06	25%	0.125	
W1710	0.59	1.33	64%	0.376	
W1800	0.14	0.47	28%	0.039	Ricardo Road to WWTP
W1810	0.4	0.81	5%	0.020	
W1860	0.8	0.98	10%	0.080	
W1910	0.38	0.69	5%	0.019	
W1960	0.08	0.31	26%	0.021	
W2010	0.43	0.69	5%	0.022	
W2060	0.1	0.3	10%	0.010	
W2110	0.26	0.59	10%	0.026	
W2160	0.26	0.43	10%	0.026	
W2210	0.38	0.69	57%	0.218	
W2260	0.22	0.43	57%	0.126	
W2310	0.69	1.02	8%	0.055	
W2360	0.19	0.68	59%	0.112	
W2400	0.48	0.86	60%	0.290	
W2410	0.42	0.59	63%	0.266	
W2460	0.6	0.99	2%	0.012	
W310	0.01	0.14	65%	0.007	
W380	0.34	0.47	15%	0.051	
W420	0.55	1.24	12%	0.066	
W440	0.65	1.01	2%	0.013	
W610	0.79	0.94	13%	0.103	
W660	1.16	1.04	10%	0.116	
Total West-side Reach	**20.36**		**19%**	**3.950**	Weighted Average

Source: USACOE 2007 based on 2004 and 2005 aerial photography by the City of Santa Fe, Santa Fe County and State of New Mexico and soil data.

References:

US Army Corps of Engineers. 2007. Santa Fe River, New Mexico Watershed Management Plan Study. Draft Hydrologic and Hydraulic Assessment.

Williams, Neil. 2008. Instantaneous data for Nichols, above St. Francis and Ricardo Road gages provided via email July 18, 2008.