Sediment Characteristics for Run-of-River Impoundments in the Guadalupe River Basin

Document No. 010328
PBS&J Job No. 444215

SEDIMENT CHARACTERISTICS FOR RUN-OF-RIVER IMPOUNDMENTS IN THE GUADALUPE RIVER BASIN

Prepared for:

Guadalupe-Blanco River Authority
Texas Clean Rivers Program
933 E. Court Street
Seguin, Texas 78155

Prepared by:

PBS&J and GBRA
206 Wild Basin Road, Suite 300
Austin, Texas 78746-3343

October 2001

Printed on recycled paper

EXECUTIVE SUMMARY

The Guadalupe River basin has a substantial number of run-of-river impoundments that provide many functions including aquatic habitat and habitat diversity, hydroelectric power in some, groundwater recharge, providing a point for water diversion, recreation, and aesthetic appreciation. In recent years many of these impoundments have been impacted by nuisance aquatic growth, primarily macrophytes such as hydrilla, duckweed, or water hyacinth. In 1998 the Clean Rivers Program supported a study of the problem and the effects of nutrient conditions in Lake Dunlap, the first of six hydroelectric impoundments. One of the findings of that study was that reducing nutrient concentrations in the water may not be an effective control measure because these aquatic plants have the ability to obtain their nutrients from lake sediments.

Recognizing that sediments play a major role in water quality conditions in these shallow impoundments, the Clean Rivers Program Steering Committee authorized conducting this study of sediment nutrient concentrations. The primary goals were to characterize sediment concentrations of important nutrients and sediment types over a wide geographic range. Also, because the earlier study had involved one round of sediment collection on Lake Dunlap in 1997, there was the opportunity to examine the effects of the major flood of October, 1998.

The sediment monitoring took place on a quarterly basis during fiscal years 2000 and 2001. All the study sampling objectives were met, with the exceptions of stations that became too scoured by higher flows during the winter of 2000 to sample. Impoundments sampled included two reservoirs in the Kerrville area (UGRA and Flat Rock) and four of the main hydro reservoirs in the lower river, Lakes Dunlap, McQueeney, Placid and Wood. While these impoundments differed in size, they all had very similar hydraulic residence times.

This report presents the results of the sampling program and attempts to extract spatial and temporal patterns from the data. One spatial trend noted was that there appears to be a trend of increasing phosphorus concentrations and decreasing nitrogen concentrations moving from upstream to downstream. Also the clay content of sediments increased towards the lower basin, as might be expected from the differences between Hill Country and Coastal Plain soils. The data did not reveal any marked differences in sediment concentrations in relation to point source wastewater discharges. The October 1998 flood event had a major impact on the sediment patterns in Lake Dunlap.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

Mike McCall of the GBRA was the key individual in the study. He collected almost all the sediment samples and either analyzed or supervised the analysis of the samples. He was assisted by Brian Lyssy and Alison Koehler of the GBRA. Also assisting in upper basin sampling were Scott Loveland and Keith Marquart of the Upper Guadalupe River Authority.

1.0 INTRODUCTION

Special studies are an integral component of the Clean Rivers Program (CRP). Through coordinated monitoring meetings and active public communication, the Guadalupe-Blanco River Authority (GBRA) determines specific needs for targeted assessment. An area of interest identified in 1999 was sediment conditions in the Guadalupe River hydroelectric lakes and small impoundments with particular emphasis on the effect of the October 1998 flood.

In the recent past the CRP supported an analysis of the possible need for point source nutrient removal to help control accelerated aquatic plant growth on Lake Dunlap. Lake Dunlap is a hydroelectric generation impoundment immediately downstream of the IH-35 crossing that receives treated effluent from the New Braunfels area (GBRA & EH&A, 1998). The basic conclusion of that work was that while wastewater nutrient removal would limit plankton levels to some degree during low flow periods, it would be hard to justify because of the marginal benefit, large cost and relatively infrequent need. However, it was noted in the study that the use of the effluent for irrigation during dry periods would be useful and cost-effective. One of the reasons that point source nutrient removal was found to be of questionable value was that many of the problem plants such as hydrilla could obtain nutrients directly from the sediments. In that case, point source nutrient removal would have little effect.

Because of the significant role that may be played by sediments in supplying nutrients to nuisance vegetation, the CRP supported some basic data collection efforts in the basin lakes. One purpose of this effort was to get an initial set of data to better understand spatial and temporal differences in the sediment within the study impoundments. Additionally, because of the previous study on Lake Dunlap, the study would allow observation of the possible effects of the October 1998 flood on the sediment distribution in that impoundment.

Six impoundments were selected for analysis. The six are all run-of-river impoundments extending from near the headwaters of the Guadalupe River to well downstream. They include the UGRA and Flat Rock Lakes in Kerr County, and Lakes Dunlap, McQueeney, Placid and Wood (H-5) further downstream. Figure 1-1 shows the location of the reservoirs in the river basin. Figure 1-2 shows the locations of the sampling stations in each reservoir.

Table 1-1 provides a brief tabular summary of the impoundments including size and long-term median flow and residence time information. The flow used in the Kerrville area is from USGS gage 08166200, at the UGRA lake. No adjustment is made for the slightly higher flow at Flat Rock, but the reader should recognize that the flow will be slightly larger due to additional watershed area and wastewater flow from the City of Kerrville. The flow for the lower river impoundments is the sum of 08168500, the Guadalupe River near New Braunfels, primarily reflecting Canyon Reservoir releases, and 08169000, the Comal River at New Braunfels, primarily reflecting spring flows. Again, the reader should recognize that while no adjustment is made for additional flow going downstream, there will be an

increase. The major basin tributary, the San Marcos River, enters below Lake Wood. The two upstream impoundments are considerably smaller than those in the lower basin, but the median residence times for all of the impoundments are very similar.

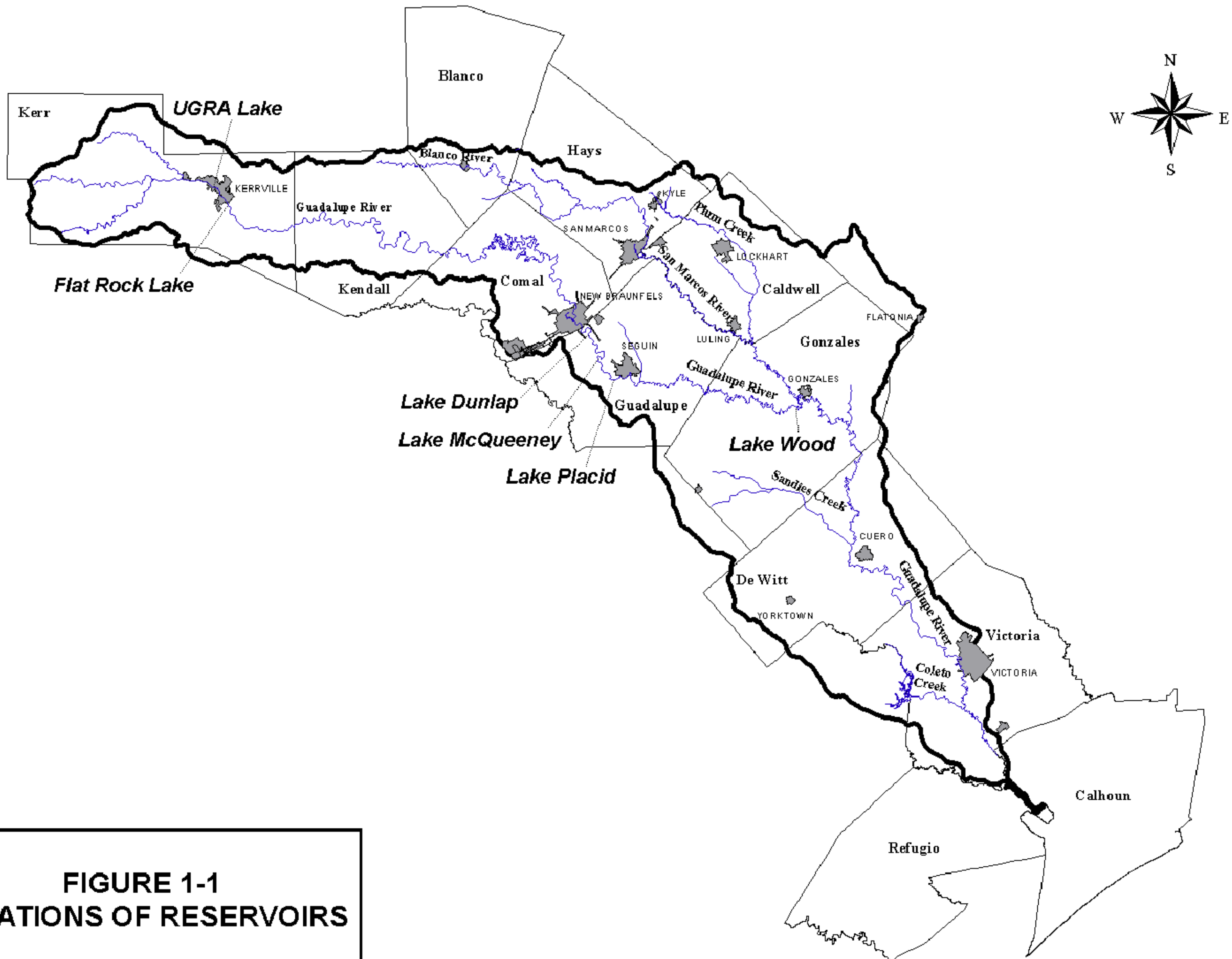


FIGURE 1-1
LOCATIONS OF RESERVOIRS

10 0 10 Miles

FIGURE 1-2A
LOCATIONS OF SAMPLING STATIONS
(UGRA LAKE AND FLAT ROCK LAKE)

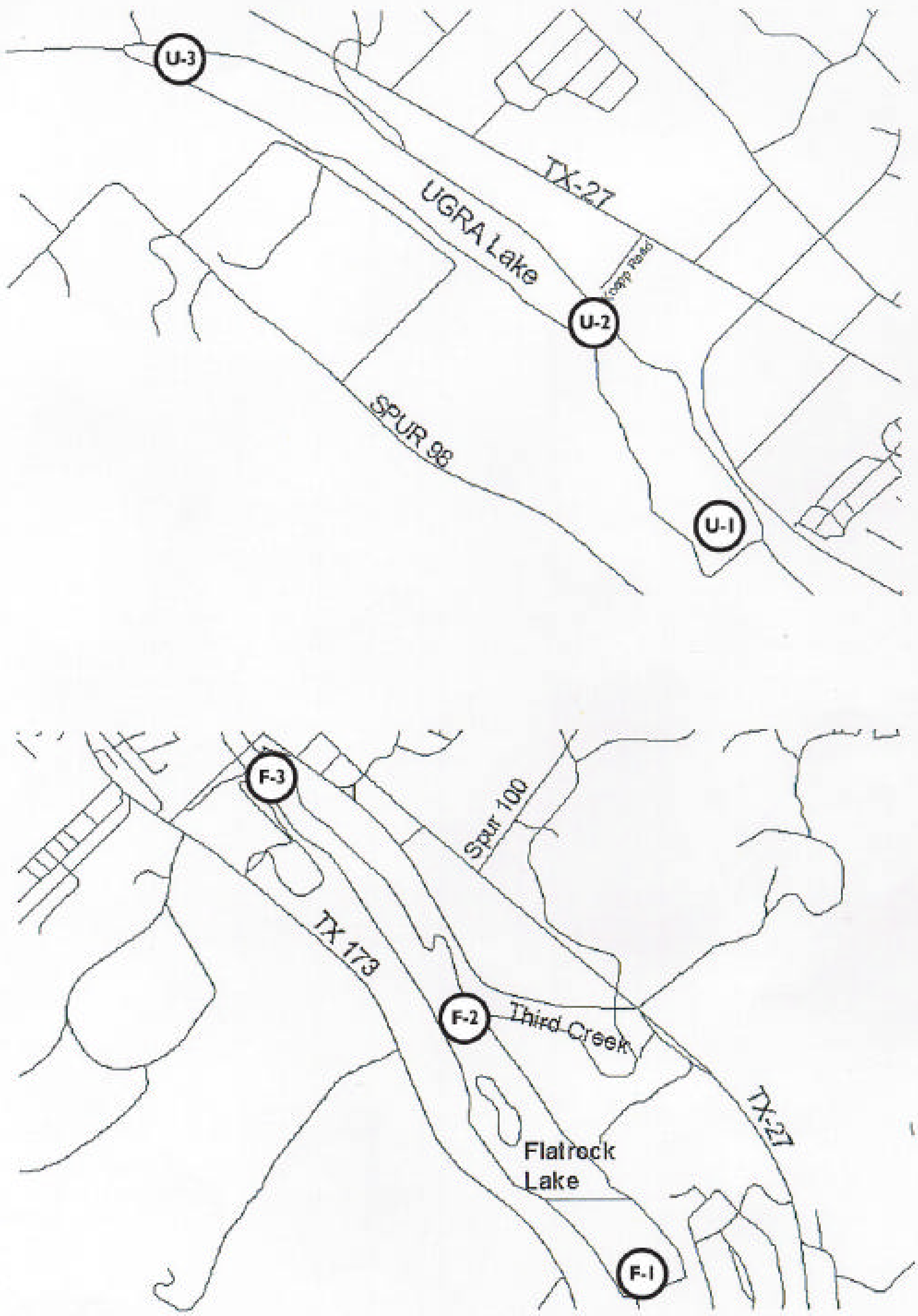


FIGURE 1-2B
LOCATIONS OF SAMPLING STATIONS
(LAKE DUNLAP)

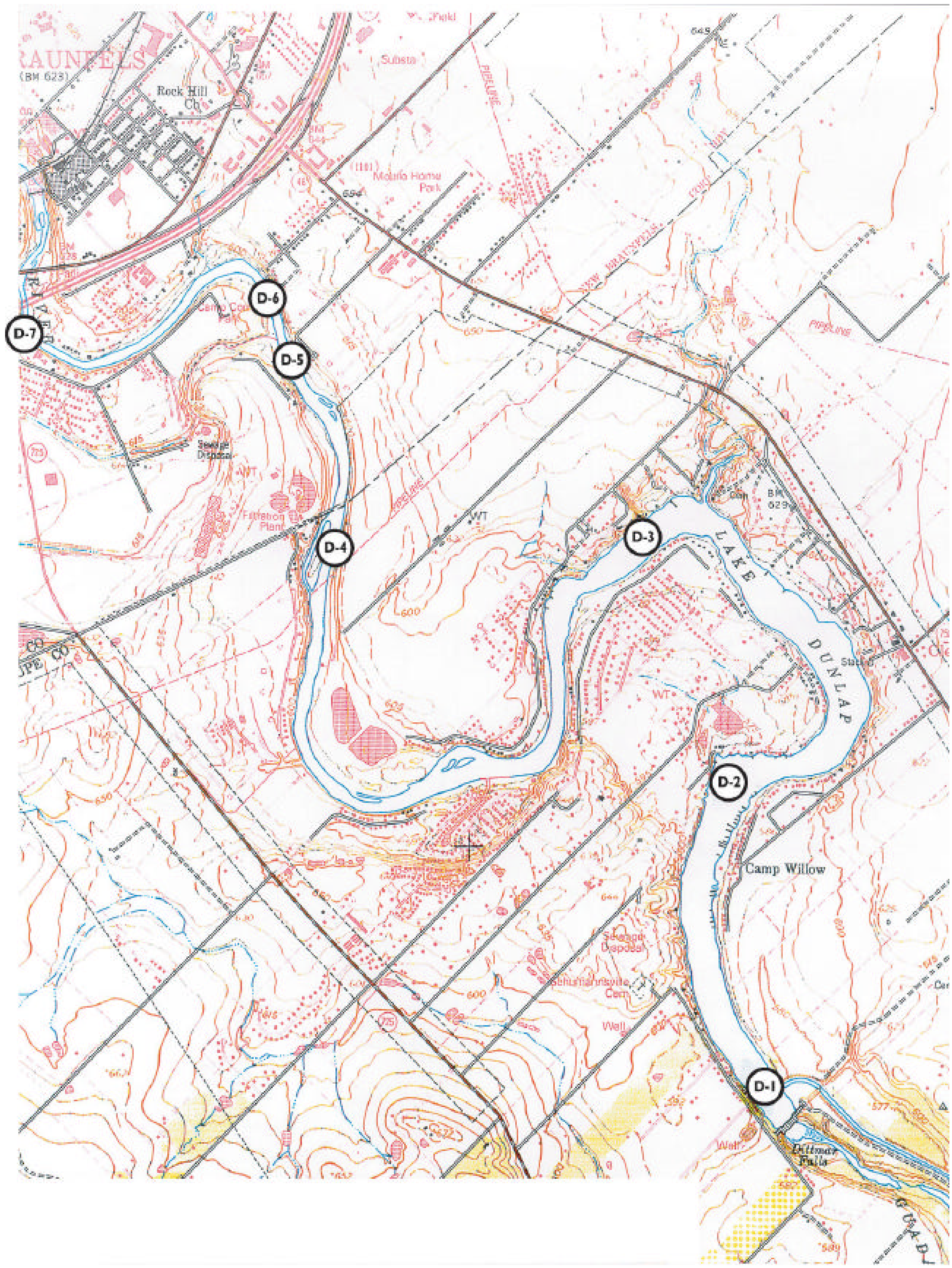


FIGURE 1-2C
LOCATIONS OF SAMPLING STATIONS
(LAKE MCQUEENEY)

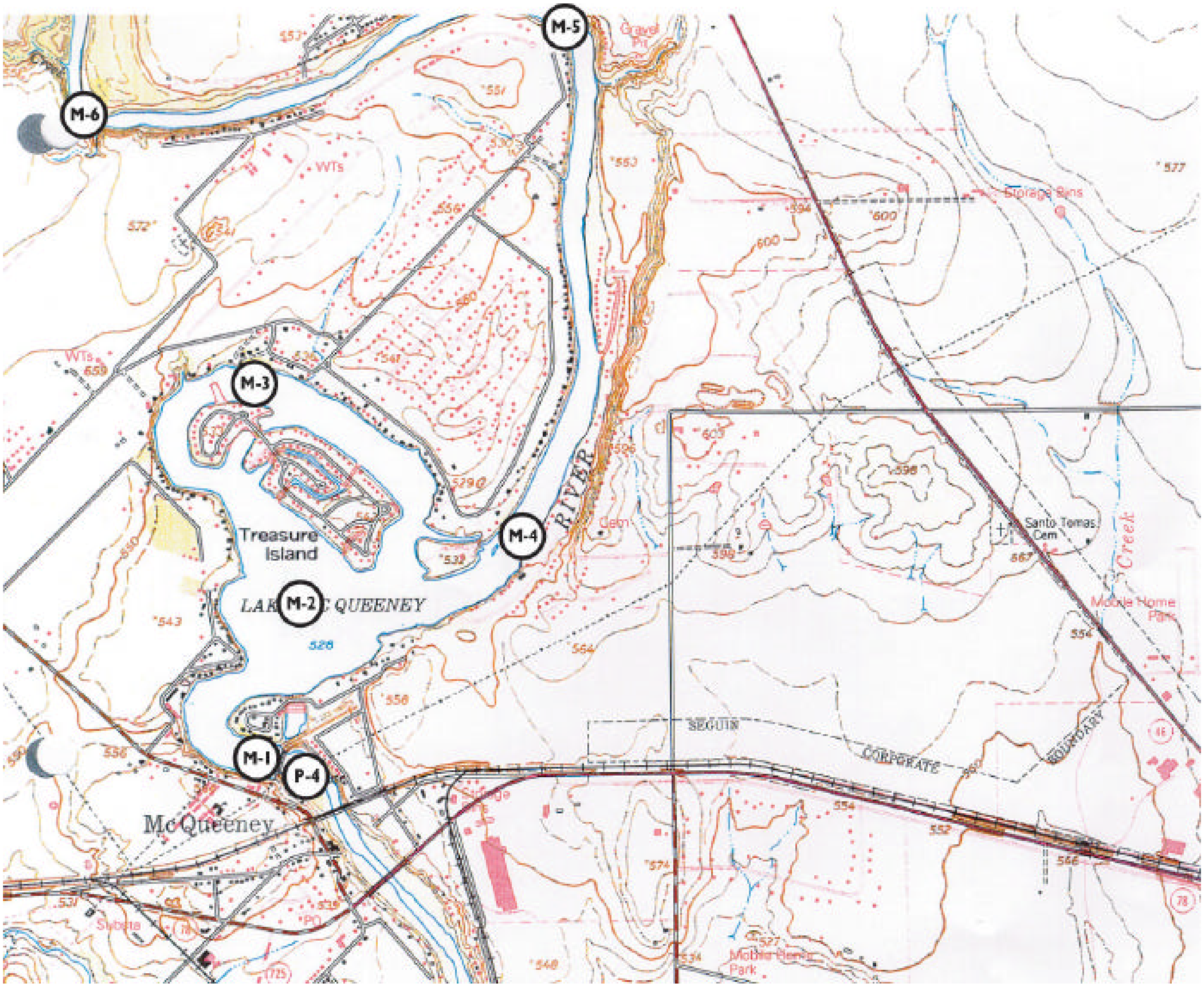


FIGURE 1-2D
LOCATIONS OF SAMPLING STATIONS
(LAKE PLACID)

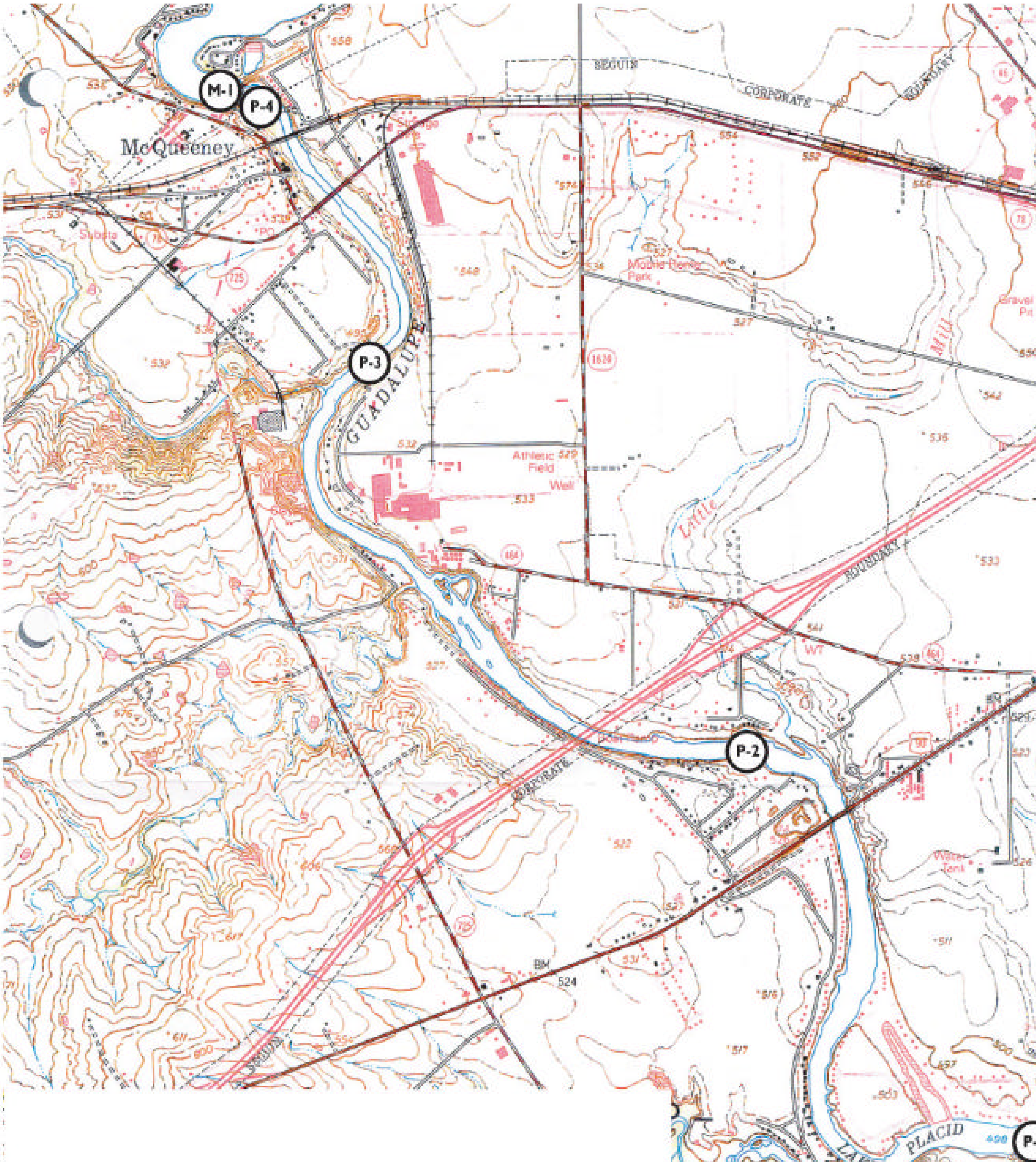


FIGURE 1-2E
LOCATIONS OF SAMPLING STATIONS
(LAKE WOOD)

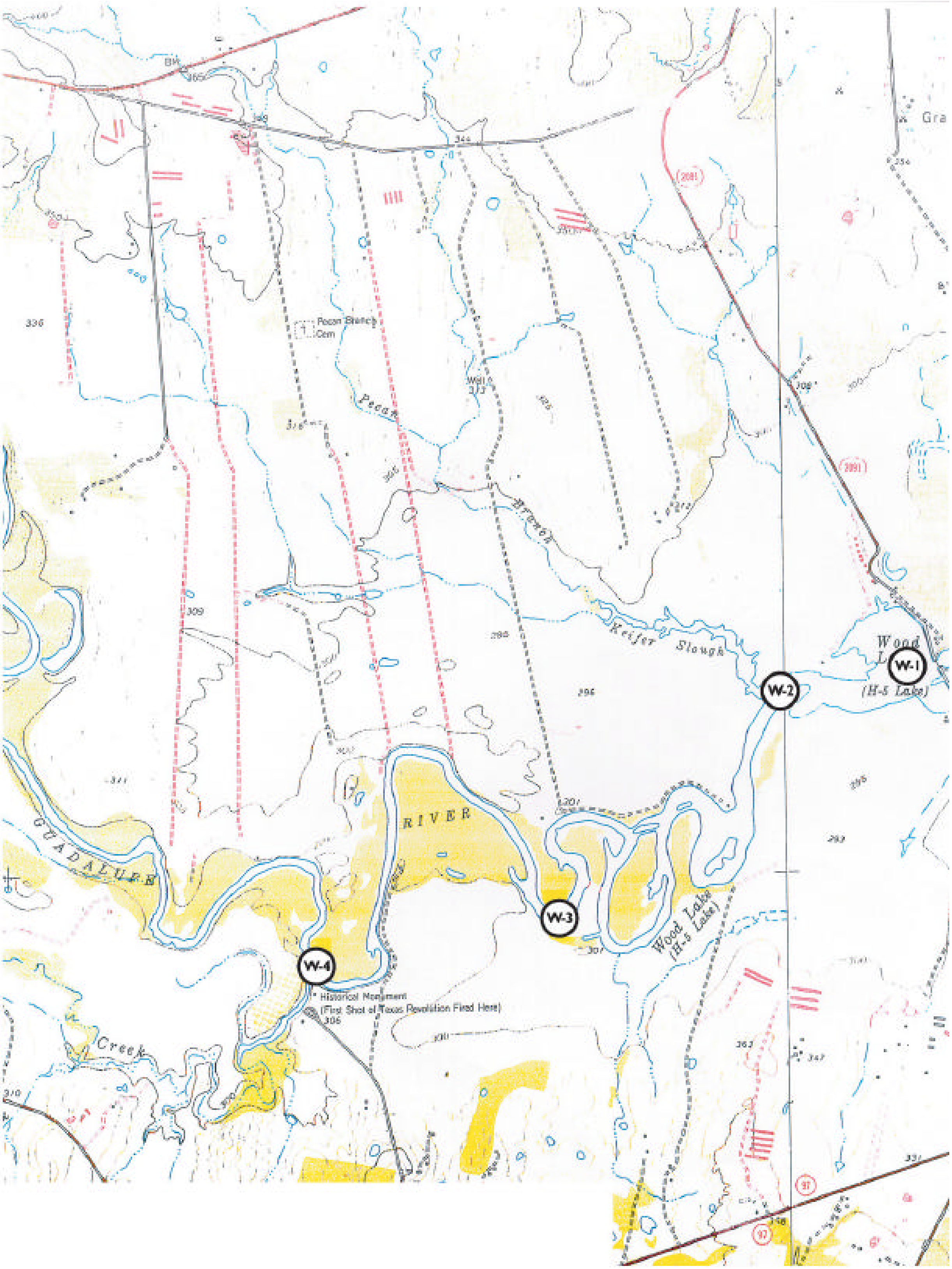


TABLE 1-1

PHYSICAL CHARACTERISTICS OF IMPOUNDMENTS

Reservoir	Volume (ac-ft)	Area (acres)	Depth (feet)	Elevation (feet MSL)	Median Flow (cfs)	Median Residence Time (days)
Kerrville Ponding Lake (UGRA)	840	105	8.0	1,621.0	91	4.65
Flat Rock Lake	793	104	7.6	1,564.0	91	4.39
Lake Dunlap	5,900	410	14.4	575.2	583	5.10
Lake McQueeney	5,050	400	12.6	528.7	583	4.37
Lake Placid	2,624	248	10.6	497.5	583	2.27
Lake Wood	4,000	488	8.2	290.9	583	3.46

Data sources: GBRA and USGS data, EH&A, 1991a & b.

2.0 METHODS

This effort began in the fall of 1999 and a total of five sampling runs were completed, although not all lakes and stations were sampled in each run. Three sediment grabs were collected and composited to make up a single sample analyzed for each station. All sampling was done from a small boat. The Standard Operating Procedure used for the sampling is included as Attachment A.

The individual grabs were at mid-channel and on both sides of the impoundment. Grabs were collected with an Ekman dredge. This is a stainless steel square section 6 inches on the side that has spring-loaded jaws that are closed after the dredge is dropped into the sediment. Figure 2-1 shows an Ekman dredge with the jaws open, ready to be placed on the sediment, and closed, ready for hauling the sample to the boat. The dredge is then pulled into the boat, the jaws are opened and the sample is placed in a deep plastic pan. The top two inches of the mud are taken and placed in a stainless steel bowl. Two additional grabs are collected at each station with the top layer placed into the same bowl. The bowl contents of the three grabs are then mixed and a subsample is taken and placed into a wide-mouthed sample jar. This jar is labeled, placed on ice, and taken to the GBRA laboratory for analysis. The sample represents an average of the surface sediment at the station.

Sediment samples were analyzed for percent solids and percent volatile solids, Total Kjeldahl Nitrogen (TKN), Total Organic Carbon (TOC), Total Phosphorus (TP), and percentage of gravel, sand, silt and clay. Water column samples were also measured for pH, conductivity, temperature and dissolved oxygen. Analytical methods are described in the QAPP. The sediment samples were analyzed by solid waste methods, digesting the samples to release N, C, and P and then analyzing the liquid by water analysis means. All sediment results are expressed on a dry weight basis.

Table 2-1 presents a chronology of data collection efforts. Several factors played a role in limiting the data collection. A major problem was times when river flows were high that made sampling difficult if not impossible, particularly in the upper reaches of the lakes. These higher flows also tended to scour the soft sediment, limiting the ability to collect a sample even if the dredge could be placed on the bottom. This was the case for a number of upper reservoir stations on several trips. On one sampling trip (8/15/2000) the Ekman dredge was lost over the side, which halted sampling until a replacement could be obtained.

FIGURE 2-1
EKMAN DREDGE

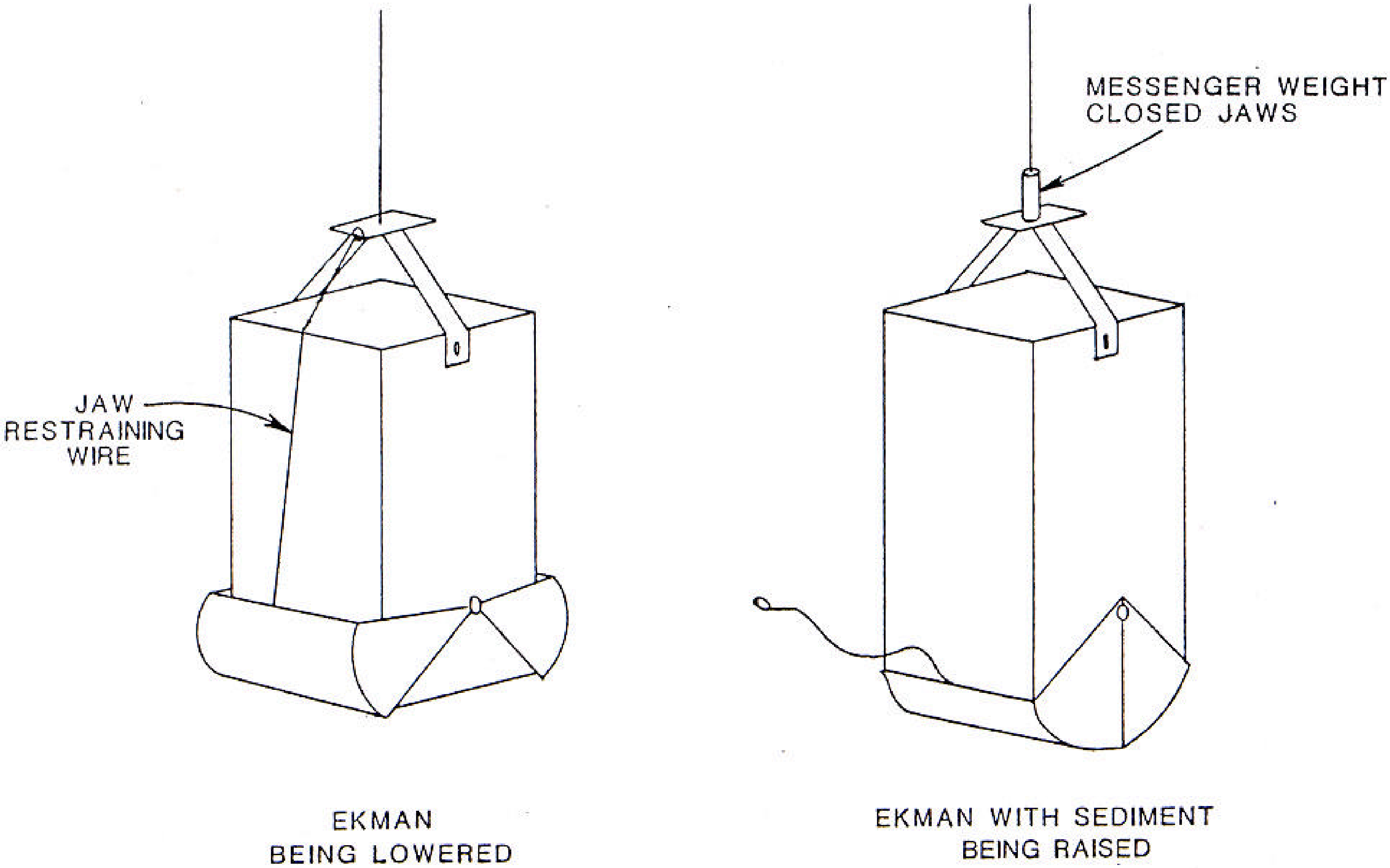


TABLE 2-1

CHRONOLOGY OF SEDIMENT SAMPLING

Date	*Sites Sampled*	*Special Notes*
11/15/99	U,F	First sampling event with Ed Oborny, PBS&J. Clear, 65
11/16/99	D	
11/17/99	W	
11/22/99	P,M	
2/21/00	W,P,M,D	overcast, 58
2/28/00	U,F	11/2" rain on 2/22 & 2/25
8/8/00	M	Partly cloudy, 97
8/9/00	D	
8/15/00	P	Lost the Ekman dredge when high waves caused by a ski boat caused the sampling boat to tilt.
8/30/00	U,F	85, clear
2/26/01	W,P,D	Overcast, 60, *First sampling event since the heavy rains of October and the high release rates out of Canyon Reservoir. The high river flows lasted through December and caused scouring of the upper sites of Flat Rock Lake, Lake Placid and Lake Dunlap. Sites F2, D4, D5, D6 no longer sampled.
2/27/01	M	Showers last night
2/28/01	F,U	Light rain during sampling
5/8/01	P,M,D	Partly cloudy, 75
5/10/01	W	Partly cloudy, 85
5/22/01	F,U	Clear
7/12/01	M,P	Clear, 100
7/13/01	D	Clear, 100
7/18/01	F,U	Clear
7/19/01	W	Last sampling event for the study

3.0 RESULTS

The numerical data are presented in Table 3-1. The pre-flood observations in 1997 are also tabulated but they only exist on Lake Dunlap. The data are listed by order of time first, then from downstream to upstream. For example, the W1 site in Lake Wood is at the downstream end near the dam and the W4 site is the most upstream. The U2 site is the most upstream location in the UGRA reservoir, upstream of the City of Kerrville.

Figure 3-1 plots the TKN, TOC, and TP data together with percentage of solids and volatile solids and percentage sand, silt and clay for the individual sampling runs. The reservoirs are arranged on the figure from upstream near Kerrville on the left to downstream near Gonzales on the right. The data for each are also arranged from upstream on the left to the downstream dam on the right. A dam symbol is included for the downstream end of each reservoir.

A general discussion of sediment data may be useful before getting into the details of the results. All of the sediments sampled are recent depositional materials, rather than stiff clays deposited in geologic time. A given volume of mud is composed of solids and water. Typically, the more fine silts and clay particles and the more organic matter present, the lower the solids content. The percentage of volatile solids indicates the amount of organic matter in the sediment. This organic matter is what contains the bulk of the N, P and C in the sediment.

A correlation matrix is presented below as Table 3-2 showing the relations between the main sediment parameters. This matrix shows the correlation coefficient between each parameter. A value of 1.0 indicates perfect correlation and a zero indicates no relationship. A negative correlation indicates the parameters may be related but in opposite directions. An example is the correlation between % sand and % silt of –0.92. Sediment that is high in sand is low in silt, and visa versa. As might be expected, there is a negative relation between % solids and % volatile solids and also with C, N, P and the % silt and clay. The samples with low % solids tend to be finer and more organic materials. There is a positive correlation between % solids and % sand.

Figure 3-2 is a similar plot to Figure 3-1, but with the post-flood data averaged at each sampling station to make the figure less cluttered and the broad patterns easier to discern. Only stations with three are more data points are used in the figure. The patterns and general trends are discussed below.

3.1 FLOOD EFFECTS ON LAKE DUNLAP SEDIMENTS

The flood of October 1998 was a major event that claimed many lives as it reshaped the river. Figure 3-3 shows the flow at the headwaters of Lake Dunlap (combination of gages 08168500 and 08169000) from September 1, 1998 to September 1, 2001. The magnitude of the event relative to more

TABLE 3-1

SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS OF GUADALUPE RIVER

Station [1]	% Solids	% Volatile solids	TOC mg/kg	TKN mg/kg	Total Phos. Inorg. mg/kg	pH SU	Temp. deg C	Cond. µmhos/cm	DO mg/L	% Clay	% Silt	% Sand	% Gravel
September 1997													
D1	38.4	7.9	13,900	1,831	517	7.87	26.92	400	8.47	24	73	4	0
D2	44.5	7.3	7,803	1,933	412	7.71	26.33	420	7.60	22	70	8	0
D3	53.8	6.4	5,217	1,238	333	7.73	25.80	420	7.73	18	39	43	0
D4	53.8	6.1	3,089	1,390	334	7.66	25.41	410	7.77	9	28	63	0
D5	26.2	4.0	2,333	1,488	852	7.82	25.35	450	7.92	10	14	76	0
D6	43.0	11.6	8,261	1,682	322	7.78	25.20	440	8.27	8	16	76	0
D7	86.9	6.8	7,321	1,368	320	7.72	25.25	440	8.82	15	40	45	0
D8	55.1	6.2	7,018	1,404	281	7.93	26.09	430	8.58	8	16	76	0
November 1999													
W1	48.9	5.9	6,446	1,014	605	8.11	19.79	539	8.20	36	50	14	0
W2	43.7	4.8	6,704	1,354	697	8.09	20.08	536	8.72	32	52	16	0
W3	44.4	6.3	6,100	1,307	528	8.06	20.41	541	8.99	35	55	10	0
W4	49.6	2.9	4,783	1,307	643	8.04	20.41	542	9.36	30	51	18	1
P1	47.0	6.4	5,114	1,131	580	7.46	20.47	561	7.53	32	55	13	0
P2	45.6	7.8	2,299	1,138	966	7.63	20.77	549	8.04	33	56	11	0
P3	57.5	5.7	4,286	916	617	7.75	20.74	544	8.74	24	16	58	2
M1	52.4	5.4	7,041	1,250	563	7.76	20.76	540	8.36	25	39	36	0
M2	48.8	7.4	6,556	1,720	649	7.79	20.97	539	8.41	23	45	32	0
M3	32.9	10.9	9,406	1,764	1,075	7.83	21.21	548	9.59	22	44	34	0
M4	45.1	9.8	6,629	1,108	819	7.79	20.95	535	8.45	20	49	31	0
M5	62.2	4.8	4,848	941	396	7.83	21.27	535	8.75	20	49	30	1
M6	55.3	9.1	5,370	1,030	514	7.95	20.97	538	8.31	21	45	34	0
D1	45.2	4.7	6,562	1,286	680	7.39	21.28	545	7.48	22	64	14	0
D2	44.7	6.8	7,300	1,396	648	7.49	21.04	548	8.20	25	60	15	0
D3	50.8	5.4	6,274	1,621	733	7.39	21.41	537	8.79	15	44	41	0
D4	53.0	5.3	6,195	992	563	7.39	21.67	532	8.74	9	25	66	0
D5	45.2	7.8	8,776	2,100	621	7.39	21.43	589	8.39	10	32	58	0
D6	52.3	5.6	5,755	1,419	534	7.56	21.42	527	8.67	9	35	55	1
D7	38.0	14.4	10,829	2,618	585	7.45	21.17	527	9.07	9	34	56	1
February 2000													
W1	54.6	4.4	7,479	1,178	574	8.01	18.19	519	9.03	40	50	10	0
W2	49.7	5.8	9,677	1,600	678	8.07	18.80	520	8.49	38	48	14	0
W3	51.6	6.2	10,118	952	653	8.04	19.10	530	8.23	36	45	19	0
W4	52.4	5.4	8,163	938	518	8.24	19.00	526	8.51	32	42	24	2
P1	45.4	8.5	9,070	1,515	841	8.07	19.27	518	7.94	35	52	13	0
P2	39.9	9.5	9,762	1,458	976	7.95	18.74	516	8.37	37	55	8	0
P3	46.8	8.1	9,770	1,410	750	7.93	18.68	516	8.50	22	35	41	2
M1	48.5	8.2	8,333	1,416	681	8.15	19.32	517	8.46	26	41	33	0
M2	53.7	6.4	7,647	1,410	524	7.97	18.34	512	8.44	22	40	38	0
M3	45.2	6.2	9,760	1,232	696	7.96	18.66	506	8.66	20	38	42	0
M4	49.3	7.2	9,204	1,192	660	7.94	19.75	520	8.36	19	45	36	0
M5	51.8	8.4	7,913	1,052	627	7.92	19.81	521	8.38	17	46	36	1
M6	62.8	4.0	7,395	528	428	7.91	19.99	522	8.60	15	44	39	2
D1	44.7	8.5	9,368	1,470	740	8.04	19.91	523	8.15	28	68	4	0
D2	49.0	7.9	8,478	1,683	760	7.89	20.56	532	8.06	26	70	4	0
D3	51.4	7.5	7,857	1,287	714	7.86	20.38	520	8.58	20	44	36	0
D4	59.7	5.1	7,699	912	476	7.80	21.17	516	8.83	18	30	51	1
D5	54.6	7.0	8,492	1,154	587	7.82	20.89	511	8.86	11	27	60	2
D6	68.3	3.0	6,693	614	534	7.75	20.96	560	8.54	12	22	65	1
F1	38.0	7.9	13,239	2,004	752	8.05	16.89	427	9.80	29	58	13	0
F2	43.3	7.4	12,731	1,806	623	8.26	16.55	449	9.09	22	37	38	3
U1	32.0	4.2	13,824	2,222	582	7.97	16.88	399	9.10	28	55	17	0
U2	51.6	5.7	9,783	776	568	8.56	16.73	399	9.06	22	41	36	1
August 2000													
P1	47.9	5.5	8,936	1,329	706	7.83	31.15	552	8.51	28	49	23	0
P2	45.6	6.2	8,901	1,354	800	7.88	31.33	555	9.38	35	48	17	0
P3	56.5	3.8	7,788	992	655	7.83	31.15	541	8.71	30	32	29	9
M1	38.1	6.0	9,336	1,227	909	7.83	31.04	535	9.19	28	39	33	0
M2	49.4	5.6	9,192	1,342	577	7.95	31.88	534	8.77	20	47	33	0
M3	33.8	6.0	13,281	1,692	1,062	7.81	32.38	524	10.25	22	42	36	0
M4	45.4	6.1	8,037	1,431	653	7.74	30.96	548	9.73	17	40	43	0
M5	48.7	6.5	9,118	1,411	600	8.13	30.86	547	11.75	15	38	45	2
M6	47.2	6.0	11,136	1,178	554	7.85	29.61	548	7.29	18	25	54	3
D1	41.5	7.7	11,153	1,768	769	7.69	29.31	545	9.88	31	55	14	0
D2	45.7	6.4	8,364	2,113	723	7.32	30.07	518	12.24	29	54	17	0
D3	41.5	6.5	8,977	2,100	878	7.33	30.53	520	12.01	23	42	35	0
D4	41.4	8.3	10,488	2,137	596	7.41	27.93	609	9.17	19	25	56	0
D5	47.4	6.0	9,306	1,403	706	7.40	27.77	626	7.45	11	23	65	1
D6	71.6	1.7	7,698	415	500	7.41	28.04	610	8.79	13	20	58	9
F1	35.4	6.4	13,913	2,158	730	7.92	28.58	471	10.63	29	54	17	0
U1	35.8	6.3	16,333	2,249	571	7.85	28.36	421	9.10	24	55	21	0
U2	58.0	3.8	9,385	1,221	475	7.78	28.60	419	9.74	30	43	27	0

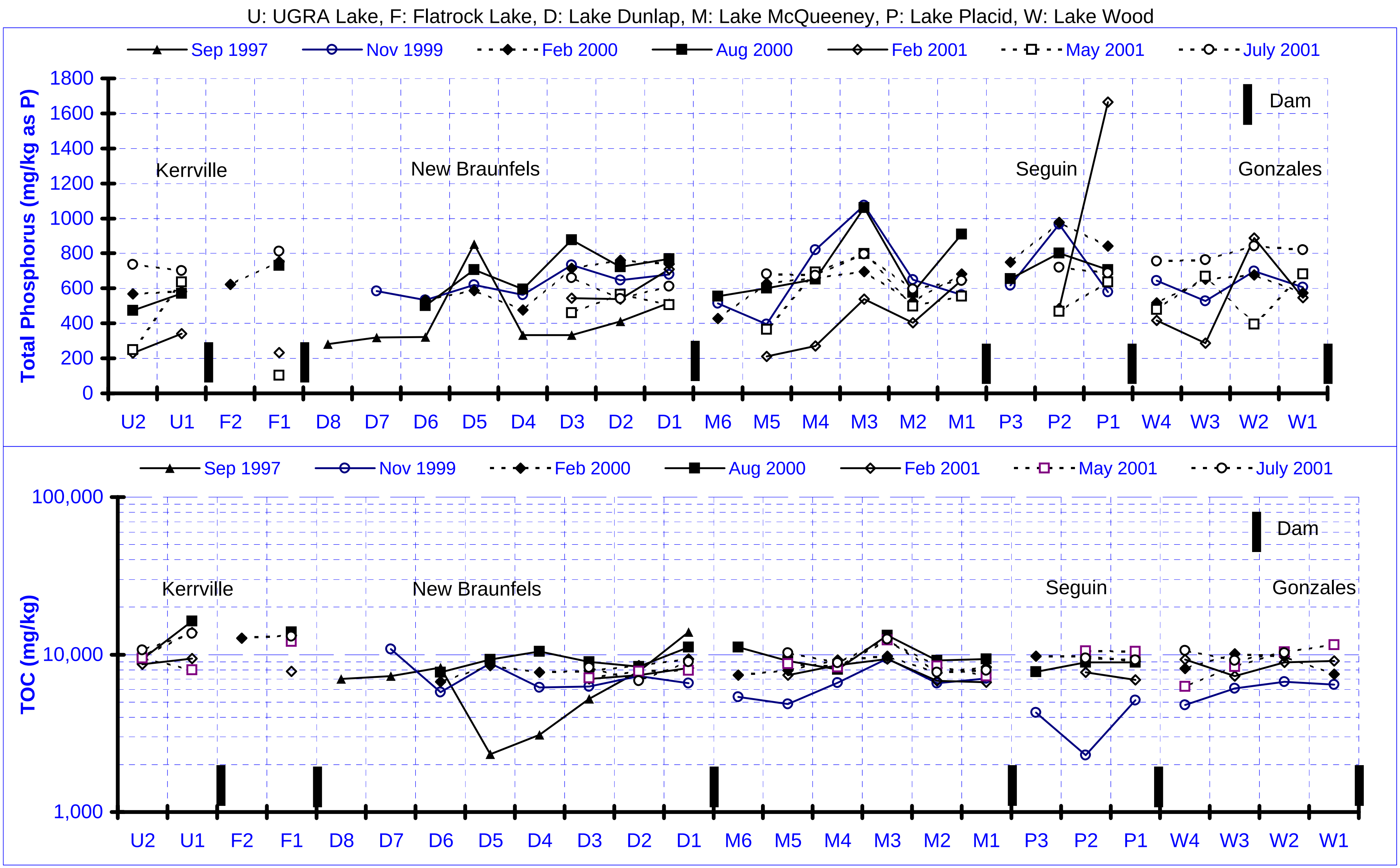
TABLE 3-1 (CONCLUDED)

SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS OF QUADALUPE RIVER

Station [1]	% Solids	% Volatile solids	TOC mg/kg	TKN mg/kg	Total Phos. Inorg. mg/kg	pH SU	Temp. deg C	Cond. µmhos/cm	DO mg/L	% Clay	% Silt	% Sand	% Gravel
February 2001													
W1	43.2	5.5	9,128	1,050	548	8.20	18.26	531	11.26	40	51	9	0
W2	40.6	6.1	8,922	1,180	887	8.19	18.30	530	11.15	37	53	10	0
W3	43.8	6.4	7,288	813	288	8.17	18.39	525	11.01	39	55	6	0
W4	43.2	4.9	9,310	848	416	8.12	18.44	520	10.53	38	52	10	0
P1	41.7	6.2	6,896	1,100	1,666	8.16	16.91	494	10.92	30	61	9	0
P2	45.9	5.5	7,692	881	485	8.16	16.81	493	11.15	32	60	6	2
M1	49.8	4.5	6,692	630	648	8.08	17.41	487	11.66	30	34	36	0
M2	47.4	6.7	6,807	1,588	404	8.08	17.46	489	11.59	37	60	3	0
M3	38.5	7.0	9,333	1,786	540	8.09	18.07	491	11.34	37	59	4	0
M4	43.7	7.5	8,557	1,200	271	8.07	16.64	487	11.20	38	50	12	0
M5	47.5	10.0	7,402	1,080	212	7.98	16.39	486	11.12	24	37	37	2
D1	40.0	8.1	8,210	1,250	708	8.15	16.40	485	11.09	31	58	11	0
D2	45.8	5.8	7,383	1,080	540	8.15	16.24	484	11.67	33	61	6	0
D3	44.2	7.9	6,977	1,742	545	8.16	16.14	483	11.24	30	48	19	3
F1	47.0	7.7	7,815	1,874	234	8.11	16.50	586	10.13	28	33	39	1
U1	40.5	8.2	9,412	2,150	341	8.17	16.39	533	10.24	28	43	27	2
U2	42.7	9.6	8,667	2,660	229	8.12	16.33	535	10.19	37	43	20	0
May 2001													
W1	39.2	6.7	11,538	1,368	683	8.08	27.58	503	12.50	41	52	7	0
W2	37.6	7.2	10,361	1,527	395	7.93	25.99	516	9.86	39	50	11	0
W3	43.4	6.0	8,365	810	669	7.92	25.43	523	9.88	34	50	16	0
W4	48.2	5.9	6,260	914	478	7.88	25.74	532	10.68	36	50	14	0
P1	40.2	7.7	10,487	1,266	637	8.00	23.82	521	8.61	38	54	8	0
P2	36.8	7.7	10,500	1,271	468	8.13	23.56	513	8.97	31	55	14	0
M1	51.3	4.0	7,273	815	556	7.99	25.00	508	9.71	31	39	29	1
M2	43.0	6.4	8,447	1,218	498	8.05	25.80	510	10.01	34	63	3	0
M3	31.3	7.2	12,394	1,123	798	8.00	26.12	502	10.87	35	63	2	0
M4	42.8	6.9	8,317	936	692	7.92	23.74	505	9.62	39	51	10	0
M5	43.2	7.2	8,750	1,479	365	8.03	23.07	502	9.87	22	34	43	1
D1	38.5	7.2	7,957	1,631	505	7.87	35.68	520	10.27	31	57	12	0
D2	42.2	6.2	7,800	1,497	565	7.95	23.99	522	10.80	35	59	6	0
D3	46.0	7.5	7,105	1,848	459	7.93	23.95	518	11.40	35	37	24	4
F1	39.2	7.2	12,125	1,572	103	7.67	24.91	500	6.84	25	32	43	0
U1	45.2	8.5	7,965	1,652	637	7.69	26.05	457	6.83	27	41	32	0
U2	39.4	8.7	9,519	1,343	249	7.60	25.61	458	6.56	35	40	25	0
July 2001													
W1	40.1	5.2		1,089	819	7.40	31.33	538	7.24	43	53	4	0
W2	36.3	6.2	10,238	1,322	842	7.48	31.33	535	7.35	36	42	22	0
W3	39.8	5.2	9,192	793	762	7.58	31.42	527	7.27	36	41	23	0
W4	37.2	5.6	10,595	1,064	756	7.67	31.64	524	7.37	31	46	23	0
P1	42.0	6.7	9,247	1,399	688	8.07	30.35	525	9.13	36	56	8	0
P2	39.3	6.3	9,462	1,064	719	8.02	29.69	520	8.96	32	42	25	1
M1	44.6	3.8	7,928	880	644	7.72	29.51	502	9.23	16	34	49	1
M2	47.6	4.9	7,739	1,000	596	7.80	29.59	512	8.80	28	60	12	0
M3	33.0	6.7	12,537	2,237	795	7.81	30.87	510	7.62	27	63	10	0
M4	43.0	6.7	8,866	1,584	674	7.90	28.88	515	9.21	34	44	22	0
M5	41.8	7.5	10,217	1,557	682	7.88	28.63	525	9.06	16	37	46	1
D1	40.3	6.9	8,969	1,210	611	7.59	30.54	542	13.05	28	52	20	0
D2	47.1	5.7	6,825	959	542	7.68	30.89	543	12.31	36	54	10	0
D3	46.1	7.1	8,288	1,610	660	7.64	29.00	545	10.49	34	37	29	0
F1	31.4	6.4	13,077	2,072	812	7.51	29.08	501	6.31	32	31	37	0
U1	34.5	7.4	13,611	3,226	701	7.65	29.24	452	5.61	28	43	29	0
U2	33.1	8.3	10,674	2,092	737	7.70	29.26	449	6.20	32	37	30	1

[1] U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood

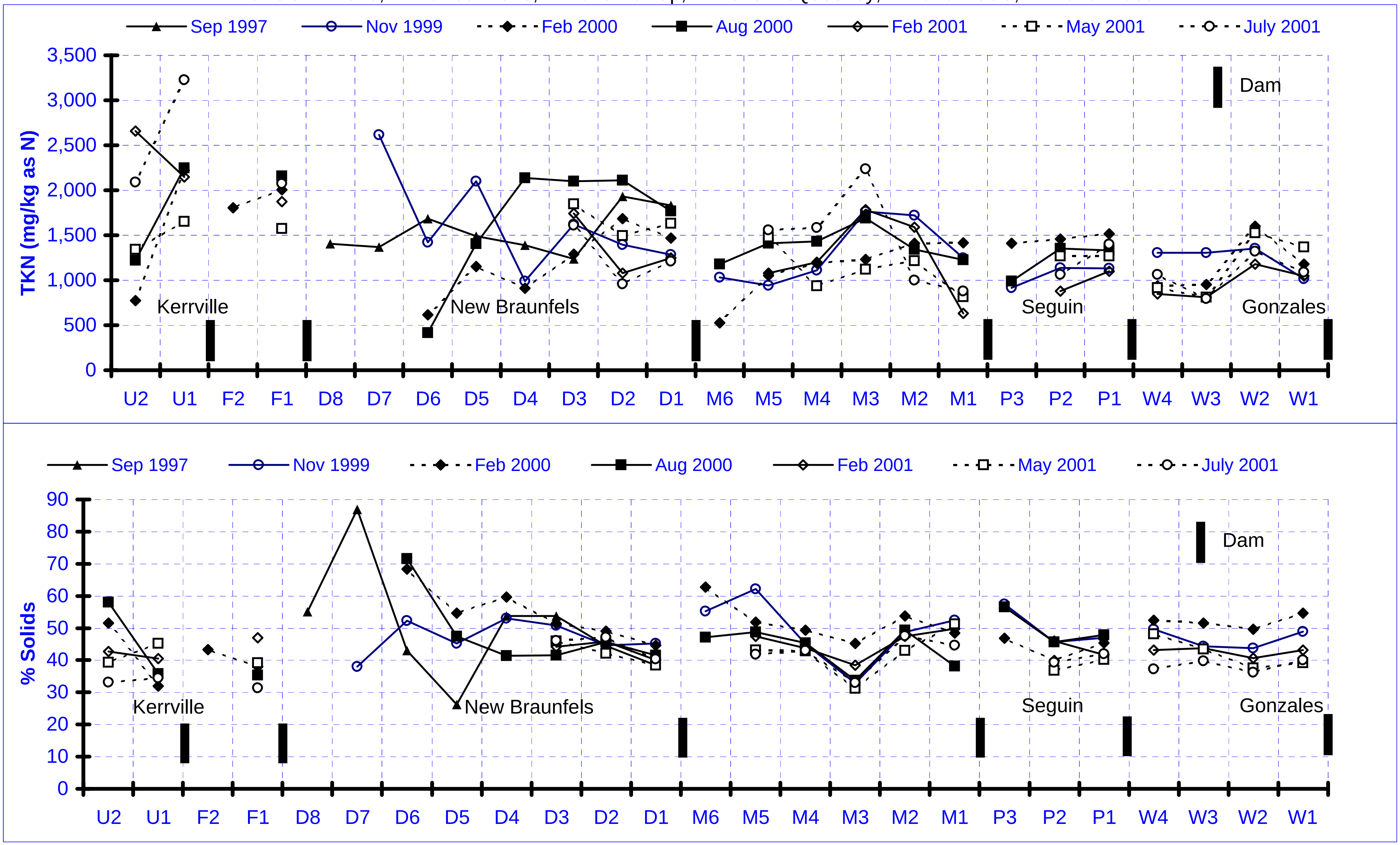
FIGURE 3-1
SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS ON THE GUADALUPE RIVER



444215/010328

FIGURE 3-1 (CONTINUED)
SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS ON THE GUADALUPE RIVER

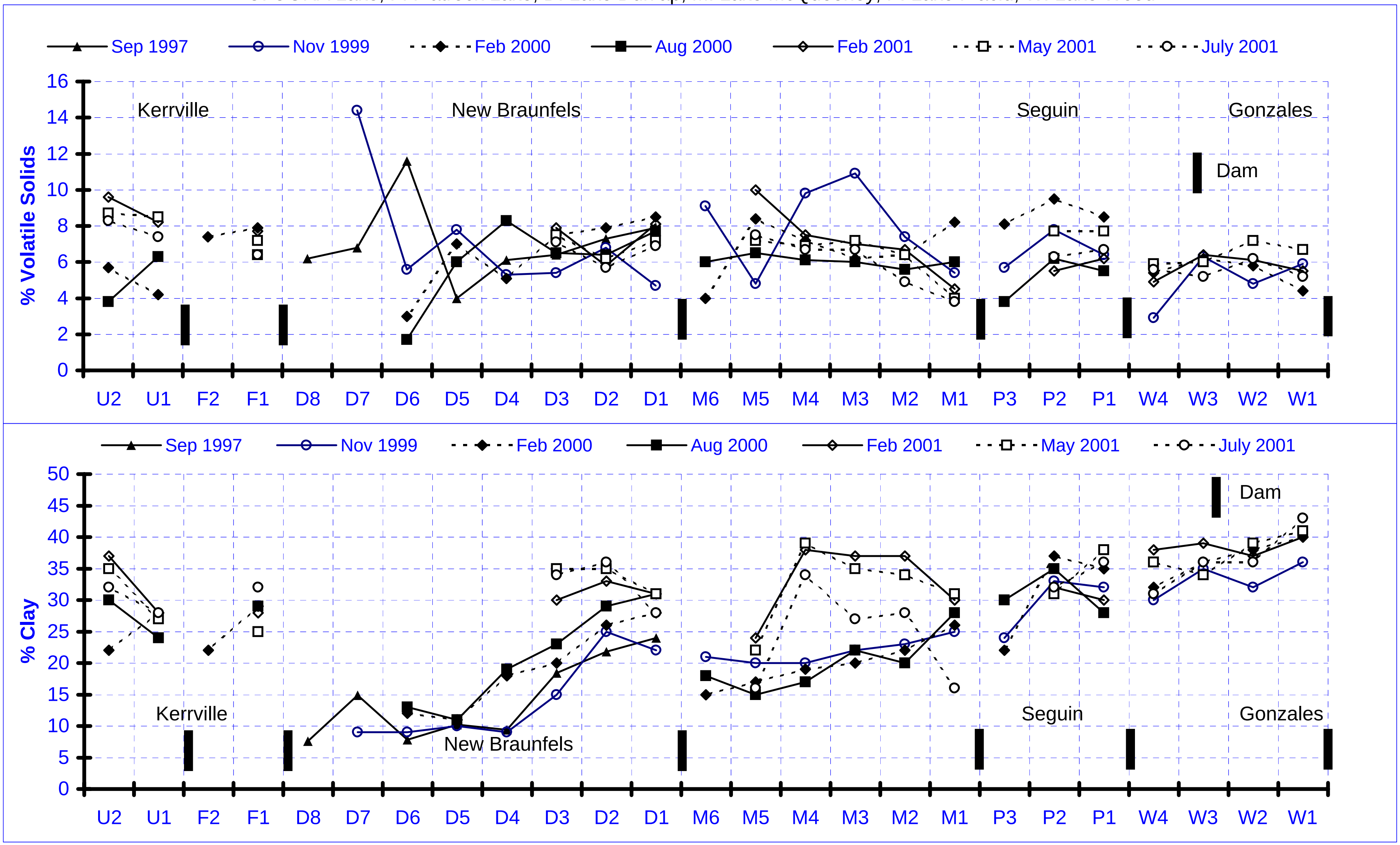
U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood



444215/010328

FIGURE 3-1 (CONTINUED)
SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS ON THE GUADALUPE RIVER

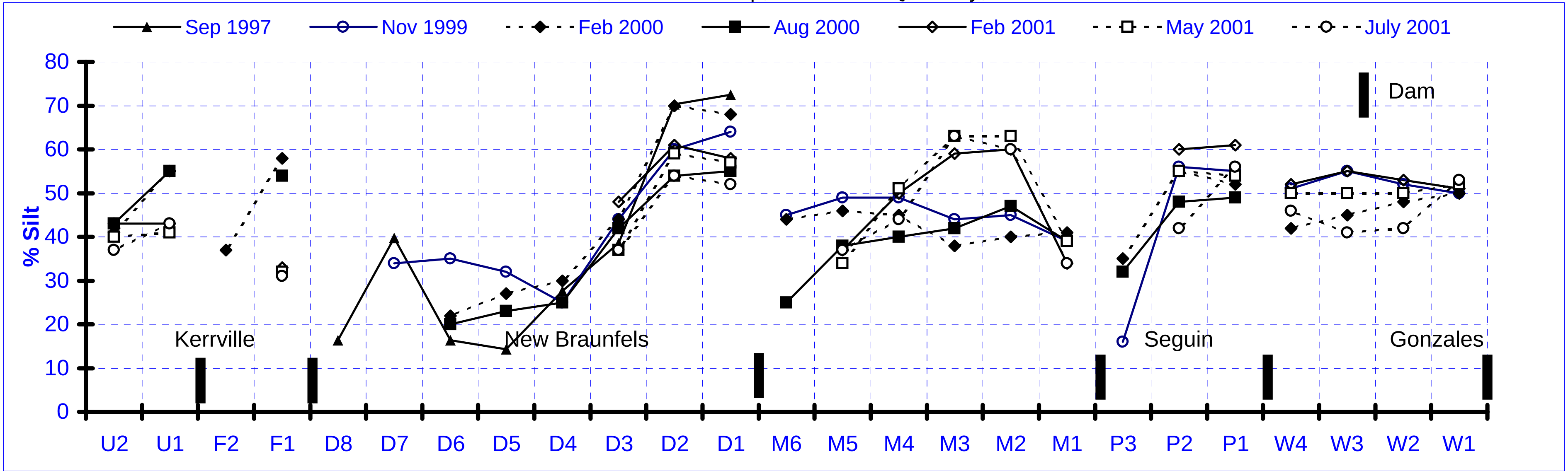
U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood



444215/010328

FIGURE 3-1 (CONCLUDED)
SEDIMENT QUALITY DATA COLLECTED FROM IMPOUNDMENTS ON THE GUADALUPE RIVER

U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood



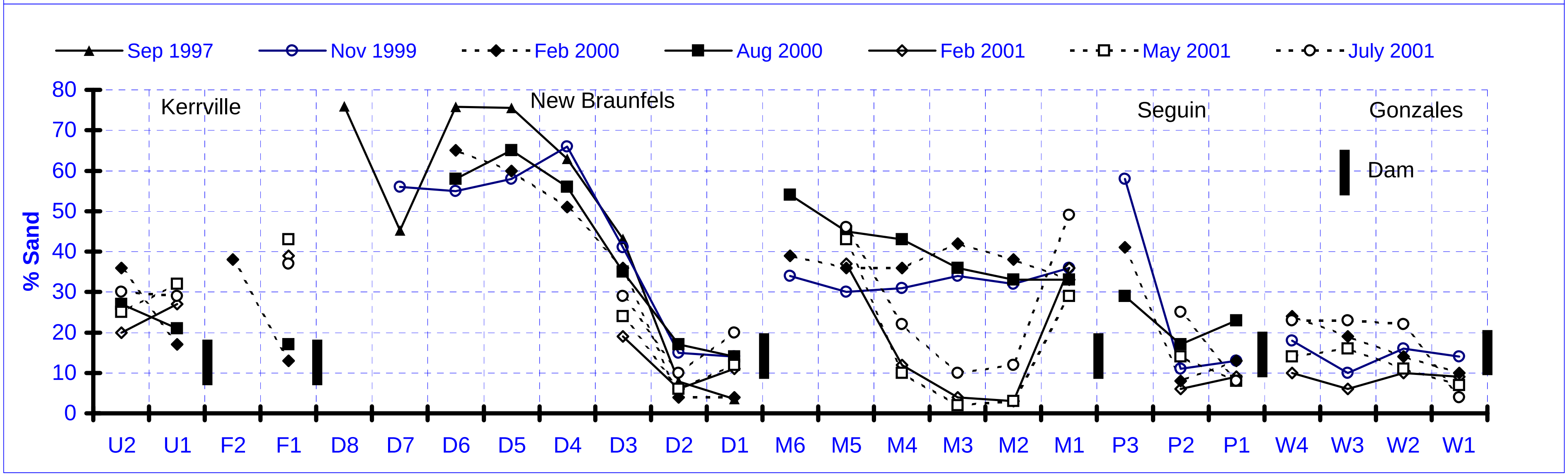


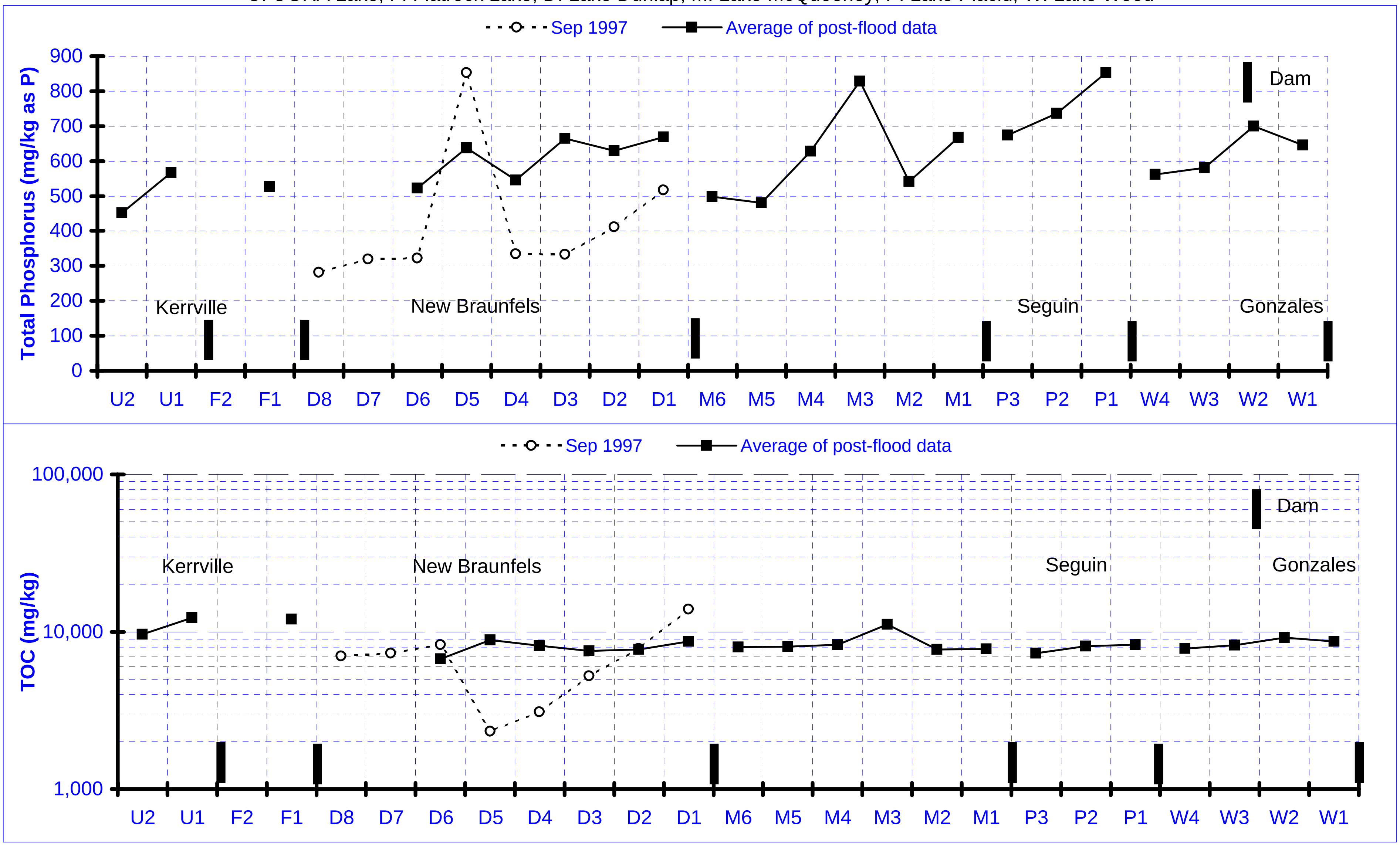
TABLE 3-2

CORRELATION MATRIX OF SEDIMENT QUALITY DATA

	% Solids	% Volatile Solids	TOC	TKN	TP	% Clay	% Silt	% Sand
% Solids	1.00							
% Volatile solids	-0.34	1.00						
TOC	-0.50	0.22	1.00					
TKN	-0.48	0.50	0.48	1.00				
TP	-0.34	-0.01	0.13	0.04	1.00			
% Clay	-0.36	-0.04	0.17	-0.06	0.11	1.00		
% Silt	-0.30	0.07	0.18	0.07	0.20	0.58	1.00	
% Sand	0.34	-0.01	-0.19	0.00	-0.18	-0.85	-0.92	1.00

FIGURE 3-2
AVERAGES OF SEDIMENT QUALITY DATA

U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood



444215/010328

FIGURE 3-2 (CONTINUED)
AVERAGES OF SEDIMENT QUALITY DATA

U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood

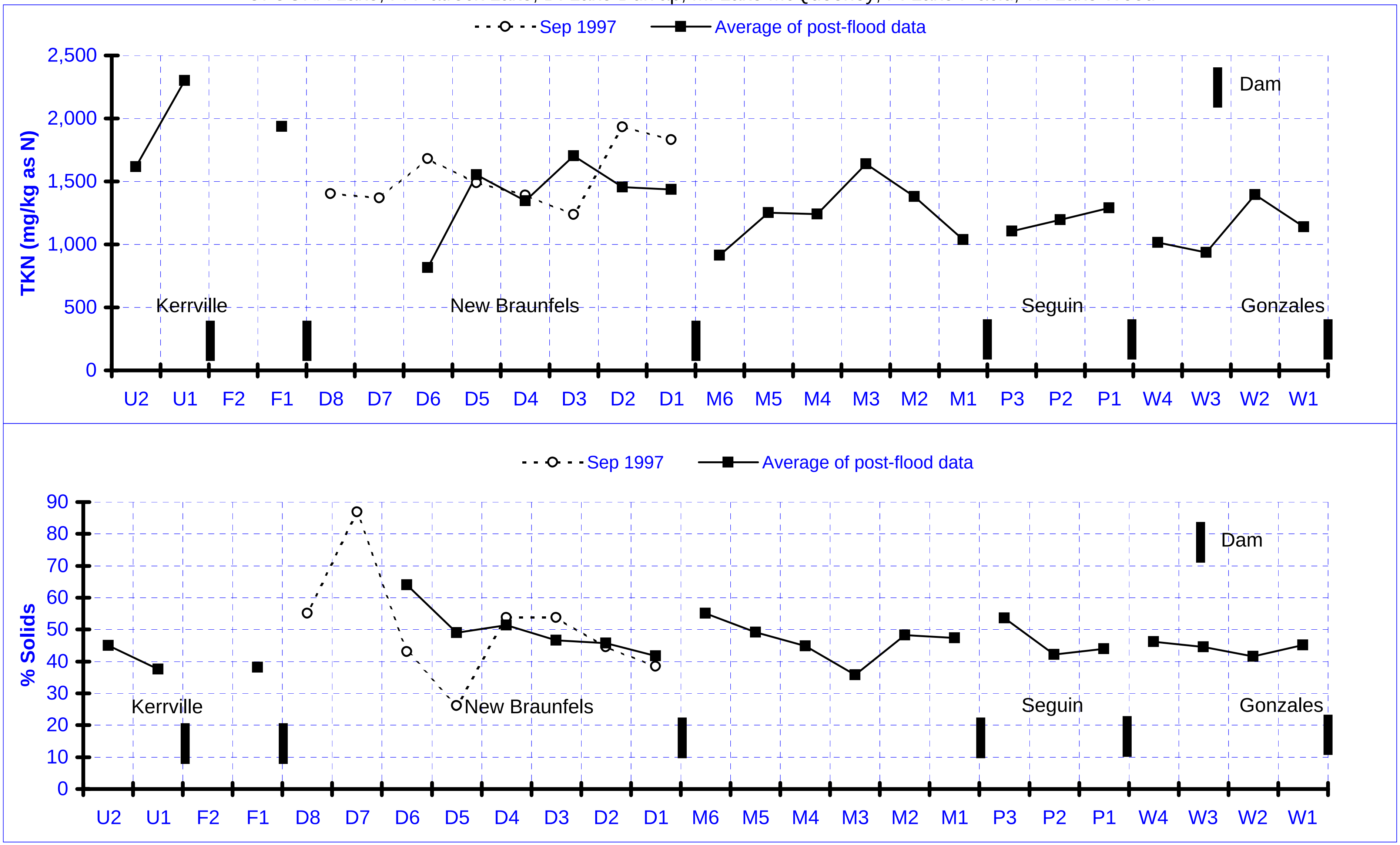


FIGURE 3-2 (CONTINUED)
AVERAGES OF SEDIMENT QUALITY DATA

U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood

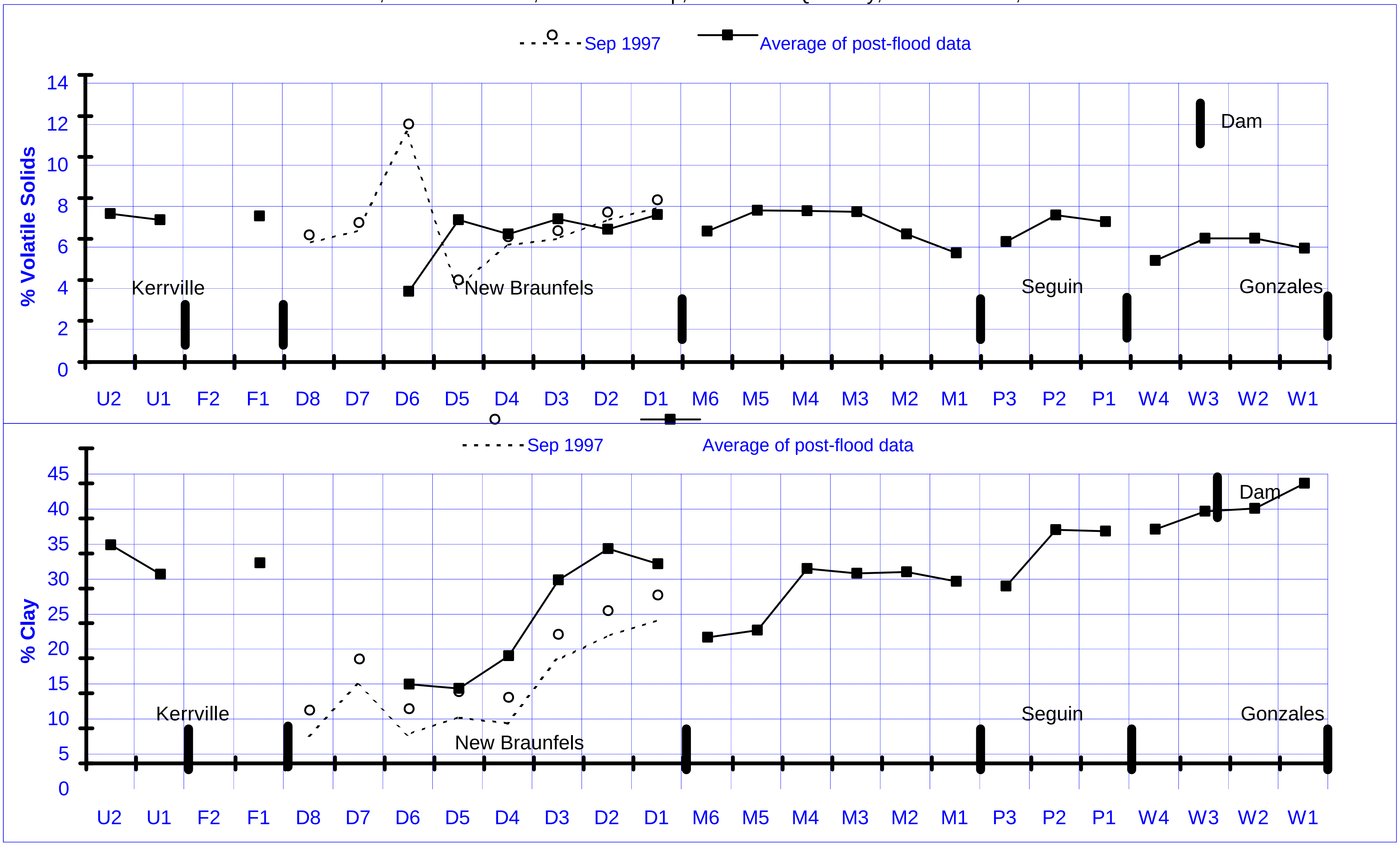
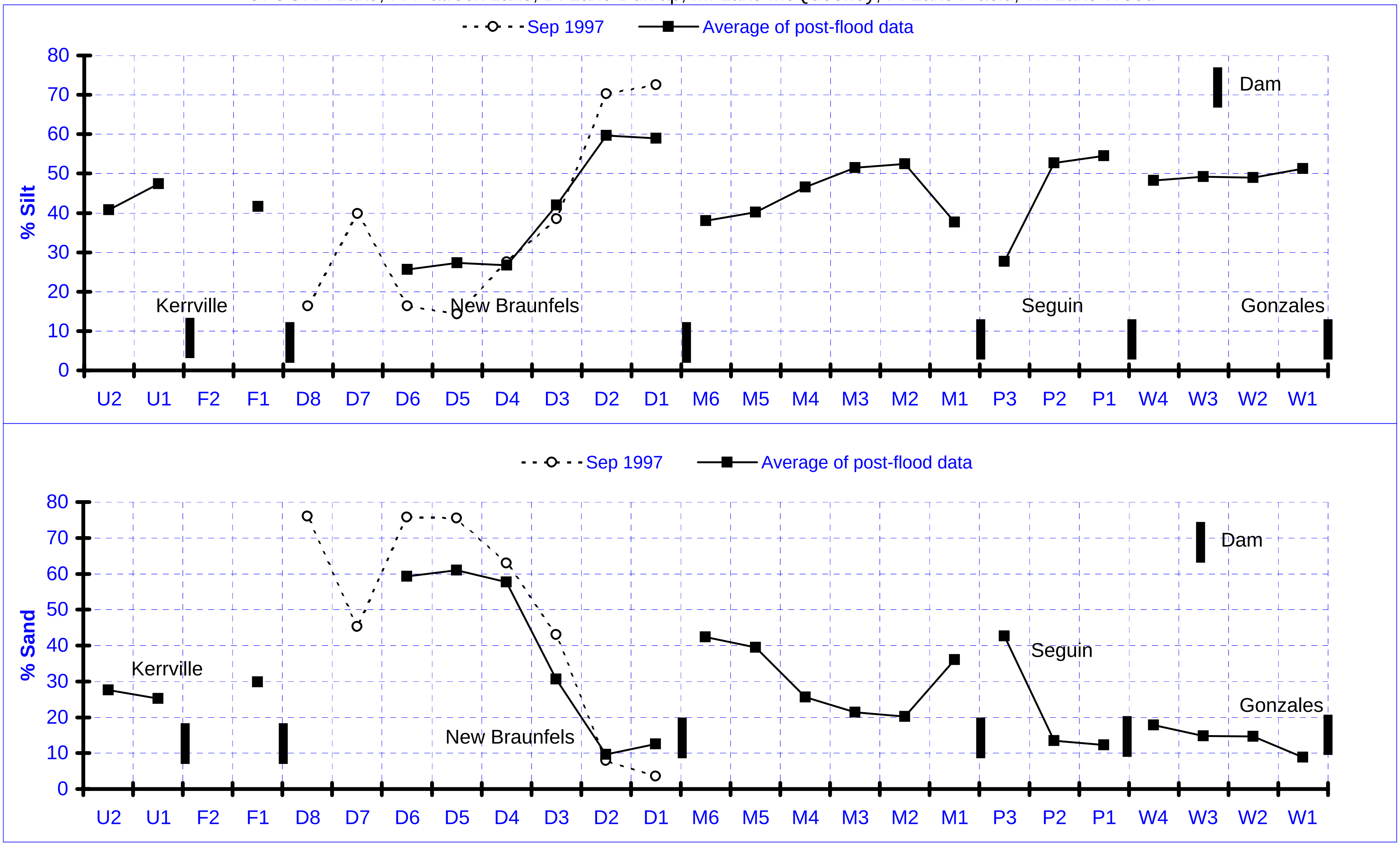
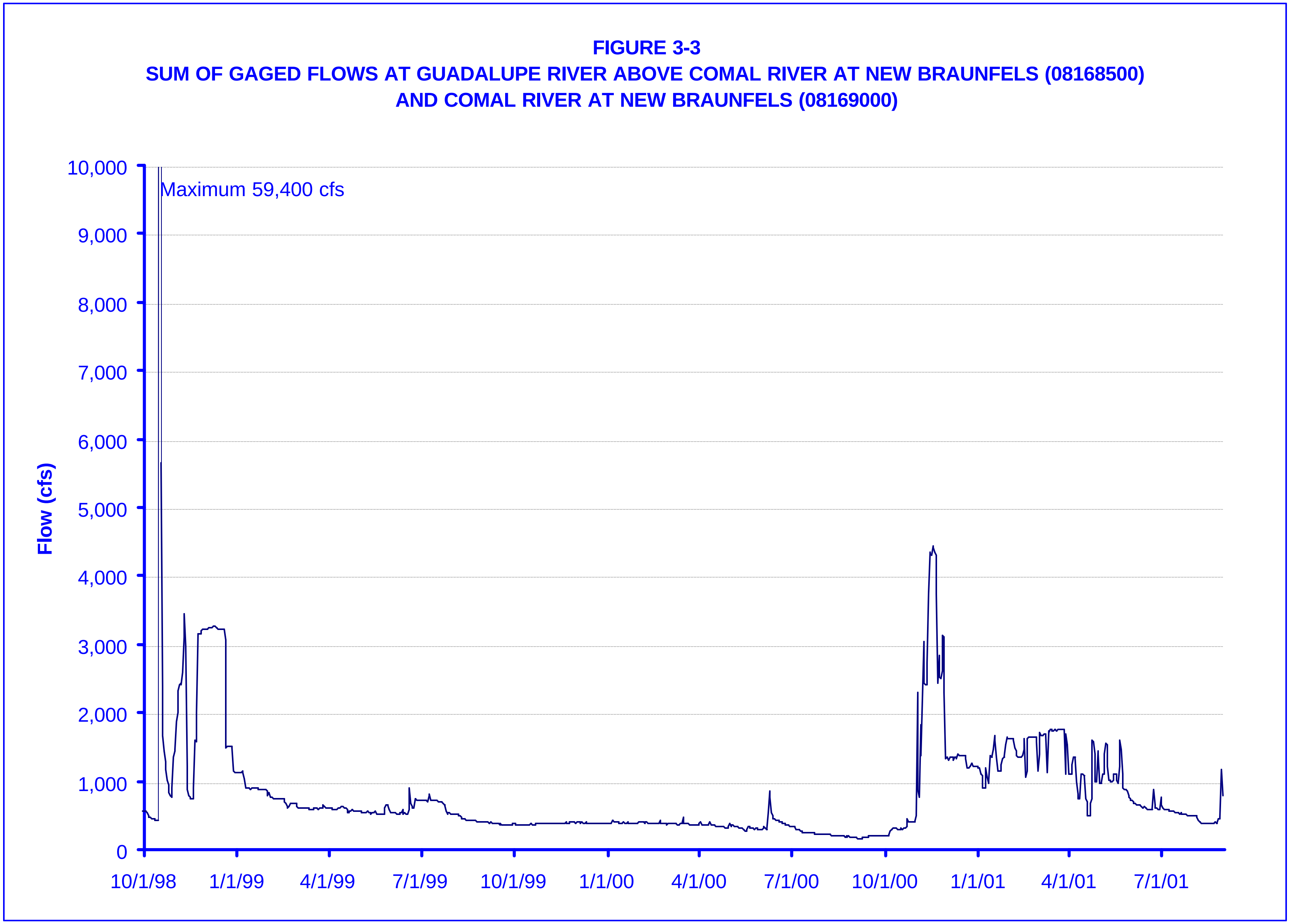


FIGURE 3-2 (CONCLUDED)
AVERAGES OF SEDIMENT QUALITY DATA

U: UGRA Lake, F: Flatrock Lake, D: Lake Dunlap, M: Lake McQueeney, P: Lake Placid, W: Lake Wood





444215/010328

normal flows is readily apparent. The high flows during the winter of 2000-01 are smaller, but extend for a substantial period of time. This may have had a significant effect on the rate of sediment scour and deposition.

Comparing the average of post 1998 flood data with the pre-flood observations, there appears to be a number of changes in Lake Dunlap sediments. The most obvious is that the most upstream stations, D8 and D7, had sediment to sample before the flood, but were substantially scoured after the flood. It was impossible to collect a sample from D8 and only one sample was collected from station D7. After the high flows of the winter of 2000, no sediment could be obtained from stations D4, D5 and D6. While the same general patterns of sand, silt and clay exist before and after the flood, there were differences in each.

The D5 station on Lake Dunlap is the point just downstream of where the wastewater effluent from New Braunfels Utilities enters the system. Before the flood, that station had a lower solids content indicating a more organic and fine particle dominated mud. Also, there was a much higher TP content at that station than the rest of the lake before the flood, but after the flood a much more uniform pattern, with concentrations close to the same level, appears to exist.

Interestingly, the TOC data exhibited a very different pattern. Before the flood the station near the wastewater discharge had low organic carbon levels, with levels increasing at stations moving towards the dam. After the flood, the organic carbon levels show a more uniform pattern throughout the lake.

3.2 PATTERNS IN INDIVIDUAL RESERVOIRS

In addition to the rearrangement of Lake Dunlap sediment, there are some general patterns exhibited in the data shown in Figure 3-2. The first is the longitudinal variation in solids and sand content and nutrient composition that might be expected in moving from the headwaters to the dam of an impoundment. First, solids content and % sand are highest in the upper reaches of each impoundment. These parameters drop moving downstream as the water tends to move more slowly allowing more settling time for fine and organic particles, and less scour potential. This makes the sediments near the dams less sandy and have more silts and clays along with more organic matter. That appears to be the case in most of the reservoirs. The one exception appears to be M1, the station near the dam at Lake McQueeney.

With TKN and TP there appears to be a related trend of increasing concentrations from up to downstream. A similar pattern may be there for TOC, but it does not appear to be as consistent. It was only strong in the pre-flood data from Lake Dunlap.

Station 3 on Lake McQueeney appears to be substantially different. As can be seen in Figure 1-2, this station is fundamentally different from the other run-of-river reservoir stations because it

is in a side embayment formed by an old ox bow portion of the river channel. Because it is out of the main river channel, it is in a fundamentally different situation with much less potential for scour in higher flows. Accordingly, it is probably helpful in viewing broad patterns, to exclude station M3.

3.3 OVERALL SPATIAL PATTERNS

The two Kerr County reservoirs appear to have higher TKN and TOC concentrations and lower TP concentrations than the downstream reservoirs. Whether this is related to landuse or to differences in the impoundments is unknown. It is important to note that despite their smaller size, the residence time for the Kerr County reservoirs is essentially the same as the reservoirs in the lower river.

Flat Rock Lake and the UGRA reservoir are about the same size and receive a similar flow. Flat Rock differs in that it receives treated wastewater from the City of Kerrville, while the UGRA reservoir does not. Also, it receives local runoff from a more urbanized area. Despite those differences in circumstances, the sediment data do not show large differences.

In the lower basin, all the reservoirs receive flows from both Canyon Lake releases and from Comal Springs. The long-term median discharge at Lake Dunlap is 583 cfs, giving a residence time of a few days. Moving further downriver the reservoirs take on a different character, with more clay and silt soil characteristics and a higher degree of shading from the banks and trees.

4.0 DISCUSSION

Sediments in shallow lakes play an important role in water quality. Traditionally, sediments have been important in aspects such as sediment oxygen demand and release of nutrients. In these small run-of-river reservoirs, oxygen demand is not a major consideration but nutrient supply can have an effect on water quality. One mechanism is for the sediments to release dissolved nutrients into the water, supplying floating plants. Another is to supply nutrients to rooted vegetation. How significant a role is played by sediments will be determined in future research. This initial attempt at measuring sediment characteristics should be viewed as a start in obtaining basic data to understand complex system interactions.

The limited amount of sediment sampling appears to indicate the expected patterns of more coarse particles in the reaches with higher velocities and more limited settling time, and more fine and organic sediments in the locations near the dams with more settling time. The upper Kerr County impoundments have higher concentrations of organic carbon and nitrogen, and lower percent solids levels. This upper end of the system has been shown to exhibit phosphorus limitation of plankton growth (EH&A, 1991a). Interestingly, the TP levels in the sediment of these two reservoirs appear to be lower than for the downstream reservoirs. This may be due to differences in watershed soils and it may also be a consequence, at least in Flat Rock Lake, of P removal from City of Kerrville wastewater discharges. It may also be a consequence of phosphorus being more in demand, with less particulate P entering the sediments.

Total P levels in lake sediments appear to increase slightly going downstream, but after the flood there does not appear to be any strong pattern tying wastewater discharges to sediment concentrations. What differences in average levels are shown in Figure 3-2 appear to be well within the range of variation shown in individual observations shown in Figure 3-1. Still, it is worthwhile to note that the Lake Dunlap TP observations before the October 1998 flood appear to show very substantial differences that might be associated with wastewater discharge.

Overall, this initial attempt at measuring lake sediment concentrations appears to have been successful in documenting baseline levels and suggesting patterns that might explain water quality conditions in the system. The amount and type of additional sediment work depends on the degree of concern with nuisance aquatic plant growth.

5.0 REFERENCES

EH&A. 1991a. Water Quality Assessment for Flat Rock Lake. Report prepared for the Upper Guadalupe River Authority. EH&A Doc. No. 900330.

_____. 1991b. Environmental Assessment of Impacts to the Fisheries, Riparian Habitats and Recreational Resources from Low-Flow Conditions on the Upper Guadalupe River near Kerrville, Texas. Report prepared for the Upper Guadalupe River Authority. EH&A Doc. No. 900548.

GBRA and EH&A. 1998. Analysis of Aquatic Plant and Nutrient Conditions in Lake Dunlap. Report prepared for the Texas Clean Rivers Program. EH&A Doc. No. 980998.

ATTACHMENT A

SEDIMENT SAMPLING STANDARD OPERATING PROCEDURE

INTRODUCTION

This standard establishes procedures for the collection of representative bottom sediment samples from standing lakes, and flowing streams, rivers and channels. The procedures are applicable to sampling performed in conjunction with GBRA's sediment collection study.

EQUIPMENT AND MATERIALS

Equipment and materials suitable for sediment sampling, are listed below. The applicability of any sampling device is dependent on the physical character of the sediment being sampled and the type and depth of sample required. In conjunction with environmental sampling, consideration shall be given to the need to use tools constructed of materials that will not interfere with any chemical analyses to be performed (e.g., stainless steel, inert plastic).

Trowel	Folding rule or tape measure
Scoop	Knife/spatula
Shovel	Sample containers
Ekman dredge	Sample labels
Ponar dredge	Pens
Core sampler	Recording forms
Core liners and end caps	Decontamination materials (if applicable)

PROCEDURE

Specific sampling equipment and procedures will be dictated by the width, depth, flow, and bed characteristics of the impoundment or channel to be sampled, as well as whether the sample will be collected from the shore or a boat. The analytical tests to be performed will require the collection of one liter of sediment.

In collecting sediment samples from any source, care needs to be taken to minimize disturbance and sample washing as the sample is retrieved through the liquid column above. Sediment fines may be carried out of the sample during collection if the overlying liquid is flowing or deep. This may result in the collection of a non-representative sample. While a sediment sample is usually considered to be a solid matrix, sampling personnel should avoid placing the sample in its container, and then decanting off the excess liquid. To the extent possible, effort will be made to maintain sample integrity by preserving its physical form and chemical composition. The tools used must be uncontaminated, and care shall be taken in sample handling.

COLLECTION

If liquid flow and depth are minimal and the sediment is easy to reach by wading, a trowel or scoop may be used to collect the sample. However, where the liquid above the sediment is either flowing or greater than approximately 4 inches in depth, a dredge or core sampler that eliminates sediment washing will be used to collect the sample to minimize loss of materials as the sample is retrieved.

For this study, the dimensions of the impoundment or channel to be sampled will likely necessitate the use of a boat. The device for sample collection in this case will, again, depend on the depth and flow characteristics of the site. Generally trowels or scoops cannot be used in an offshore situation. Instead, cores or dredges will be used for sample collection. The boat will be positioned just upstream (flowing site) of the desired sample location. As the corer or dredge is lowered it may be carried slightly downstream, depending on the force of the flow.

The actual sediment collection sites need to be free of extraneous debris that will not be included in the samples. One liter of sediment will be collected from three locations over the cross-section at each station. Equal portions of each sample will be combined in a stainless steel bucket, mixed, and transferred directly to the sample container. A clean knife, spatula, or similar tool may be used to help transfer the sample. The sampling equipment will be thoroughly washed and rinsed with site water prior to the next sample location.

DOCUMENTATION

The individual responsible for sample collection will record the following information on a sample collection log or in a field book.

- Date and time of sample collection
- Station/sample identifier
- Location (coordinates or description)
- Sample matrix
- Sampling method
- Sample type (i.e., grab, composite type)
- Sample depth
- Sample description (as appropriate)
- Quantity collected

- Containers used
- Weather conditions
- Sampling personnel