HYDRODYNAMIC AND WATER QUALITY MODELING FOR THE A.R.M. LOXAHATCHEE NATIONAL WILDLIFE REFUGE

PHASE 1: PREPARATION OF DATA

Task 1: Data Acquisition and Processing

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1. Introduction

It is well known and documented that changes in water quantity, timing and quality are introducing negative impacts to the Everglades ecosystem (Richardson et al., 1990; Walker, 1991 and 1995; Davis et al., 1994; Ligth and Dineen, 1994; McCormick et al., 1996; USFWS, 2000; Brandt et al., 2000; Raghunathan et al., 2001; Childers et al., 2003). Historically, the Kissimmee River discharged into Lake Okeechobee, and during wet cycles the lake would overflow its south bank, providing additional flow to the Everglades (Ligth and Dineen, 1994). Water, which once flowed in a broad swath across the Everglades, is now concentrated through canals, structures, and a series of water storage areas (Water Conservation Areas (WCA)). That water, when not used for municipal water supply or irrigation, is discharged to the Everglades National Park (ENP).

According to the Comprehensive Conservation Plan for the Refuge (USFWS, 2000) “the construction of the levees has had significant effects on the hydrology, vegetation and wildlife in the refuge.” The U.S. Fish and Wildlife Service (USFWS, 2000) indicated that changes in natural timing of water levels affect wading birds feeding patterns, apple snail reproductive output, and alligator nesting. Similarly, changes in the spatial distribution of water levels alter the distribution of aquatic vegetation and tree islands. In addition, and particularly during the dry season, lower water levels increase the potential for fire and damage to vegetation, soils and wildlife. The USFWS in partnership with the South Florida Water Management District (SFWMD) and the U.S. Corps of Engineers are devoting considerable resources to restore and maintain appropriate water regimes for the Refuge.

Along with the changes in water quantity and timing, the changes in water quality are an important threat to the Everglades ecosystem. High concentrations of nutrients (specifically phosphorus) in runoff from agricultural areas cause proliferation of cattails, and other undesirable species that negatively affect the ecosystem’s balance. Other negative impacts from increased nutrients include: increased soil phosphorus content, changed periphyton communities, loss of native sawgrass communities, increased organic matter in water, reduced dissolved oxygen, conversion of wet prairie plant communities to cattail, and loss of important habitats for wading birds (Stober et al., 1996).

Along with ensuring an appropriate water regulation schedule, it is a priority for the Refuge to better understand and minimize the impacts of these excessive nutrient loadings. The purpose of the planned Refuge hydrodynamic and water quality modeling is to provide a quantitative framework for management decisions related to Refuge inflow and outflow quantity, timing, and quality. This modeling effort will provide projections of water movement and water quality resulting under alternative scenarios of structure operation, Storm Treatment Area (STA) performance, and structural changes within the Refuge. When fully calibrated and validated, the selected model should provide information and assist in answering questions on the hydrologic, hydrodynamic, water quality, and ecologic processes occurring under present conditions and management rules; and how these processes would be altered by different structural changes and management scenarios. For example: How different management scenarios (structural alterations, management decisions, strategies, and regulations) alter:

- The hydrology. How will the spatial and temporal distribution of water inside the Refuge be altered? Will portions dry out and for how long? Is significant surface-groundwater interaction in the Refuge occurring? If so, what are the effects?
- The hydrodynamics. How will near field hydrodynamics close to hydraulic structures be altered? How will far field current patterns be altered?
- Water quality. How will water quality be altered? How will the spatial and temporal distribution of phosphorous inside the Refuge be altered?
- The ecosystem. How will the ecosystem be affected by changes in hydrology? Will local changes in hydroperiod sustain the needs of desired plants and wildlife?

It should be emphasized that the numerical model that will be developed is not a regional model. Therefore, it will not project the response of the natural system outside the Refuge's boundaries to any alternations. It will however, provide detailed information about the response of the Refuge to regional management changes and alterations.

This report focuses on data acquisition and processing, starting with the selection of the water quality constituents to be modeled and the selection of periods of records for calibration and validation. It assesses whether sufficient data is available to achieve the modeling goals. It also provides recommendation for monitoring where additional data is needed. The description of the Refuge's background, hydrology, soils, physiographic, water management and regulation, as well as a comprehensive literature review of previous modeling efforts within the Refuge and wetland systems, will be presented in companion reports.

1.1 Objectives

As indicated in the previous paragraph the main goals of this report are:

- Identify the period of record for calibration and validation of the numerical model.
- Identify the constituents to be modeled.
- Compile the data needed to support the modeling effort.
- Check the quality and resolution of the gathered data.
- Determine if sufficient data is available to achieve the modeling goals.

2. Constituents to Be Modeled

Since the everglades are oligotrophic-phosphorus limited systems (Childers et al., 2003; McCormick et al., 1996; Raghunathan et al., 2001; SFWMD, 2000), the discharge of excess amount of this nutrient will promote the eutrophication process and ecosystem imbalance, e.g., shifts in plant community composition. The 2000 Everglades Consolidated Report (2000 ECR) by the SFWMD indicated that the ratio of total nitrogen to total phosphorus (TN:TP) in the Refuge, increased from near 50:1 in the canal to near 150:1 in the marsh interior. Since values of TN:TP higher than 8:1 suggests phosphorus (P) limitation, the ratios for the Refuge are a clear indication that: (1) P is the more important limiting nutrient in both the marsh and canal waters; and (2) the severity of P limitation increases with increasing distance from the canal. The USFWS (2000) indicated that areas in the western, southwestern, southern and southeastern portions of the Refuge continue to be eutrophied by the influx of high nutrients runoff (specifically phosphorus) from agricultural lands. The hydrodynamic and water quality models being developed will be of value in testing this conjecture.

According to Childers et al. (2003) water column total phosphorus concentrations in the Everglades are typically less than 10 μg/L. It is well documented that water flowing into the Everglades has an anthropogenic load of nutrients and other contaminants (e.g., Richardson et al., 1990, Stober et al., 1996; USFWS, 2000). Nutrient loading from urban areas and the Everglades Agricultural Area (EAA) has significantly increased nutrient concentrations, particularly phosphorus, in the water conservation areas (USFWS, 2000). Childers et al. (2003) reported that in northern Everglades regions, near to the EAA, total phosphorus concentrations often exceed 100 μg/L. Therefore, it is a priority for the Refuge to better understand the dynamics of nutrients on the systems, particularly of phosphorus, in order to minimize the impacts of this excessive nutrient's loading. Total phosphorus in the sediments and in the water column is going to be modeled as a constituent in order to address this objective.

It is important to accurately describe the hydrodynamic processes in order to determine and evaluate water quality impacts on wetlands (Mitsch, 1988; Mitsch and Reeder, 1991; Moustafa and Hamrick, 2000). The accurate description of the hydrodynamic often requires fine-tuning of certain model parameters, i.e., calibration, to match observed and predicted values, e.g., water surface elevations, water depths, water velocities, constituents' concentrations, etc. After calibration, a validation process is usually conducted to ensure the model accuracy. However, the validation of velocities and transport subroutines are often not completed primarily due to lack of field measurements.

To the best of the authors' knowledge, there are no velocity measurements anywhere in the Loxahatchee Refuge. Therefore, a recommendation will be made to Refuge personnel to collect surface flow velocities in the rim canal as well as at interior sites. Although, the ability to model advection and diffusion can be assessed through modeling of conservative constituents, if deviation from the field measurements is observed, it would not be possible to determine whether the deviation is caused by error in the model's advection or by the diffusion terms. It is believed that even a short term measurement of velocities at multiple locations within the Refuge will be of great value to this modeling effort.

Traditionally, conductivity, total dissolved solids (TDS) and chloride have been used as conservative or semi-conservative tracers. Conductivity and TDS are highly correlated, and even though they are not fully conservative parameters, they can be used as such when high concentrations are present in the influent runoff/wastewater, assuming that wetlands have a negligible effect on these parameters. Kadlec and Knight (1996) indicated that wetlands have minimal effect on TDS. This is especially true because TDS concentrations are usually high in wastewaters and the individual components of these solids greatly exceed the biological requirements for growth. Kadlec and Knight (1996) recommended the use of chloride content as a tracer in wetland systems. They indicated that due to low biological demand, its abundance in surface water and its high solubility, the total mass of chlorine remains relatively constant in wetland systems. Based on this recommendation, the initial approach in this modeling effort will be to use chloride as tracer to evaluate the model transport subroutine.

3. Period of Record

Some of the processes and transformations that occur in wetland systems sometimes take years. An example of a long term process is the shift in plant community composition that may occur after the accumulation and/or release of phosphorus in the soil. These factors underline the need to perform long-term simulations.

An ideal period-of-record (POR) covers a large number of years with periods of extreme meteorological and hydrological conditions that adequately calibrate and test the model performance. It is also of value to have a POR that includes major structural changes (*e.g.* diversion of S-6 pump, STA-1E operation) because this further tests the models ability to project such changes. It is desirable to select a POR ending as close as practical to the present. The POR for model calibration and possible verification should consider data availability, and quality. This task will require a preliminary review of data from various sources. Accordingly, a tentative POR is selected to be 1995 – 2004. This period will be further divided into two segments where one will be used for model calibration, and the other for validation. This report summarizes the types of data that have been collected for the POR, identifying any missing periods and indicating the apparent quality of such data.

4. Types of Data

The field measurements needed to support this modeling effort include bathymetric, meteorological, hydrologic, and water quality data. Many of these datasets are spatially variable (e.g., elevation), and some are both temporally and spatially variable such as all meteorological, hydrologic, and water quality parameters. Data sources will be identified for all data types required. The types of data that have been compiled and are discussed in this report are:

- Bathymetric data
- Hydrologic data: water level and discharges through hydraulic structures
- Meteorological data: rainfall, temperature, evapotranspiration (ET), and wind
- Water quality data: concentrations of the parameters of interest at available sampling sites.

5. Procurement and Quality Assurance of Bathymetric Data

5.1 Marsh Elevation Data

Bathymetric surveys for the Loxahatchee Refuge have been available from different sources and with different resolution. Lin and Gregg (1988) indicated that, in 1988, topographic maps of the Refuge were available from three different sources: (1) the U.S. Army Corps of Engineers (1958), (2) the Fish and Wildlife Service, Department of Interior (1963 and 1965), and (3) the South Florida Water Management District (1965). Lin and Gregg (1988) reported that, in some areas, there were considerable differences between the three sources. A later survey of the Refuge was conducted by Richardson et al. (1990) who collected topographic and vegetation cover data, as part of their study of refuge habitats and relationship to water quality, quantity and hydroperiod. The topographic data was collected at a resolution of approximately 1 minute (roughly 2 Km) by measuring the water depth at all grid locations and then subtracting from an assumed horizontal water level. A flat pool condition of water in the Refuge was obtained by holding water at the 17-foot level during the time that the grid survey was being conducted.

The latest elevation data for the Refuge are available from the United State Geological Survey (USGS). The elevation data were collected as “bare earth” ground elevation on a 400 by 400 meter grid. "Bare earth" in the Everglades swamp environment is considered to be the layer of "muck" which supports a one-pound weight on a bearing surface of approximately 5.3 square inches or 2.6-inch circle. According to Desmond (2003) the horizontal positions were established by GPS observations and are referenced to the North American Datum of 1983 (NAD83). The horizontal accuracy is +/- 15 centimeters. Similarly, the elevation data have a vertical accuracy specification of +/-15 centimeters (cm) relative to the North American Vertical Datum of 1988 (NAVD88). Desmond (2003) indicated that the vertical accuracy of the elevation data was determined based on the requirements for use as input to hydrologic models. More information about this elevation data is available at the USGS’s South Florida Information Access (SOFIA) website (http://sofia.usgs.gov/projects/elev_data/). Since the water level data from the Refuge interior stations and from the water management structures are based on the National Geodetic Vertical Datum (NGVD29), the USGS’s bathymetric data were converted from the NAVD88 to the NGVD29 system using the National Geodetic Survey software "VERTCON" Version 2.1. Figure 1 shows the bathymetric contours for the Loxahatchee Refuge based on the USGS's data.

Results of this survey indicate that, in the Refuge, the bathymetry contours (excluding the rim channel) range from 18.50 to 10.61 ft (5.64 to 3.23 m) NGVD29, with a mean elevation of about 15.17 ft (4.62 m) NGVD29.

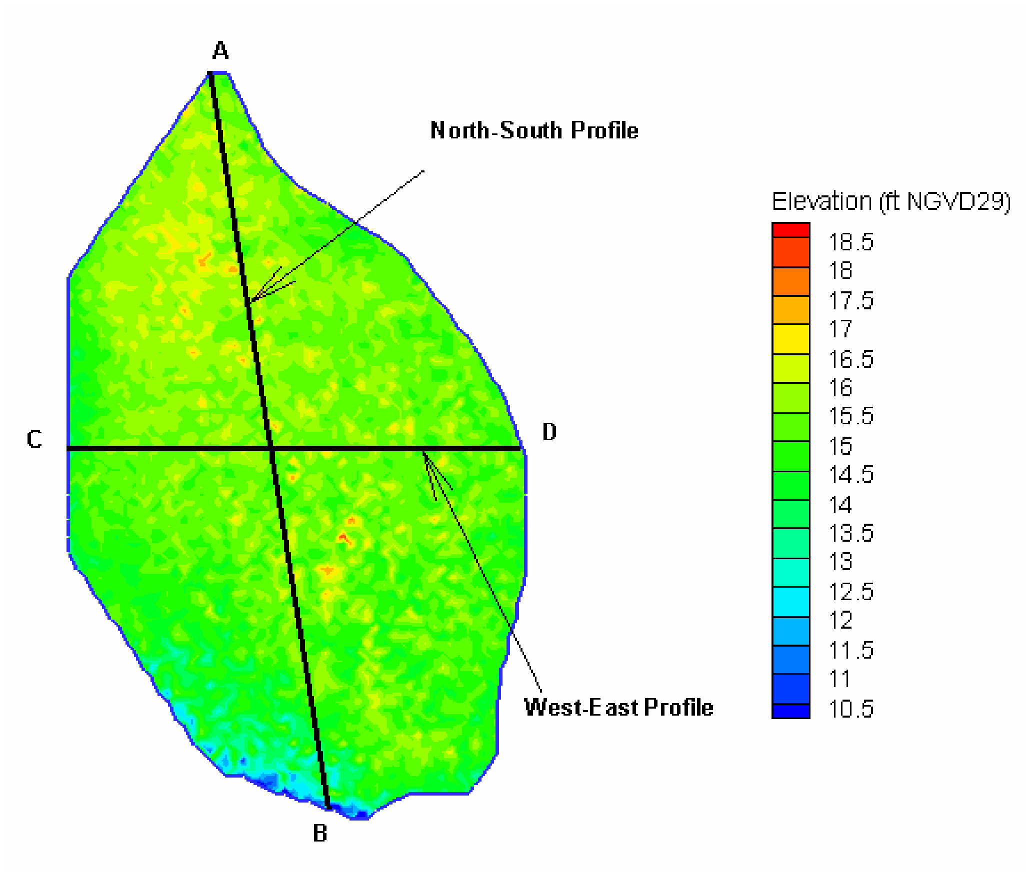

Figure 1. Loxahatchee Refuge 2003 USGS Bathymetric Data

As can be observed in the profile presented in Figure 2, the Refuge has a very mild north to south slope, which results in a generally slow southward flow movement. Lin (1979) indicated that flow through the heavily vegetated area in the Refuge is extremely slow as compared to the flow in canals. The north to south slope is estimated to be about 1.6 cm in 1 Km (1.0 inches per mile). In the west to east direction (see Figure 3), the terrain is undulated showing mounds and depressions, but with basically an average horizontal slope.

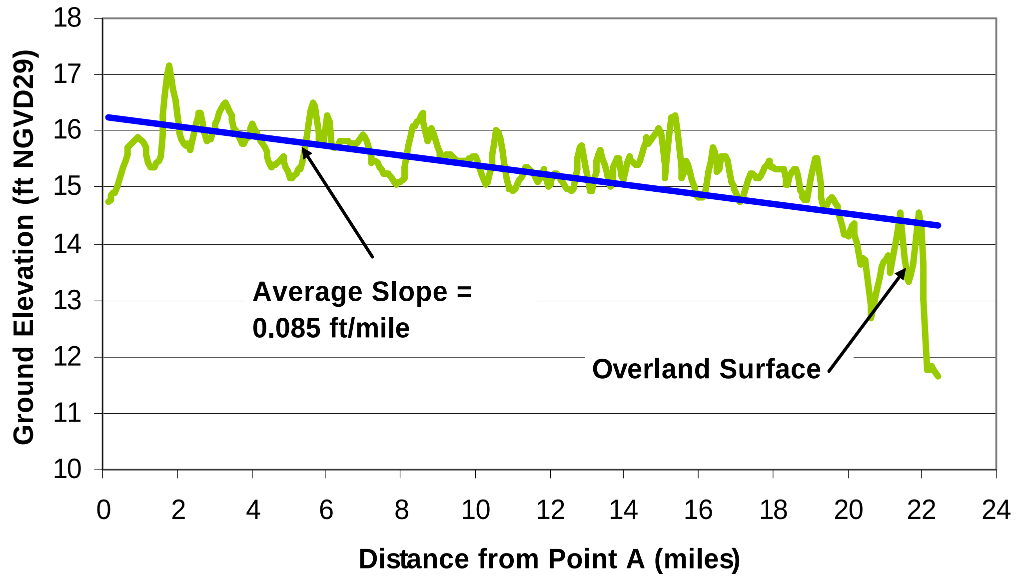

Figure 2. North to South Ground Profile of the Loxahatchee Refuge

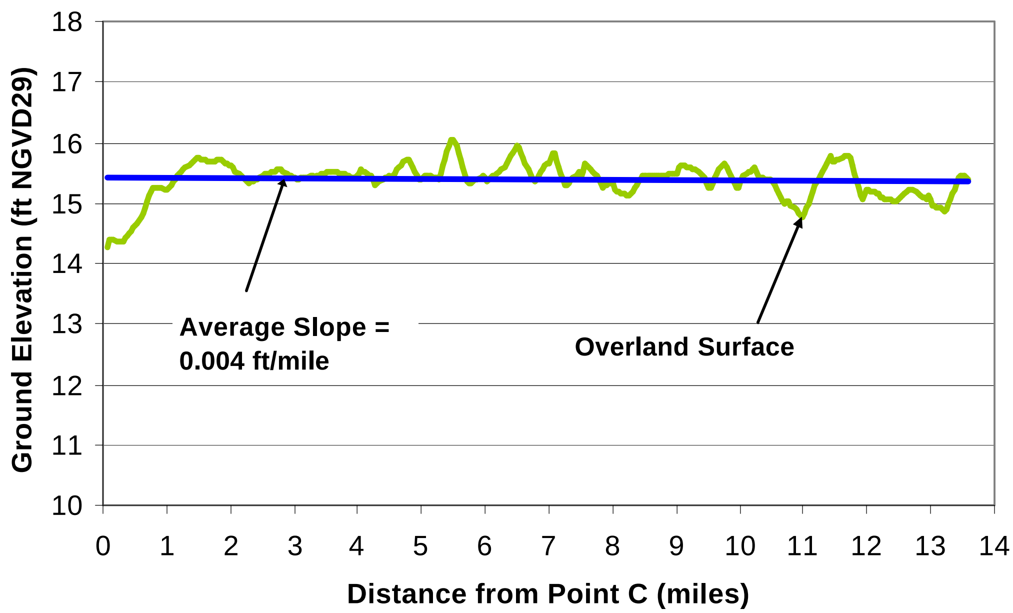

Figure 3. West to East Ground Profile of the Loxahatchee Refuge

5.2 Rim Canal Cross-Section Data

The rim canal bathymetric data were collected by the University of Florida's Institute of Food and Agricultural Sciences (IFAS), specifically by the Everglades Research and Education Center. This survey of the rim canal was performed in 2001 by Daroub et al. (2002) as part of the project: Implementation and Verification of Best Management Practices for Reducing Loading in the Everglades Agricultural Area (EAA). The survey was conducted by measuring sediment depth and channel bottom depth with reference to the transect's surface water level at the time of the measurement. The water depths were later converted to elevations using the mean tail-water elevation of station G-310 (referenced to NGVD29) that prevailed on the day of measurement. It was assumed that there was no hydraulic gradient between G-310 and the transects at the time of measurement. Sediment samples and cross section elevations were taken approximately at one-mile resolution. The transect locations of the survey are shown in Figure 4.

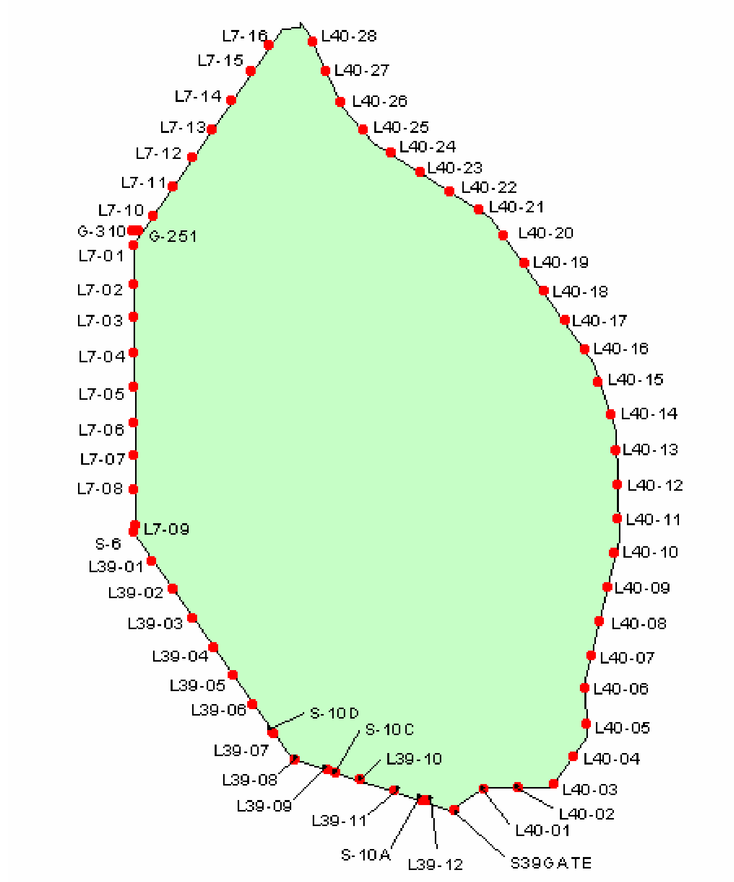

Figure 4. Rim Canal Transects (IFAS Survey)

Twenty eight transects were taken for each canal system, i.e., the western system that is formed by the L-7 and L-39 canals and the eastern system that is formed by the L-40 canal. The distance between transects ranges between 1.15 and 0.90 miles for the western system and between 1.03 and 0.92 miles for the L-40 canal, being the average distance equal to 1.0 mile for both systems. As indicated before, sediment surface levels and channel bottom levels were measured, and were standardized with the G-310 tail-water elevation as reference level. The G-310 tail-water level is based on the National Geodetic Vertical Datum (NGVD29). Figure 5 shows the cross section elevations for the L40-01 transect.

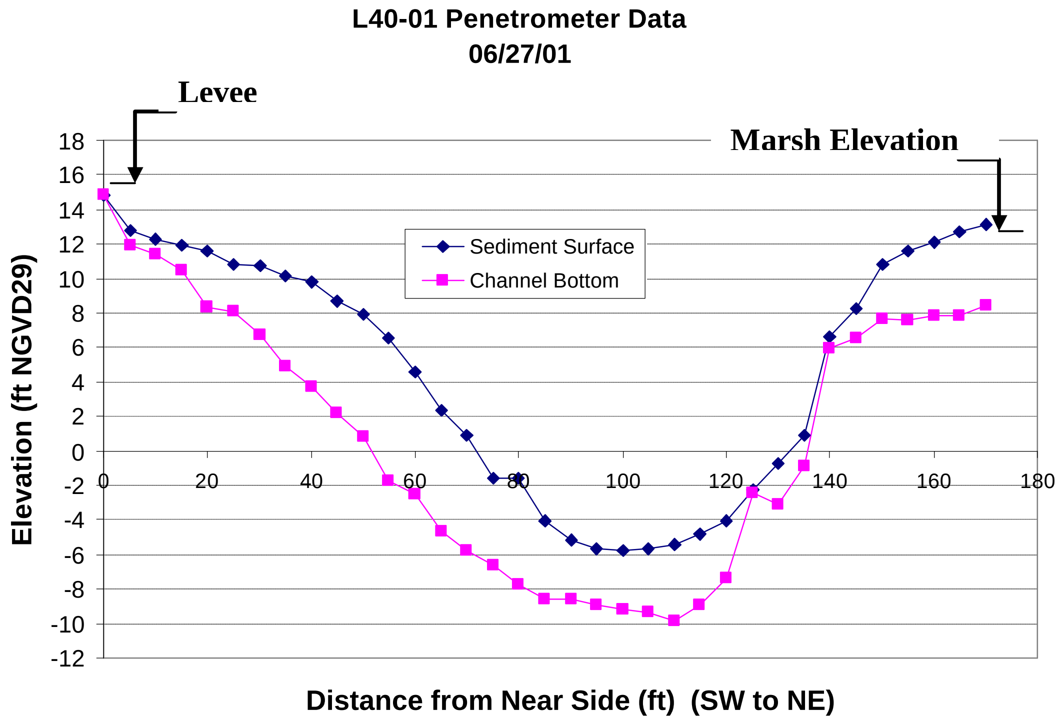

Figure 5. Cross Section for the L40-01 transect, indicating channel bottom and sediment surface elevation (Reproduced after Daroub et al., 2005).

For the western canals, the sediment surface elevations range between 7.0 and -1.5 ft NGVD29 with a mean elevation equal to 2.4 ft. For the L-40 canal, the sediment surface elevations range between 6.7 and -5.7 ft NGVD29 with a mean elevation equal to 3.2 ft. The top width ranges between 205 and 120 ft for the western canal, and between 173 and 88 ft for the L-40 canal, the mean top widths are 169.7 and 121.5 ft for the western and for the L-40 canals, respectively. Table 1 summarizes the transects' information for the L-7 and L-39 canals, and Table 2 summarizes the information for the L-40 canal.

Table 1. Cross Section Information at L-7 and L-39 canal transects.

Cross Section Label	Easting m	Northing m	Canal Mile	Sediment Surface Elev. ft	Channel Bottom Elev. ft	Top Width ft	Average Sediment Depth ft
L7-16	561525	2950503	0.00	0.87	-8.71	180	10.06
L7-15	560710	2949311	0.90	4.62	-2.04	180	6.48
L7-14	559806	2947996	1.89	4.12	-5.54	190	10.23
L7-13	558869	2946632	2.92	4.10	-5.98	175	9.45
L7-12	557955	2945304	3.92	4.19	-2.56	190	7.23
L7-11	557046	2943980	4.92	4.77	-3.48	195	6.66
L7-10	556140	2942659	5.91	3.85	-3.90	190	6.15
L7-01	555256	2941284	6.93	2.51	1.93	177	2.53
L7-02	555256	2939521	8.02	1.68	-1.15	185	2.74
L7-03	555255	2937953	9.00	2.10	-0.65	200	3.69
L7-04	555262	2936357	9.99	2.51	-1.15	175	3.01
L7-05	555260	2934769	10.98	3.93	0.51	195	3.75
L7-06	555259	2933103	12.01	3.01	1.18	195	3.19
L7-07	555263	2931591	12.95	3.56	0.22	195	4.10
L7-08	555262	2930066	13.90	3.81	-1.11	205	5.15
L7-09	555315	2928408	14.93	4.31	1.81	180	3.43
L39-01	556127	2926741	16.08	-1.28	-3.11	165	1.66
L39-02	557056	2925424	17.08	-0.69	-3.19	155	1.97
L39-03	557976	2924112	18.08	-0.47	-4.38	165	3.00
L39-04	558916	2922783	19.09	-1.47	-3.97	159	3.28
L39-05	559831	2921482	20.08	-1.22	-3.72	163	3.45
L39-06	560773	2920146	21.09	-0.97	-4.30	165	5.23
L39-07	561734	2918793	22.13	2.78	-0.72	149	2.73
L39-08	562717	2917596	23.09	7.02	-0.73	124	3.94
L39-09	564220	2917145	24.06	2.18	-1.32	135	2.70
L39-10	565732	2916662	25.05	2.52	-2.07	120	3.07
L39-11	567273	2916163	26.06	2.02	-1.73	120	2.88
L39-12	568804	2915664	27.06	2.52	0.60	125	1.87

The thalweg profiles for the sediment surface elevations and for the channel bottom elevations are presented in Figures 6 and 7, for the L-7/L39 canals and for the L-40 canal, respectively. The profiles for the L/7/L-39 canals are quite irregular with almost a horizontal average slope. Channel aggradation seems to have occurred in the L-7 canal as results of an adverse slope in the channel bed; for this canal the sediment depths vary between 10.2 and 2.5 ft with an average depth of approximately 5.5 ft. It is important to note two other major features in these profiles: a thalweg drop of more than 4 ft between canal miles 15 and 16, close to the confluence of the L-7 and L-39 canals; and a steep adverse slope with great accumulation of sediments between canal miles 21 and 23 in the L-39 canal. On the other hand, the profile for the L-40 canal is better defined with a north to south mild slope of about 3.2 inches per mile, see Figure 7. The sediment depths for the L-40 canal range between 6.6 and 0.9 ft with and average depth equal to 3.0 ft. Another interesting observation to the canal data is the difference of more than 8 ft on sediment elevations for the downstream ends of L-39 and L-40 canals, when these points are only about 1.7 miles apart.

Table 2. Cross Section Information at L-40 canal transects.

Cross Section Label	Easting m	Northing m	Canal Mile	Sediment Surface Elev. ft	Channel Bottom Elev. ft	Top Width ft	Average Sediment Depth ft
L40-28	563533	2950633	0.00	3.92	-1.00	145	4.21
L40-27	564165	2949288	0.92	4.08	-5.08	135	6.65
L40-26	564832	2947867	1.90	4.25	-4.58	145	6.55
L40-25	565882	2946594	2.92	5.08	-2.17	150	6.03
L40-24	567106	2945548	3.92	6.10	1.77	132	4.57
L40-23	568472	2944658	4.94	3.60	-1.56	88	3.01
L40-22	569828	2943776	5.94	4.94	3.02	89	2.26
L40-21	571184	2942902	6.95	5.77	-0.15	100	3.10
L40-20	572296	2941771	7.93	6.69	1.60	95	3.38
L40-19	573252	2940467	8.94	5.70	2.53	95	1.79
L40-18	574218	2939160	9.95	5.95	2.45	105	2.04
L40-17	575159	2937830	10.96	5.53	-1.22	100	3.26
L40-16	576031	2936473	11.96	5.45	3.28	104	1.68
L40-15	576694	2935015	12.96	5.28	-1.22	98	3.86
L40-14	577228	2933471	13.97	4.70	2.53	98	1.22
L40-13	577509	2931864	14.98	4.78	1.95	117	1.79
L40-12	577535	2930277	15.97	3.57	-0.43	113	2.67
L40-11	577579	2928671	16.97	3.71	-0.13	125	2.09
L40-10	577443	2927070	17.97	3.04	1.79	129	1.42
L40-09	577077	2925495	18.97	1.12	-2.71	125	2.70
L40-08	576718	2923953	19.96	0.46	-4.71	123	2.90
L40-07	576361	2922404	20.94	-1.46	-5.38	120	2.96
L40-06	576090	2920841	21.93	0.46	-1.38	130	1.46
L40-05	576115	2919246	22.92	1.36	-0.48	129	1.34
L40-04	575529	2917746	23.92	1.19	-0.23	125	0.89
L40-03	574601	2916419	24.93	-0.65	-6.98	145	1.98
L40-02	573007	2916279	25.92	0.11	-5.31	168	3.21
L40-01	571396	2916240	26.92	-5.73	-9.90	173	4.01

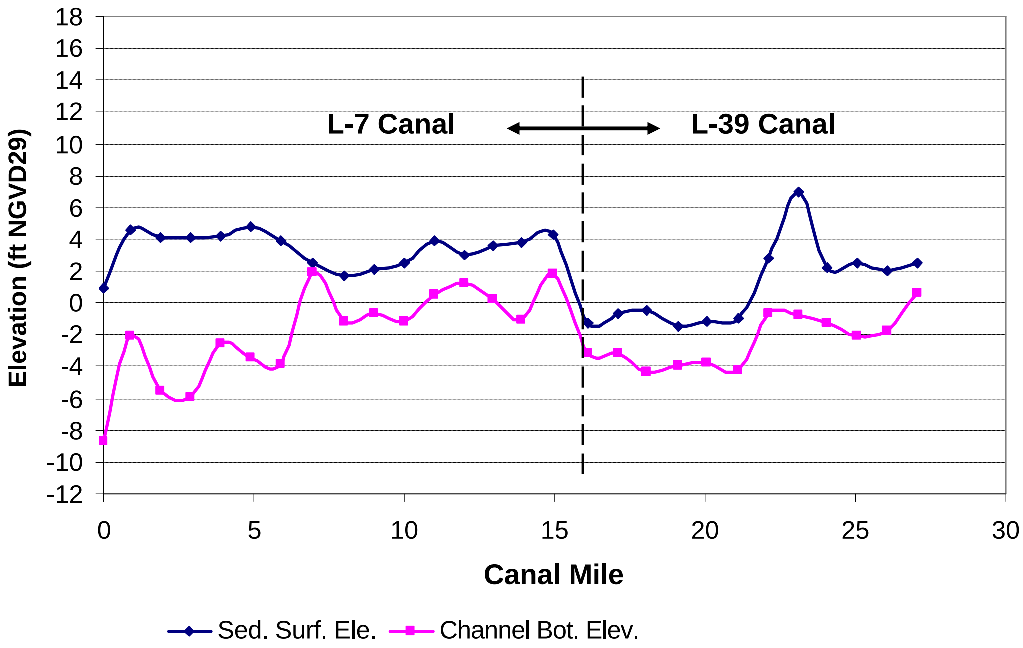

Figure 6. Thalweg Profiles for the Sediment Surface Elevation and Channel Bottom Elevation for the Western Canals (L-7 and L-39)

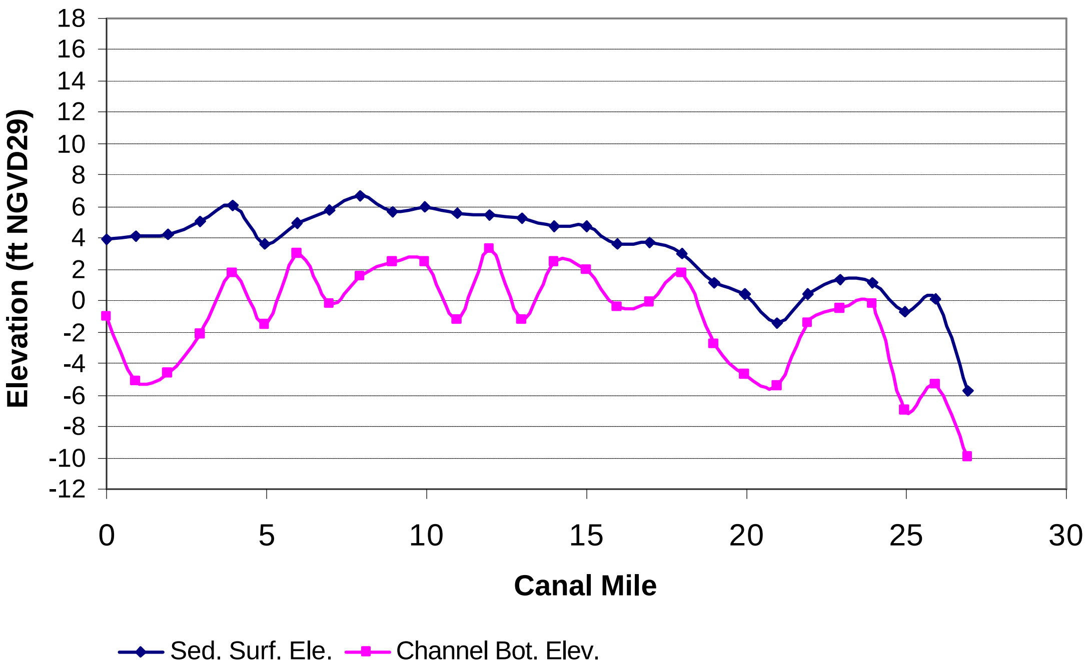

Figure 7. Thalweg Profiles for the Sediment Surface Elevation and Channel Bottom Elevation for the Eastern Canal (L-40)

6. Procurement and Quality Assurance of Water Level Data

6.1 Interior Station Stages

The water levels in the Loxahatchee Refuge change due to drought, rainfall, evapotranspiration, seepage, and surface water management based on regulation schedules that vary with the time of the year, hydrologic, and other needs (SFWMD, 2005). According to the USFWS (2000) the purpose of these schedules is to regulate the water level in WCA-1 to produce maximum benefits for flood control, water supply, fish and wildlife, and prevention of salt water intrusion. A schematic diagram of the current water regulation schedule (established in May 2005) is shown in Figure 8.

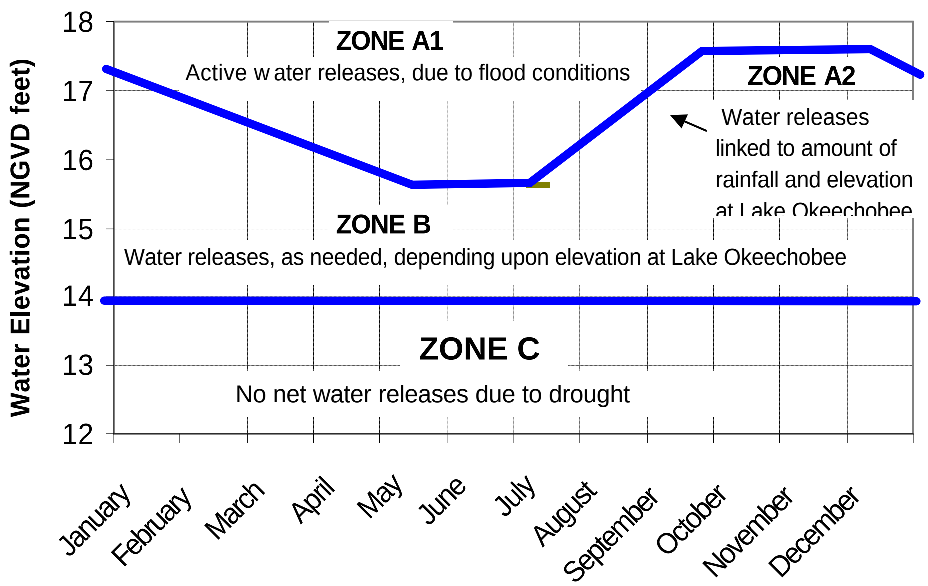

Figure 8. Water Regulation Schedule for Water Conservation Area 1 (Reproduced after Comprehensive Conservation Plan for the Loxahatchee National Wildlife Refuge, USFWS, 2000)

Spatial water level information inside the Refuge is scarce. Actually there are only five active stations inside the Refuge, two of them in operation just after mid 2001. These five stations are referred as 1-7, 1-9, 1-8T, North and South. The location of USGS's water level monitoring stations is shown in Figure 9. Historic daily average water level data from 1954 to 2005 are available at USGS sites 1-7, 1-9, and 1-8C, although the site 1-8C is located in the rim canal. The stage-monitoring site 1-8T has water level measurements since 1979. Water level data from recently installed USGS sites North and South are available only after June, 2001. The water level data can be obtained at the SFWMD's

Environmental Data Base (DBHYDRO) website (www.sfwmd.gov/org/ema/dbhydro/). Table 3 shows the available and missing data for each of these stations for the POR. A more detailed description of the interior stage missing data is presented in Appendix G.1.

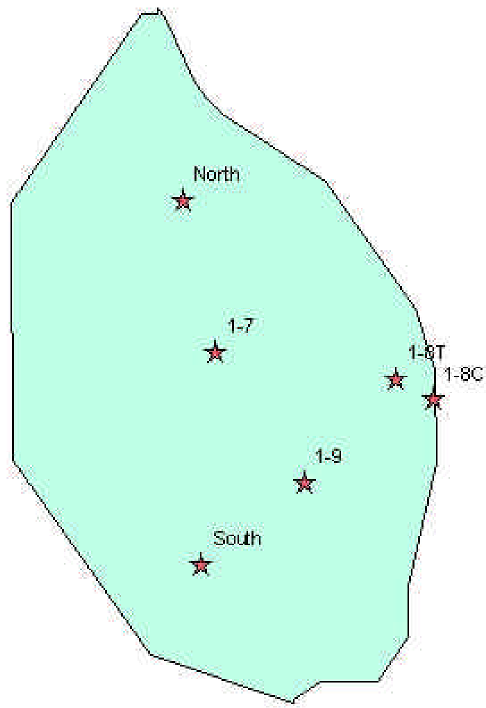

Figure 9. USGS water level monitoring stations

Table 3. Available Interior Stage Data

Station	**Available Data**										Available Data		Missing Data Days from Available Period	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
1-7											1/1/1995	12/31/2004	0	0
1-8T											1/1/1995	12/31/2004	7	3
1-8C											1/1/1995	12/31/2004	88	88
1-9											1/1/1995	12/31/2004	0	0
North											6/26/2001	12/31/2004	24	6
South											5/11/2001	12/31/2004	27	6

Note: In this Table and in the rest of the document the data reported yearly correspond to a calendar year (if it is not otherwise indicated).

The DBHYDRO database usually presents more than one time series available for each gage. For the selected POR (1995 to 2004), there are between 3 and 5 different time series available for each of the sites 1-7, 1-8T, 1-8C and 1-9. Most of these time series data sets have overlapping time periods. There is no explanation at the website about this issue, however, the DBHYDRO browser user documentation manual recommends that “whenever "PREF" data are available for a date record of interest it should be used to exclusion of all other data” since “such data sets already underwent a second level of quality assurance and quality control (QA/QC) by engineers in Environmental Monitoring and Assessment Division” (SFWMD, 2003). Since not all the stations include a “PREF” file or the “PREF” file does not always cover the complete period of interest, all the time series available were retrieved from the DBHYDRO website and compared against each other. Appendix A1, Figures A1.1 to A1.22, shows the time series available for each gage and also the comparisons between them. Table 4 shows the names of the time series available for each gage, and also the time series that were selected to be used during the Refuge modeling effort. This table also indicates the arithmetic means of daily average water levels for the POR, and the maximum and minimum daily average stages reported during such period. The major observations to the time series, as well as any modification to the data, are also reported in Table 4.

For the POR, the arithmetic means of daily average water levels for the interior stations (1-7, 1-8T, and 1-9) range between 16.55 and 16.26 ft NGVD29, and the maximum and minimum daily average stages are 18.12 and 13.94 ft NGVD29, respectively. For gage 1-8C (located in the rim canal) the arithmetic mean of daily average water level is 16.31 ft NGVD29, and the maximum and minimum daily average stages are 18.19 and 12.06 ft NGVD29, respectively. Gage North presents a higher average stage (16.73 ft NGVD29) than the rest of the stations, and gages South has a lower average stage (16.10 ft NGVD29), but these stations only have data for the period from May 2001 to December 2004.

Table 4. Summary of Water Level Data Available at Interior Stations

Gage	Available Data		Time Series Availables	Time Series to be used	Data Information (ft, NGVD 29)			Observations/Modifications to data
	Start	End			Average	Maximum	Minimum	
1-7	1/1/1995	12/31/2004	7627, 15808, FE775	FE775	16.55	18.12	14.88	File 7627 was discarded for comparison due to the short period it covers. Files 15808 and FE775 are very similar (Maximum difference is 0.12 ft, and average difference is 0.01 ft) There are 15 days of apparently inconsistent data from 18/10/95 to 11/01/95
1-8T	1/1/1995	12/31/2004	7637, 15809, P1031	P1031+15809	16.26	18.03	13.94	File 7637 was discarded for comparison due to the short period it covers. Files 15809 and P10315 are identical
1-8C	1/1/1995	12/31/2004	5400, 7636, 15810, FE776, P1030	FE776	16.31	18.19	12.06	Files 5400 and 7636 were discarded for comparison due to the short period they cover. The files 15810, FE776 and P1030 are very similar, but FE776 was selected because it is the PREF file. The minimum stage equal to 12.06 ft corresponds to an "extreme event" on May 2001. There is a long period of missing data (88 consecutive days from 9/5/04 to 12/1/04) in all the files
1-9	1/1/1995	12/31/2004	7628, 15811, FE777, P1032	FE777	16.35	17.90	14.78	File 7628 was discarded for comparison due to the short period it covers. Files 15811, FE777 and P1032 are very similar (average difference is 0.003 ft, and the maximum difference is 0.15 ft). FE777 was selected because it covers the complete period without missing data, and is the PREF file
North	6/26/2001	12/31/2004	RW494	RW494	16.73	18.00	15.67	Only one file is available
South	5/11/2001	12/31/2004	MW671	MW671	16.10	17.27	14.23	Only one file is available

6.2 Head and Tail Water Levels from Hydraulic Structures

Head-water and tail-water stage data, for the hydraulic structures associated with the Refuge, are also available from the DBHYDRO website. These data are essential for documenting the spatial and temporal stage variations along the rim canal. The water level data for the hydraulic structures were divided into four groups according to the structure location: a) the northern stations, this group includes structures S-5A, S-5AS, G-301 and G-300; b) the western stations, this group includes structures G-310, G-251, S-6, S-10E and G-338; c) the southern stations, structures S-10D, S-10C, S-10A and S-39 are included in this group; and d) the eastern stations, structures S-362, ACME-1, ACME-2 or G-94D, G-94C, G-94B and G-94A are included in this group. Figure 10 shows the location of the hydraulic structures associated with the Refuge.

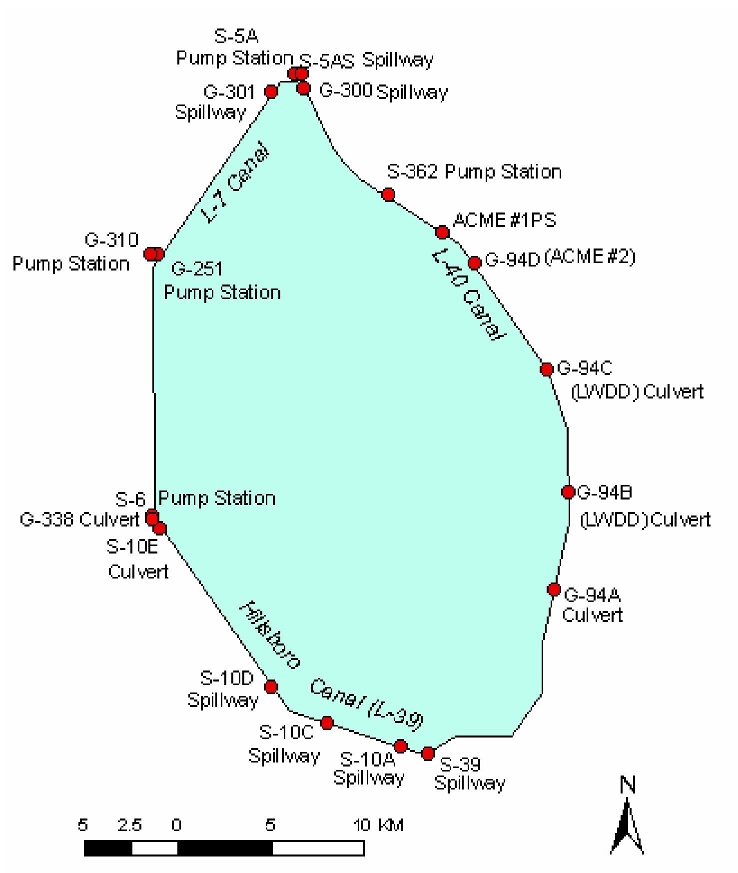

Figure 10. Location of Hydraulic Structures in the Loxahatchee Refuge

Table 5 shows the available head- and tail-water level data for the nineteen hydraulic structures around the Refuge. As can be observed in the table, not all the structures were in operation from the start date of the POR. For example, structures G-301 and G-300 started operating in August 1999 (Waldon, 2005). Structure G-310 started operating on

July 2000 (Waldon, 2005). On the other hand, the structures located at the eastern part of the Refuge (ACME-1, G-94D, G-94C, G-94B and G-94A) were in operation for the complete POR. For these stations, the time series available at the DBHYDRO website are missing between 57 and 89 months with respect to their head and tail water levels, while some stations do not have head water levels available (see Table 5). The investigators are continuing to search for the missing data.

Head and Tail water level data for the stations S-10D, S-10C and S10-A is also available at the USGS website (http://water.usgs.gov/data.html). A more detailed description of the head and tail water level missing data is presented in Appendix G.2.

Table 5. Available Head and Tail Water Level Data

Station	**Data Type**	**Available Data**										Available Data		Missing Data Days from Available Period	
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
S-5A	HW											01/01/95	12/31/04	0	0
	TW											01/01/95	12/31/04	0	0
S-5AS	HW											01/01/95	09/30/04	0	0
	TW											01/01/95	12/31/04	0	0
G-300	HW											11/02/99	12/31/04	0	0
	TW											11/02/99	12/31/04	0	0
G-301	HW											08/26/99	12/27/04	0	0
	TW											08/26/99	12/31/04	0	0
G-310	HW											07/07/00	07/31/03	0	0
	TW											07/07/00	12/31/04	0	0
G-251	HW											01/01/95	12/31/04	14	14
	TW											01/01/95	12/31/04	10	10
S-6	HW											01/01/95	12/31/04	0	0
	TW											01/01/95	12/31/04	0	0
S-10E	HW											01/01/95	12/31/04	0	0
	TW											01/01/95	12/31/04	20	19
G-338	HW											03/19/02	12/31/04	0	0
	TW											03/19/02	12/31/04	0	0
S-10D	HW											01/01/95	12/31/04	58	16
	TW											01/01/95	12/31/04	106	15
S-10C	HW											01/01/95	12/31/04	14	9
	TW											01/01/95	12/31/04	22	7
S-10A	HW											01/01/95	12/31/04	74	12
	TW											01/01/95	12/31/04	106	23
S-39	HW											01/01/95	12/31/04	21	21
	TW											01/01/95	12/31/04	1	1
S-362	HW											10/14/04	12/31/04	0	0
	TW											10/14/04	12/31/04	0	0
ACME#1	HW											09/09/99	12/31/04	10	8
	TW											09/09/99	12/31/04	8	6
G-94D	HW											09/08/99	12/31/04	9	9
	TW											09/08/99	12/31/04	9	9
G-94C	HW											06/03/02	12/31/04	7	7
	TW											01/18/00	12/31/04	24	10
G-94B	HW											---	---	---	---
	TW											01/18/00	12/31/04	40	12
G-94A	HW											---	---	---	---
	TW											01/18/00	12/31/04	40	12

Head water data are available for this period

Tail water data are available for this period

Structure was in operation but data are not available

Structure was not in operation during this period

As in the case of the interior stations, the DBHYDRO database sometimes shows more than one time series available for the same station (see Tables 6 to 9); unfortunately, for the head/tail water levels there were not “PREF” files available. The time series available for each station, as well as the comparison among them, are included in Appendix A2, Figures A2.1 to A2.66. Data for the S-362 station is only available after 10/14/2004, and therefore the head and tail water levels time series for this station were not included in the appendices. Tables 6 to 9 summarize the major observations to the head and tail water level data, and also indicate the time series recommended to be used for the modeling effort. If not otherwise indicated, the data in the time series shown in Tables 6 to 9 and Appendix A2 are daily mean values.

As seen in Tables 6 to 9, the arithmetic means of daily average water levels inside the Refuge range from 16.28 to 15.93 ft NGVD29 for the 17 hydraulic structures, and for the POR. Similarly, the maximum and minimum daily average stages are 18.98 and 11.54 ft NGVD29, respectively. It is observed that for the POR the water level for the structures along the rim canal, on average, is lower than that of the interior stations. However, the maximum daily average stage reported for the structures (i.e., 18.98 ft) is higher than the maximum value reported for the interior stations (i.e., 18.12 ft). This information shows that, on average, the water level in the channel is lower than the water level of the marsh. However, under certain conditions the water may overflow the rim canal and moves as sheet flow toward the interior of the Refuge. According to Waldon (2005) at high stages there is typically little difference between stage in the marsh and at non-operating structures and pumps. When outflow gates are opened, stages at the structure headwaters fall below the stage representative of the broader region of the canal in the vicinity of the structure. At lowest canal stage, water surface elevation falls below interior marsh soil elevation and monitored marsh stages.

Note in Tables 4 to 9 and for the rest of this document, the term “extreme event” has been used arbitrarily to indicate a period of time when a particular parameter, e.g., water level, shows an unusual high or low value when compared to other high/low values and/or to the arithmetic or geometric mean of the data. The classification of a period of time as an “extreme event” is partially subjective, and has no other purpose than to illustrate such particularity of the data.

Table 6. Summary of Head/Tail Water Level Data Available at Northern Hydraulic Structures

Gage	Type Location	Available Data Start	Available Data End	Time Series Available	Time Series to be used	Data Information (ft, NGVD 29) Average	Maximum	Minimum	Observations/Modifications to data
S-5A Pump Station	HW Outside	1/1/1995	12/31/2004	318, 6676, TA382	TA382 + 6676	10.32	12.27	7.74	The files 318 and TA382 are identical. The times series presented in files 6676 and TA382 are similar (the average difference is 0.05 ft and the maximum difference is 0.31 ft). TA382 is the MOD1 file. The MOD1 file was used as input file for the South Florida Water Management Model (SFWMM). The minimum stage equal to 11.91 ft corresponds to an "extreme event" on May 2001
	TW Inside	1/1/1995	12/31/2004	320, 6677, TA384	320	15.47*	18.83*	10.43*	The files 320 and TA384 are identical. The times series presented in files 6677 and 320 are similar (the average difference is 0.04 ft and the maximum difference is 0.32 ft). TA384 is the MOD1 file *The tendency of the data changed after September 1999. The average, maximum and minimum tail water stages until September 1999 are 16.20, 18.76 and 13.91 ft NGVD 29, respectively
S-5AS Spillway	HW Outside	1/1/1995	9/30/2004	323, 6692, PN454	323	13.91	19.33	9.48	The files 323 and PN454 are very similar, but the files 323 and 6692 have major differences (the average difference is 0.07 ft and the maximum difference is 1.49 ft). This gage is outside of the Refuge
	TW Inside	1/1/1995	12/31/2004	6693	6693	15.48*	18.98*	10.50*	Only one file available *The tendency of the data changed after September 1999. The average, maximum and minimum tail water stages until September 1999 are 16.18, 18.98 and 13.84 ft NGVD 29, respectively
G-300 Spillway	HW Outside	11/2/1999	12/31/2004	KN627	KN627	14.83	18.39	10.54	Only one file available This structure started operating on August 26, 1999, hence there are 67 days of missing data
	TW Inside	11/2/1999	12/31/2004	KN628	KN628	16.01	17.94	11.91	Only one file available This structure started operating on August 26, 1999, hence there are 67 days of missing data. The minimum stage equal to 11.91 ft corresponds to an "extreme event" on May 2001
G-301 Spillway	HW Outside	8/26/1999	12/27/2004	KS685	KS685	14.90	18.87	10.58	Only one file available
	TW Inside	8/26/1999	12/31/2004	KS686	KS686	16.18	18.58	11.95	Only one file available The minimum stage equal to 11.95 ft corresponds to an "extreme event" on May 2001

Table 7. Summary of Head/Tail Water Level Data Available at Western Hydraulic Structures

Gage	Type Location	Available Data Start	End	Time Series Available	Time Series to be used	Data Information (ft, NGVD 29) Average	Maximum	Minimum	Observations/Modifications to data
G-310 Pump Station	HW Outside	7/7/2000	7/31/2003	M5154	M5154	8.88	9.99	7.22	Only one file available
	TW Inside	7/7/2000	12/31/2004	M5155, PI326	M5155 + PI326	16.08	17.96	11.51	The files M5155 and PI326 present similar information, the average stage difference among the two files is 0.03 ft and the maximum difference is 0.12 ft. The minimum stage equal to 11.51 ft corresponds to an "extreme event" on May 2001
G-251 Pump Station	HW Outside	1/1/1995	12/31/2004	16218	16218	11.07	13.64	8.83	Only one file available
	TW Inside	1/1/1995	12/31/2004	16219	16219	16.28	18.43	12.06	Only one file available The average value for station G-251 is 0.20 ft higher than the average value for station G-310
S-6 Pump Station	HW Outside	1/1/1995	12/31/2004	356, 6684	6684	10.35	12.50	7.81	The two time series (356 and 6684) present major differences (the average difference is 0.15 ft and the maximum difference is 2.45 ft); however, since this gage is outside of the Refuge it won't affect the modeling effort
	TW Inside	1/1/1995	12/31/2004	6685	6685	15.17*	18.15	10.81	*The average stage is low compared to surrounding stations; but, the tendency of the data changed after May 2001. The average tail water stage until May 2001 is 16.20 ft NGVD 29. Only one file available
S-10E Culvert	HW Inside	1/1/1995	12/31/2004	16229, P0854	16229 + P0854	16.23	18.15	12.20	Both time series (16229 and P0854) are very similar
	TW Outside	1/1/1995	12/31/2004	16230, 5556	16230	14.32	16.81	12.28	The time series only have 1 day in common (06/4/95) and the values for this day are different. The file 5556 only has data for two months, and therefore a time series was not included in the appendixes. A value equal to 0.07 ft on May 2, 1999, was converted into missing data. This gage is outside of the Refuge.
G-338 Culvert	HW Outside	3/19/2002	12/31/2004	TA863	TA863	13.58	16.97	10.82	Only one file available
	TW Inside	3/19/2002	12/31/2004	TA865	TA865	16.12	17.28	13.58	Only one file available This structure is part of the S-6 diversion structure. It is located next to the S-6 pump and would allow water to flow into the Refuge from the S-6.

Table 8. Summary of Head/Tail Water Level Data Available at Southern Hydraulic Structures

Gage	Type Location	Available Data Start	Available Data End	Time Series Available	Time Series to be used	Data Information (ft, NGVD 29) Average	Maximum	Minimum	Observations/Modifications to data
S-10D Spillway	HW Inside	1/1/1995	12/31/2004	7912, USGS-S10D-U	USGS-S10D-U	16.15	17.75	13.35	The data in the 7912 file are daily water readings (DWR). The data in the USGS-S10D-U are daily mean values. The file 7912 was discarded due to the short period it covers and the amount of missing data. The USGS-S10D-U file ID is USGS262300080220001
	TW Outside	1/1/1995	12/31/2004	7621, USGS-S10D-D	USGS-S10D-D	13.35	16.98	11.45	The data in the 7621 file are daily water readings (DWR). The data in the USGS-S10D-D are daily mean values. The file 7621 was discarded due to the short period it covers and the amount of missing data.
S-10C Spillway	HW Inside	1/1/1995	12/31/2004	7910, G5070, USGS-S10C-U	USGS-S10C-U + G5070	16.11	17.75	11.88	The data in the 7910 file are DWRs. The data in the files USGS-S10C-U and G5070 are daily mean values. The file 7910 was discarded due to the short period it covers and the amount of missing data. The data in the files USGS-S10C-U and G5070 are very similar. The USGS-S10C-U file ID is USGS262200080210001 The minimum stage equal to 11.88 ft corresponds to an "extreme event" on May 2001
	TW Outside	1/1/1995	12/31/2004	7911, G5071, USGS-S10C-D	USGS-S10C-D + G5071	13.32	16.90	11.47	The data in the 7911 file are DWRs. The data in the files USGS-S10C-D and G5071 are daily mean values. The file 7911 was discarded due to the short period it covers and the amount of missing data. The data in the files USGS-S10C-D and G5071 are very similar.
S-10A Spillway	HW Inside	1/1/1995	12/31/2004	7908, USGS-S10A-U	USGS-S10A-U	16.08	17.73	12.06	The data in the 7908 file are DWRs. The data in the USGS-S10A-U are daily mean values. The file 7908 was discarded due to the short period it covers and the amount of missing data. The USGS-S10D-U file ID is USGS262100080190001 The minimum stage equal to 12.06 ft corresponds to an "extreme event" on May 2001
	TW Outside	1/1/1995	12/31/2004	7909, USGS-S10A-D	USGS-S10A-D	13.31	16.74	11.44	The data in the 7909 file are DWRs. The data in the USGS-S10A-D are daily mean values. The file 7909 was discarded due to the short period it covers and the amount of missing data.
S-39 Spillway	HW Inside	1/1/1995	12/31/2004	6660	6660	15.93	17.99	11.54	Only one file available The minimum stage equal to 11.54 ft corresponds to an "extreme event" on May 2001
	TW Outside	1/1/1995	12/31/2004	4362, 6661	6661	7.99	11.50	5.07	This gage is outside of the Refuge

Table 9. Summary of Head/Tail Water Level Data Available at Eastern Hydraulic Structures

Gage	Type Location	Available Data Start	Available Data End	Time Series Available	Time Series to be used	Data Information (ft, NGVD 29) Average	Maximum	Minimum	Observations/Modifications to data
S-362 Pump Station	HW Outside	10/14/2004	12/31/2004	T0891	T0891	13.50	14.29	12.88	Only one file available This time series was not included in the appendices (Due to the short period it covers)
	TW Inside	10/14/2004	12/31/2004	T0893	T0893	16.39	16.71	16.31	Only one file available This time series was not included in the appendices (Due to the short period it covers). This pump discharges from the STA-1E into the Refuge
ACME # 1 Pump Station	HW Outside	9/9/1999	12/31/2004	JO090	JO090	12.82	14.41	10.08	Only one file available A value reported as 0 ft on 9/5/04 was converted to missing data
	TW Inside	9/9/1999	12/31/2004	JO091	JO091	16.24	18.98	12.01	Only one file available Stage is measured in a small basin hydraulically connected to the L-40 Canal. When the pump is not discharging the stage should be representative of the L-40 stage (Waldon, 2005)
ACME # 2 Pump Station	HW Outside	9/8/1999	12/31/2004	JO092	JO092	12.87	15.56	9.37	Only one file available
	TW Inside	9/8/1999	12/31/2004	JO093	JO093	16.16	18.93	11.98	Only one file available Stage is measured in a small basin hydraulically connected to the L-40 Canal. When the pump is not discharging the stage should be representative of the L-40 stage (Waldon, 2005)
G-94C Culvert	HW Inside	6/3/2002	12/31/2004	OR352	OR352	16.18	17.36	13.43	Only one file available
	TW Outside	1/18/2000	12/31/2004	MG648, OR351	MG648 + OR351	15.69	16.75	13.10	The two time series (MG648 and OR351) present major differences; however, since this gage is outside of the Refuge it may not affect the modeling effort
G-94B Culvert	HW Inside	---	---			---	---	---	Not gauged. No file is available from the DBHYDRO website
	TW Outside	1/18/2000	12/31/2004	NI745	NI745	12.23	15.78	9.53	The maximum stage equal to 15.78 ft corresponds to an "extreme event" during March 15 to 18, 2002,. besides this event, the maximum stage is equal to 13.86 ft
G-94A Culvert	HW Inside	---	---			---	---	---	Not gauged. No file is available from the DBHYDRO website
	TW Outside	1/18/2000	12/31/2004	NI744	NI744	12.37	13.82	9.99	Only one file available

7. Procurement and Quality Assurance of Flow Data

The nineteen hydraulic structures associated with the water management of the Refuge are shown in Figure 10. In the previous section, these structures were classified according to their geographical location. They can also be classified according to the direction of the flow as: a) inflow structures: S-5A, G-310, G-251, S-6, S-362, ACME -1 and ACME -2 (ACME-2 is also referred as G-94D); b) outflow structures: S-10E, S-10D, S-10C, S-10A, S-39, G-94A, and G-94B; and c) bidirectional flow structures: S-5AS, G-301, G-300, G-338 and G-94C.

Discharge Data are available for the 19 structures from the DBHYDRO website (additional data for the S-362 station was obtained from SFWMD's personal). However, the data for some of the stations do not cover the complete period of record, namely from January 1995 to December 2004 (see Table 10). A more detailed description of the flow missing data is presented in Appendix G.3.

Table 10. Available Flow Data

Station	Available Data										Available Data		Missing Data Days from Available Period	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
S-5A	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-5AS	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
G-300						■	■	■	■	■	11/2/1999	12/31/2004	0	0
G-301						■	■	■	■	■	8/26/1999	12/31/2004	0	0
G-310						■	■	■	■	■	7/7/2000	12/31/2004	0	0
G-251	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-6	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-10E	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
G-338								■	■	■	3/19/2002	12/31/2004	0	0
S-10D	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-10C	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-10A	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-39	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
S-362											9/21/2004	12/31/2004	15	7
ACME#1	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
G-94D	■	■	■	■	■	■	■	■	■	■	1/1/1995	12/31/2004	0	0
G-94C	X	X	X	X	X	■	■	■	■	■	4/15/2000	12/31/2004	0	0
G-94B	X	X	X	X	X	■	■	■	■	■	4/15/2000	12/31/2004	0	0
G-94A	X	X	X	X	X	■	■	■	■	■	4/15/2000	12/31/2004	0	0

■ Flow data are available for this period

X Structure was in operation but data are not available

□ Structure was not in operation during this period

Table 10 shows that there are data available for the complete POR for stations S-5A, S-5AS, and S-6. However, these stations were diverted away from the Refuge at some points during this period. The S-5A pump station discharged into the Refuge until August 1999, when it was diverted to the western stormwater treatment area (STA-1W). Similarly, structure S-5AS and the S-6 pump were diverted away from the Refuge in June 1999 and May 2001, respectively. The diversion of the S-6 pump represented a major removal of water and phosphorus loading from the Refuge (Waldon 2005). On the other hand, structures G-301 and G-300 started operating in August 1999. These structures are bidirectional and allow occasional discharge of water from the West Palm Beach Canal directly into the Refuge, and also release of water at the north end of the Refuge to the C-51 Canal. The water from the West Palm Beach Canal is normally discharge to STA-1W, and the effluent water from STA-1W is later discharged into the Refuge, approximately 10.6 Km south of G-301 structure, through the large pumping station G-310 (3,040 cfs capacity), and a much smaller pumping station G-251 (Waldon 2005). Structure G-310 started operating in May 1999. On the other hand, structures G-94A, G-94B and G-94C have been in operation during the complete POR. According to Waldon (2005) these structures are primarily for agricultural and urban water supply; they intermittently discharge relatively small volumes out of the Refuge during the dry season. The time series available from the DBHYDRO website for these stations are missing approximately 63 months of discharge data for each of the sites.

For the selected POR (1995 to 2004), The DBHYDRO database presents between 2 and 6 different time series available for each hydraulic structure, with the only exception of stations G-338 and S-362 that have only one time series available. As mentioned earlier, the DBHYDRO browser user documentation manual recommends the utilization of the data identified with the “PREF” recorder, since these time series already underwent a second level of QA/QC by SFWMD personnel. However, since not all the stations include a “PREF” file or the “PREF” file does not always cover the complete period of interest, all the time series available were retrieved from the DBHYDRO website and analyzed. Appendix B shows the discharge time series available for the hydraulic structures, as well as the comparisons among them (see Figures B.1 to B.84).

Each of the available time series was reviewed, looking for outliers and discrepancies in the data. Tables 11 to 14 indicate the time series available for each site, summarize the major observations to the data, and indicate the time series that are recommended for future use during the Refuge modeling effort. The arithmetic mean of daily average, and the maximum and minimum daily average discharges were calculated for each structure, and are also reported in Tables 11 to 14. These tables also report the major periods of consecutive operational days, i.e., days of non-zero flow (this is referred as “flowing period”) and the major periods of zero-flow (this is referred as “non-flowing period”), and the modifications to the selected time series after the completion of the quality assurance checks.

Based on the POR and according to the management structures’ operation, pumping stations G-310, S-6 and S-5A present the highest arithmetic mean of daily average inflows, with a flow close to 400 cfs. The maximum recorded daily average discharge is equal to 4,779 cfs through pumping station S-5A. Meanwhile, stations G-310 and S-6 show maximum daily average discharges equal to 3,224 and 2,920 cfs, respectively. Structures S-39 and S-10D present the highest arithmetic mean of daily average outflows to the Refuge with a flow close to 180 cfs. Structures S-10C and S-10A have an arithmetic mean of daily average discharge (outflow) close to 145 cfs. The maximum recorded daily average outflow from the Refuge is 4,921 cfs through spillway S-10A.

Table 11. Summary of Flow Data Available at Northern Hydraulic Structures

Structure/Type/ Flow	Available Data		Time Series Available	Time Series to be used	Data Information (cfs)			Observations/Modifications to data
	Start	End			Average	Maximum	Minimum	
S-5A Pump Station in	1/1/1995	12/31/2004	6739, TA383, JW226	6739	471.0	4837.0	0.0	The three files (6739, TA383 and JW226) are very similar. 6739 was selected because it covers the complete period. The flow is intermittent and unidirectional. During the studied period, the structure is "flowing" during 49.7% of the days with the maximum flowing period equal to 67 days, from 07/29/02 to 10/3/02. On the other hand, the structure is "not-flowing" 50.3% of the days with the maximum non-flowing period equal to 62 days (12/22/00 to 02/21/01). The S-5A pump station discharge was diverted away of the Refuge on August 26, 1999. The average, maximum and minimum daily discharge until August 26, 1999 are 391.8, 4779 and 0 cfs; respectively.
S-5AS Spillway in - out	1/1/1995	12/31/2004	6758, 6757, 12899, T0951,TA410, L7444	6758 + TA410	-79.5	1495.0	-1019.0	No time series covers the complete period. The files 6758, 12899 and 6757 cover from 1/1/95 to 4/30/00. The files TA410 and L7444 cover from 6/1/99 to 12/31/04, and T0951 covers from 1/1/95 to 9/30/04. TA410 is the PREF file and it matches perfectly with L7444, but not with T0951. 6757 has lot of missing data. 12899 and 6758 have major differences, but since 6758 matches better with TA410, for the overlapping period, it will be selected along with TA410. The flow is intermittent and bidirectional (positive flow is in). For the studied period, the structure is "flowing" 42.1% of the time, drawing water out of the Refuge 86.7% of this time. This structure was diverted away from the Refuge on 6/07/99. Until this day the average, max and min daily discharge are -112.8, 1495 and -966 cfs; respectively.
G-300 Spillway in - out	11/2/1999	12/31/2004	KD315, TA411	TA411	2.4	2494.0	-1302.0	The files KD315 and TA411 are identical. TA411 is the PREF file. The flow is intermittent and bidirectional (positive flow is in). The structure is "flowing" 30.6% of the time, with 60.5% of negative flow. The maximum flowing period is 104 days (11/9/00 to 2/22/01), and the maximum non-flowing period is 264 days (10/13/03 to 7/3/04). This structure started operating on August 26, 1999; but, the first flow is reported on November 2, 1999.
G-301 Spillway in -out	8/26/1999	12/27/2004	JJ809, TA412	TA412+JJ809	28.4	2758.0	-1158.0	The two files (JJ809 and TA412) present major differences. TA412 is the PREF file, but only covers the period from 11/2/99 to 12/31/04. The JJ809 file starts at 08/26/99, and will be used for filling the gap between this date and 11/2/99. The flow is intermittent and bidirectional. The structure is "flowing" only 18.9% of the time, with negative flow 50.1% of the time. The maximum flowing period is 30 days (10/5/99 to 11/5/99), and the maximum non-flowing period is 148 days (9/14/01 to 02/09/02). This structure started operating on late August 1999. According to Waldon (2005) calibration of flow rating is complicated at this gage by interaction with the G-302 gate (inflow to STA-1W)

Table 12. Summary of Flow Data Available at Western Hydraulic Structures

Structure/Type/ Flow	Available Data		Time Series Available	Time Series to be used	Data Information (cfs)			Observations/Modifications to data
	Start	End			Average	Maximum	Minimum	
G-310 Pump Station in	6/8/2000	12/31/2004	LQ977, M2901, PK919	M2901	411.0	3224.0	0.0	The files LQ977 and M2901 are very similar, while the file PK919 presents major differences with respect to these two files. M2901 is the PREF file and will be used for forcing the model. The flow is intermittent and unidirectional. The maximum flowing period is 93 days (7/17/04 to 10/17/04) and the maximum non-flowing period is 64 days (1/26/01 to 3/31/01) This structure started operating on July 7, 2000.
G-251 Pump Station in	1/1/1995	12/31/2004	15848, JW222, P1047	15848	118.6	430.0	0.0	The three time series available are identical (15848, JW222 and P1047). The file 15848 will be used because it covers the complete period (1/1/95 to 12/31/04). The flow is intermittent, but the flowing periods are dominant. The maximum flowing period is 329 days (7/12/97 to 6/5/98) and the maximum non-flowing period is 164 days (10/17/00 to 3/30/01)
S-6 Pump Station in	1/1/1995	12/31/2004	6741, 15034, P1019, 357	15034	385.7	2920.0	0.0	The time series 15034 and P1019 are identical. The time series 6741 is similar to these two with minor differences, and the 357 file presents major differences with respect to the other files. The file 15034 covers the complete period and is the PREF file. The flow is intermittent and unidirectional. The maximum flowing period is 88 days (8/13/99 to 11/8/99) and the maximum non-flowing period is 144 days (10/17/00 to 3/9/01). The S-6 pump station discharge was diverted away from the Refuge on May 2001. The average, maximum and minimum daily discharge until May 2001 are 398.6, 2920 and 0 cfs; respectively.
S-10E Culvert out	1/1/1995	12/31/2004	16228, K5484, P1066	K5484	33.4	554.0	0.0	The files K5484 and P1066 are very similar, but the file 16228 presents major differences. K5484 is the PREF file and covers the complete period. The flow is intermittent and unidirectional. This structure draws water out of the Refuge. The maximum flowing period is 150 days, from 2/5/96 to 7/3/96. The structure shows virtually no flow after August 7, 1997.
G-338 Culvert in - out	3/19/2002	12/31/2004	MC705	MC705	0.0	1.0	-17.7	Only one file available This structure is part of the S-6 diversion structure. It is located next to the S-6 pump and would allow water to flow into the Refuge from the S-6. This structure has not been used during the POR; however, the gates may have been opened for maintenance at times. Positive flows are into the Refuge. The time series MC705 was not included in the Appendices (the flow for this structures is negligible).

Table 13. Summary of Flow Data Available at Southern Hydraulic Structures

Structure/Type/ Flow	Available Data		Time Series Available	Time Series to be used	Data Information (cfs)			
	Start	End			Average	Maximum	Minimum	
S-10D Spillway out	1/1/1995	12/31/2004	3790, 15263, TA421	TA421	175.9	2724.0	0.0	The file 3790 is empty. The files 15263 and TA421 are very similar, but TA421 is the PREF file. The flow is intermittent and unidirectional. Non-flowing periods are dominant over flowing periods. The maximum non-flowing period is 329 days (9/18/03 to 8/12/04), while the maximum flowing period is "only" 37 days (9/7/04 to 10/13/04). This structure draws water out of the Refuge (positive flow is out). The time series 15263 presents a Q= -1622 cfs on 5/2/2004, however the S-10D gates were closed at this date (Sylvester et al., 2005) and this negative value was discarded.
S-10C Spillway out	1/1/1995	12/31/2004	3796, 15262, TA420	TA420	146.3	3276.0	0.0	The file 3796 is empty. The files 15262 and TA420 are very similar, but TA420 is the PREF file. The flow is intermittent and unidirectional. Non-flowing periods are dominant over flowing periods. The maximum non-flowing period is 435 days (6/4/03 to 8/12/04), while the maximum flowing period is "only" 44 days (9/2/04 to 10/15/04). This structure draws water out of the Refuge (positive flow is out). The time series 15262 presents a Q= -726 cfs on 5/2/2004, however the S-10D gates were closed at this date (Sylvester et al., 2005) and this negative value was discarded.
S-10A Spillway out	1/1/1995	12/31/2004	3784, 15261, TA419	TA419	141.4	4921.0	0.0	The file 3784 is empty. The files 15261 and TA419 are very similar, but TA419 is the PREF file. The flow is intermittent and unidirectional. Non-flowing periods are dominant over flowing periods. The maximum non-flowing period is 456 days (6/4/03 to 9/1/04), while the maximum flowing period is "only" 42 days (9/2/04 to 10/13/04). This structure draws water out of the Refuge (positive flow is out). The time series 15261 presents two negative values, Q= -1337 cfs on 5/2/04 and Q=-58 on 12/14/01, however the S-10D gates were closed at these dates (Sylvester et al., 2005) and these negative values were discarded. The data present an "extreme event" of high flow from October 15 to October19, 1999
S-39 Spillway out	1/1/1995	12/31/2004	6733, K5489, P1012	K5489	184.7	888.0	0.0	The files K5489, 6733 and P1012 are very similar. K5489 was selected because it is the PREF file. The flow is intermittent and unidirectional. For the studied period 57% of the days are "flowing" and 43% are "not-flowing". The maximum flowing period is 140 days (11/10/98 to 3/29/99) and the maximum non-flowing period is 169 days (5/12/97 to 10/27/97). This structure draws water out of the Refuge

Table 14. Summary of Flow Data Available at Eastern Hydraulic Structures

Structure/Type/Flow	Available Data		Time Series Available	Time Series to be used	Data Information (cfs)			Observations/Modifications to data
	Start	End			Average	Maximum	Minimum	
S-362 Pump Station in	9/21/2004	12/31/2004	T0897, SFWMD-S362	T0897 + SFWMD-S362	98.2	2044.5	0.0	The file SFWMD-S362 covers the period form 9/21/04 to 10/6/04. This files was provided by SFWMD's personal. The file T0897 was obtained from DBHYDRO and covers the period from 10/14/04 to 12/31/04. Since both time series cover short periods and these periods don't overlap, the time series were combined into one (see Appendices). The S362 pump discharges from STA-1E. It discharged during the 2004 hurricane season on an emergency basis.
ACME # 1 Pump Station in	1/1/1995	12/31/2004	15022, OH647, PI317, JO088	OH647	21.4	358.6	0.0	The files OH647, PI317 and JO088 are similar. The file 15022 presents major differences with respect to the other files. OH647 is the PREF file and covers the complete period. The flow is intermittent and unidirectional. During the studied period 23.9% of the days were "flowing" and 76.1% were "not-flowing". The maximum flowing period is 19 days (9/20/04 to 10/8/04), and the maximum non-flowing period is 100 days (12/14/02 to 3/23/02)
ACME # 2 Pump Station in	1/1/1995	12/31/2004	15023, OH648, PI318, JO089	OH648	19.8	401.0	0.0	The files OH648, PI318 and JO089 are similar. The file 15023 presents major differences with respect to the other files. OH648 is the PREF file and covers the complete period. The flow is intermittent and unidirectional. During the studied period 25.3% of the days were "flowing" and 74.7% were "not-flowing". The maximum flowing period is 19 days (9/20/04 to 10/8/04), and the maximum non-flowing period is 100 days (12/14/02 to 3/23/02)

Cont. Table 14. Summary of Flow Data Available at Eastern Hydraulic Structures

Structure/Type/Flow	Available Data		Time Series Available	Time Series to be used	Data Information (cfs)			Observations/Modifications to data
	Start	End			Average	Maximum	Minimum	
G-94C Culvert in-out	4/15/2000	12/31/2004	MW385, OR446, TA424	MW385 + TA424	38.6	400.1	-257.3	The information for this structure is incomplete. This structure was already operational on 1/1/1995, and therefore the files are missing about 57 months of flow data. The files TA424 and OR446 are very similar, but TA424 is the PREF file. The files TA424 and OR446 only overlap for 119 days, presenting major differences during this period. The PREF time series (TA424) only has data after 6/4/02. The flow is intermittent and bidirectional, with outflows being positives. During the 1715 days of available data, 1202 days (70.1%) are "not-flowing" days, 502 days (29.3%) are outflow days, and only 11 days are inflow days (0.6%).
G-94B Culvert out	4/15/2000	12/31/2004	NI750, SX615, TA423	NI750 + TA423	4.7	268.9	0.0	The information for this structure is incomplete. This structure was already operational on 1/1/1995, and therefore the files are missing about 57 months of flow data. The files TA423 and SX615 are very similar, but TA423 is the PREF file. The files NI750 and TA423 only overlap for 220 days, presenting minor differences during this period. The PREF time series (TA423) only has data after 6/3/02. The flow is intermittent and unidirectional (outflow). During the 1703 days of available data, 1644 days (96.5%) are "not-flowing" days, and only 59 days are "flowing" (3.5%)
G-94A Culvert out	4/15/2000	12/31/2004	NI751, SX614, TA422	NI751 + TA422	20.3	227.5	0.0	The information for this structure is incomplete. This structure was already operational on 1/1/1995, and therefore the files are missing about 57 months of flow data. The files TA422 and SX614 are very similar, but TA422 is the PREF file. The files NI751 and TA422 only overlap for 219 days, presenting minor differences during this period. The files TA422 only has data after 6/4/02. The flow is intermittent and unidirectional (outflow). During the 1703 days of available data, 1311 days (77%) are "not-flowing" days, and 392 days are "flowing" (23.0%)

Table 15 shows the total cumulative inflows and outflows from water management structures into and out of the Loxahatchee Refuge. For the POR, the yearly average inflow to the Refuge is 579,038 acre-ft and the yearly average outflow is 576,141 acre-ft. For this long-term cumulative the total outflow is only 0.5% lower than the total inflow. The close balance between inflows and outflows through the water control structures, and the fact that the annual average rainfall and potential evapotranspiration (ETp) are similar (Abtew et al. 2005), indicates that water losses through seepage may not be significant in the long-term average scenario. The average annual rainfall in the entire region managed by the SFWMD is 52.8 inches, while the average ETp is reported to be 52.6 inches (Waldon 2005).

Table 15. Cumulative Inflows and Outflows to the Loxahatchee Refuge for the Period that Goes from January 1995 to December 2004. Flow Through Water Control Structures.

Structure	Type of Flow	Type of Flow	Operational Dates		Total Operative Days during the POR	Daily Average Flow (cfs)	Net Inflow Volume (Ac-ft)	Net outflow Volume (Ac-ft)
			Start	End				
S-5A	Pump Station	Inflow	1/1/1995	8/26/1999	1698	391.8	1,319,556	0
S-5AS	Spillway	Bidirectional	1/1/1995	6/7/1999	1618	112.8	0	362,004
G-300	Spillway	Bidirectional	8/26/1999	12/31/2004	1954	2.4	9,302	0
G-301	Spillway	Bidirectional	8/26/1999	12/27/2004	1950	28.4	109,845	0
G-310	Pump Station	Inflow	7/7/2000	12/31/2004	1638	411.0	1,335,308	0
G-251	Pump Station	Inflow	1/1/1995	12/31/2004	3652	118.6	859,095	0
S-6	Pump Station	Inflow	1/1/1995	5/15/2001	2326	398.6	1,838,963	0
S-10E	Culvert	Outflow	1/1/1995	12/31/2004	3652	33.4	0	241,937
G-338	Culvert	Inflow	1/1/1995	5/15/2001	2326	0.0	0	0
S-10D	Spillway	Outflow	1/1/1995	12/31/2004	3652	175.9	0	1,274,156
S-10C	Spillway	Outflow	1/1/1995	12/31/2004	3652	146.3	0	1,059,744
S-10A	Spillway	Outflow	1/1/1995	12/31/2004	3652	141.4	0	1,024,250
S-39	Spillway	Outflow	1/1/1995	12/31/2004	3652	184.7	0	1,337,900
S-362	Pump Station	Inflow	9/21/2004	12/31/2004	101	99.2	19,873	0
ACME # 1	Pump Station	Inflow	1/1/1995	12/31/2004	3652	21.4	155,014	0
ACME # 2	Pump Station	Inflow	1/1/1995	12/31/2004	3652	19.8	143,424	0
G-94C	Culvert	Bidirectional	1/1/1995	12/31/2004	3652	38.7*	0	280,329
G-94B	Culvert	Outflow	1/1/1995	12/31/2004	3652	4.7*	0	34,045
G-94A	Culvert	Outflow	1/1/1995	12/31/2004	3652	20.3*	0	147,046
					Total		5,790,380	5,761,411

* This value was extrapolated by the authors to the period that covers the structure operational dates (1/1/95 to 12/31/04), from the period of available data (4/15/00 to 12/31/04)

8. Procurement and Quality Assurance of Meteorological Data

8.1 Rainfall Data

Daily rainfall data are available at different locations inside and close to the Loxahatchee Refuge. There are five stations inside the Refuge: 5A, S-6, S-39, WCA1ME, LOXWS and one station located at the Everglades Nutrients Removal Project (ENRP) site, which is located adjacent to the northwestern boundary of the Refuge. These six rainfall measurements stations are operated by the SFWMD and Data are available from the DBHYDRO website. There are also ten additional rain gages located adjacent to the Refuge. Data for these stations were provided by USFWS's personnel. The location of the rainfall measurements stations is shown in Figure 11. Stations S-5A, S-6, and S-39 have daily average rainfall measurements since 1956, 1960 and 1963, respectively. The weather station WCA1ME has rainfall measurements since 1994, and weather stations LOXWS and ENRP have measurements since 1996. The aforementioned ten additional rain gages are located adjacent to the Refuge in Basin A and Basin B. Location of rain gages in Basin B (Gage 6 through Gage 10) is shown in Figure 11. Daily rainfall measurements from these gages are available since January 1997. Gage10 (PS-2) was added to this rain gage network in April 2000, and its daily rainfall Data are available since then.

Historical rainfall measurements at USGS water level monitoring sites 1-7, 1-8C, and 1-9 are also available at the DBHYDRO website. However, these rain gages are not currently in operation. Daily average rainfall data from these gages are available only for the period of 1960 to 1984.

Availability of rainfall data for the POR (1995-2004) is shown in Table 16. This table also includes the information about missing data along with start and end dates of available periods. A more detailed description of the rainfall missing data is presented in Appendix G.4.

Daily rainfall measurements from all these rain gages are plotted and presented in Appendix C. There are more than one time series of rainfall data available from stations S-39, S-5A, and S-6. Rainfall stations S-5A and S-6 have "PREF" time series files that will be used to estimate rain at those stations. Rainfall station S-39 has three time series files (6035, 16677, and K8674) that do not have a good agreement with each other. Time series 6035 and K8674 have better match with each other than with the time series file 16677. Thus, the time series files 6035 and K8674 will be used to estimate rainfall at S-39 station. Plots showing comparison of rainfall records for different time series are also presented in Appendix C.

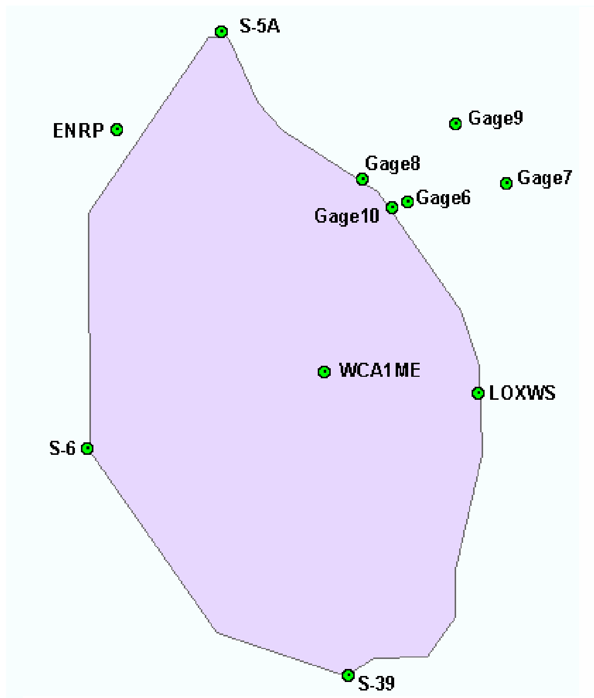

Figure 11. Location of Rain Gages and Weather Stations

Table 16. Available Rainfall Data

Station	Available Data										Available Data		Missing Data Days from Available Period	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
S-5A											1/1/1995	12/31/2004	0	0
S-6											1/1/1995	12/31/2004	0	0
S-39											1/1/1995	12/31/2004	32	7
STA1W											1/1/1995	9/30/2004	0	0
WCA1ME											2/12/1996	12/31/2004	640	359
LOXWS											12/31/1995	12/31/2004	216	85
Gage 1											1/1/1997	12/31/2004	0	0
Gage 2											1/1/1997	12/31/2004	0	0
Gage 3											1/1/1997	12/31/2004	0	0
Gage 4											1/1/1997	12/31/2004	0	0
Gage 5											1/1/1997	12/31/2004	0	0
Gage 6											1/1/1997	12/31/2004	0	0
Gage 7											1/1/1997	12/31/2004	0	0
Gage 8											1/1/1997	12/31/2004	0	0
Gage 9											1/1/1997	12/31/2004	0	0
Gage 10											4/1/2000	12/31/2004	0	0

Summary of rainfall measurements from all the rain gages is shown in Table 17. This table indicates that the average annual rainfall records from new gages (Gage 1 to Gage 9 in the table) are higher than the average annual rainfall from SFWMD's rain gages. Years with more than 30 days of missing data were not included in the calculation of the annual average rainfall. For years with less than 30 days missing, the total sum of rainfall was compared with nearby gages with complete data. If the total cumulative rainfall for the year with missing data was smaller than the nearby gages, then a decision was made to discard such a year from the calculation of the annual average of rainfall. An exception was made with the 1999 data for the LOXWS gage. For this year the gage has 48 days missing, but the total rainfall sum was higher than nearby gages and also the highest individual year value for the gage, and therefore it was included in the calculation without filling any missing day. In summary, annual average rainfall recorded from these new gages from the year 1997 to 2004 is 64.56 inches, whereas, average rainfall recorded from SFWMD's rain gages for the same period is 49.18 inches. The difference in annual rainfall measurements from these two different sources is about 15 inches, which is considerable. Such a large discrepancy must be addressed before the modeling efforts commence. Effort is underway to obtain RADAR rainfall estimates from the SFWMD. These estimates will be compared to the point gauge estimates and possibly used in the modeling effort. More discussion on this issue will be provided in subsequent reports.

In terms of seasonality, more rainfall seems to be occurring during the months June-October compared to the rest of the year. Maximum daily rainfall over the refuge was recorded on October 15, 1999. On that day, most rain gages recorded about 8 inches of rainfall, whereas stations S-39 and S-5A recorded less than 2 inches of rain.

Table 17. Summary of Available Rainfall Data.

Station	Available Time Series	Selected Time Series	Maximum Daily (inch)	Maximum Monthly (inch)	Minimum Monthly (inch)	Annual Average (inch)
S5A	5895, 16176, 15202, 16645, K8682	15202	7.18	17.48	0.00	53.04
S6	15203, 16202, 16651, K8685	15203	6.36	16.78	0.01	48.74
S39	6035, 16677, K8674	6035+K8674	6.66	15.24	0.00	49.77
LOXWS	DU551	DU551	9.46	22.68	0.01	49.55
WCA1ME	DU517	DU517	8.35	18.33	0.00	51.28
STA1W	KN809, J5744	KN809+J5744	6.88	17.88	0.03	47.76
Gage1	Shop (Basin A)		8.60	24.89	0.25	65.74
Gage2	Water Plant (Basin A)		10.68	23.59	0.14	65.50
Gage3	PS-3 (Basin A)		8.80	18.80	0.02	63.78
Gage4	PS-4 (Basin A)		8.30	20.90	0.05	61.45
Gage5	PS-5 Lift Sta. (Basin A)		8.30	21.10	0.13	66.82
Gage6	Sth. Shore Sth. End (Basin B)		8.40	19.11	0.00	66.11
Gage7	Wells @ Homeland (Basin B)		8.52	22.81	0.00	64.73
Gage8	PS-1 (Basin B)		8.20	16.22	0.05	61.12
Gage9	Sewer Plant (Basin B)		9.88	22.86	0.15	65.86
Gage10	PS-2 (Basin B)		5.55	16.51	0.00	59.31

8.2 Evaporation and Potential Evapotranspiration Data

Evapotranspiration (ET) data for the Refuge are available from the ENRP (STA-1W) site. Also, pan evaporation and potential evapotranspiration are available from stations S-5A and LOXWS, respectively. The location of these stations is shown in Figure 11, and the availability of data is summarized in Table 18. A more detailed description of the evaporation and ET missing data is presented in Appendix G.5. Time series of evaporation and ET measurements are included in Appendix D. A comparison between ET measurements from STA-1W and potential ET from weather station LOXWS is also included in this Appendix. This comparison shows that, in general, potential ET estimated from LOXWS is less than ET measurements from STA-1W.

Figure 12 shows the ET's seasonal variation estimated from STA-1W for the POR. As can be observed in this figure, ET is higher during the months of March to August (with values higher than 4.5 inches), reaching a peak of about 6 inches in May. A regional evaluation of ET in the everglades conducted by German (2000) presented similar results to those shown in Figure 12. Annually, the average ET from the STA-1W station for the POR is equal to 52 inches, which is almost equal to the annual average rainfall from SFWMD's rain gages.

Table 18. Available Evaporation and Evapotranspiration Data

Station	Available Data										Available Data		Missing Data Days from Available Period	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
Pan Evaporation														
S5A											1/1/1995	12/31/2004	1107	30
Evapotranspiration														
STA1W											1/1/1995	12/31/2004	0	0
Potential Evapotranspiration														
LOXWS											1/1/1995	10/31/2004	807	106

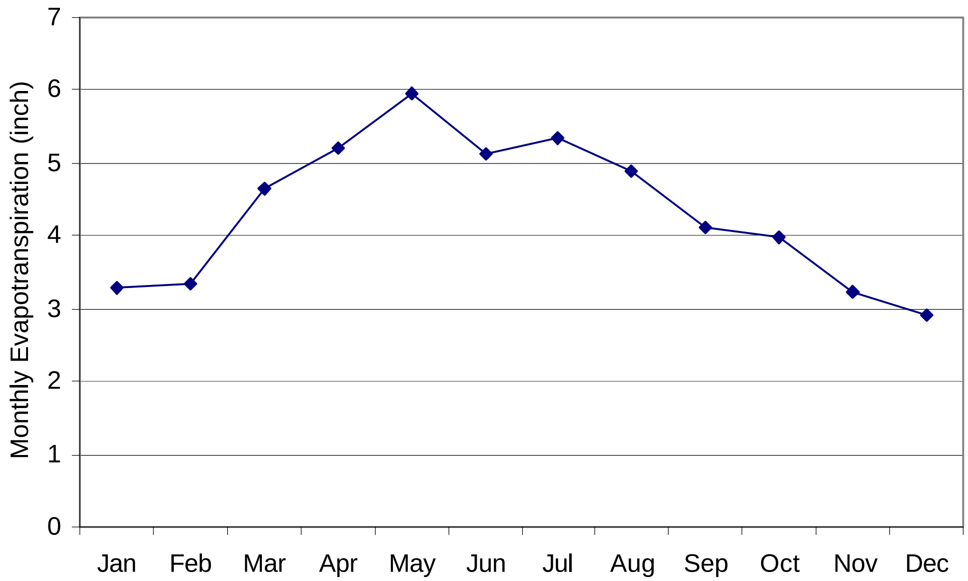

Figure 12. Seasonal Variation of ET Estimated at STA1W

8.3 Air Temperature Data

Air temperature data for the Refuge are available from weather station LOXWS (see Figure 11). The available data covers the complete POR; however, there are 320 days of missing data from which 85 days are continuous. A detailed description of the air temperature missing data is presented in Appendix G.6. It should be noted that there were five days with temperature equal to 0ºC that were converted to missing data. Figure 13 shows the temperature time series from station LOXWS including the missing and zero-temperature days. Excluding the five days with temperature equal to 0ºC, the daily temperatures range between 7°C to 30°C, with an annual average of 23.4 °C for the POR.

Figure 14 shows the seasonal variation of air temperature observed at LOXWS for the POR. As can be observed in this figure, air temperature is higher during the months of May to October (with values close or higher than 25°C), reaching a peak of about 27.3°C in August. For the POR, the monthly average temperature ranges from 17.8°C to 27.3°C.

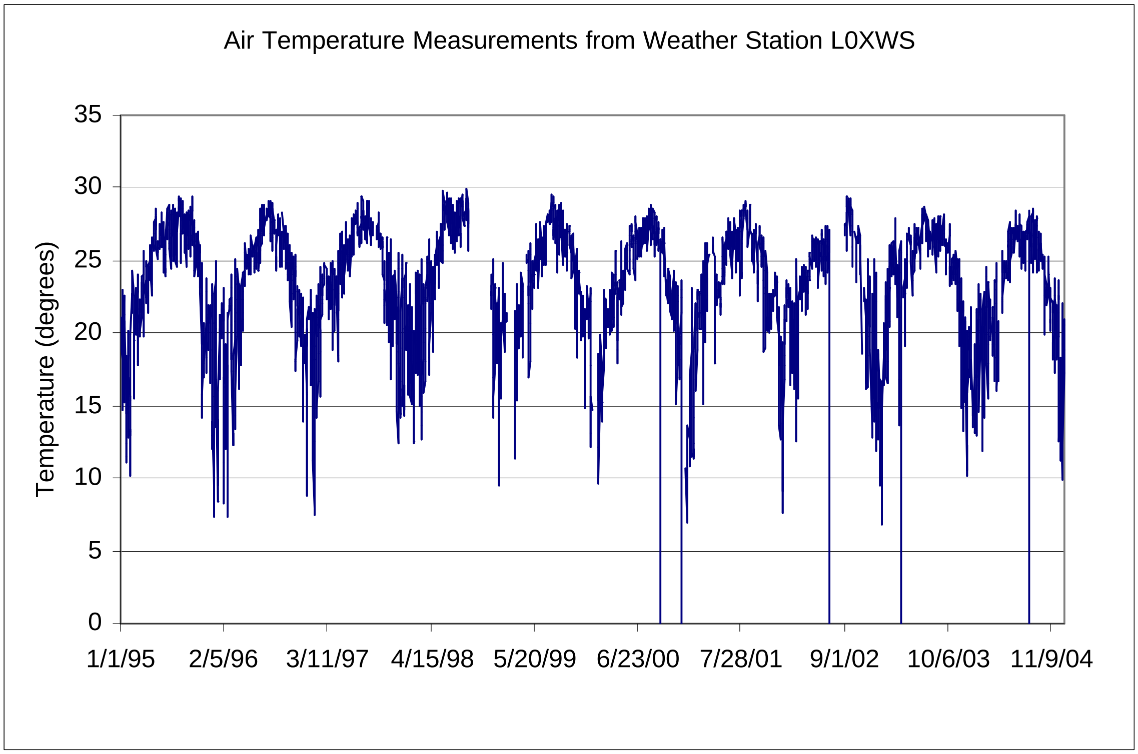

Figure 13. LOXWS Air Temperature

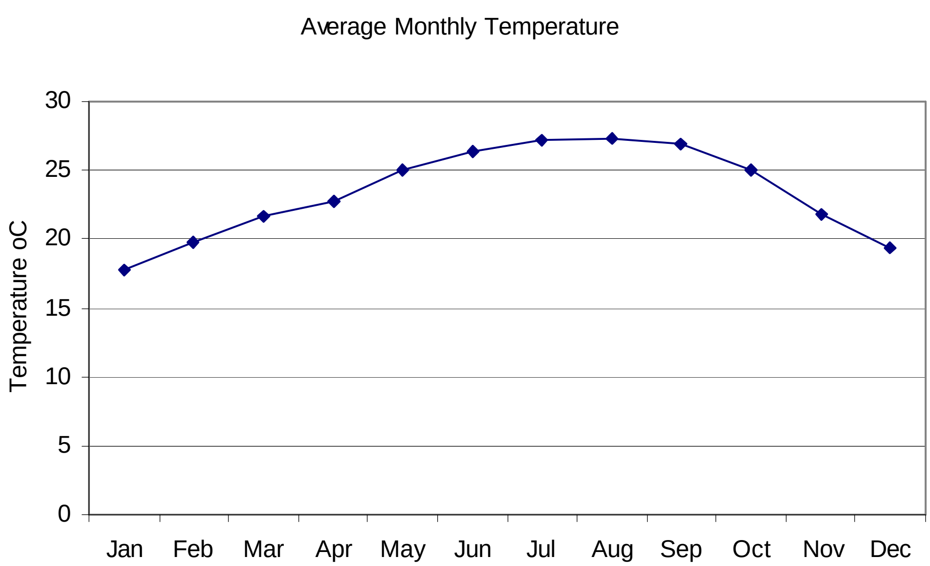

Figure 14. Average Monthly Temperature from 1995 to 2004 Observed at Weather Station LOXWS.

8.4 Wind Data

Wind speed data for the Refuge are available from weather stations LOXWS and ENR308 from the DBHYDRO website. For these sites, wind speed data are available for the complete POR, but there is not information about wind direction. The ENR308 site is a weather station located at the Everglades Nutrients Removal Project (ENRP), which is located adjacent to the northwestern boundary of the Refuge. Station S-5A also has wind speed measurements, but it covers only until August 1998, and wind direction data are also not available. Wind speed and wind direction data are available at three USGS stations located close to the Refuge, but data for two of these stations are only available for 1996 and 1997. The other USGS station has data for the period of January 1996 to September 1999. There is a fourth USGS station close to the Refuge, but the wind data are missing. More information about the USGS stations is presented in German (2000). Additional to the data of the aforementioned stations, wind direction along with wind speed data were obtained from the National Climatic Data Center (NCDC). The Local Climatological Data for the NCDC are collected at the West Palm Beach International Airport (PBI). The location of the wind stations is shown in Figure 15, and Table 19 summarizes the availability of wind data.

Table 19. Available Wind Data

Station	Available Data										Available Data		Missing Data Days from Available Period	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Start Date	End Date	Total	Continuous
Wind Speed														
ENR308											1/1/95	9/25/04	1	1
LOXWS											1/1/95	12/31/04	253	85
S-5A											1/1/95	8/31/98	29	29
PBI											1/1/95	12/31/04	4	1
USGS-1											1/1/96	12/31/97	17	13
USGS-2											---	---		
USGS-3											1/1/96	12/31/97	58	58
USGS-4											1/1/96	9/30/99	97	21
Wind Direction														
West Palm Beach International Airport (PBI)														
PBI											12/31/95	12/31/04	7	2
USGS-1											1/1/96	12/31/97	15	13
USGS-2											---	---		
USGS-3											1/1/96	12/31/97	0	0
USGS-4											1/1/96	9/30/99	97	21

A more detailed description of wind missing data is presented in Appendix G.7.

Plots of the available wind speed and wind direction dara are presented in Appendix E. For the POR, the average wind speed for stations ENR308 and LOXWS are 6.97 and 6.59 mile/hour, respectively. The maximum recorded daily average wind speed for these stations are 36.87 and 38.59 mile/hour respectively. The maximum wind speed at ENR308 was recorded on September 4, 2004, where the maximum wind speed at LOXWS was observed on March 01, 2001. Average S-5A wind speed from 1995 to 1998 is 4.67 mile/hour, which is lower than wind speed from the other weather stations. The average wind speed for the USGS stations 1, 3 and 4 (see Figure 15) are 3.78, 4.67 and 4.68 mile/hour, respectively.

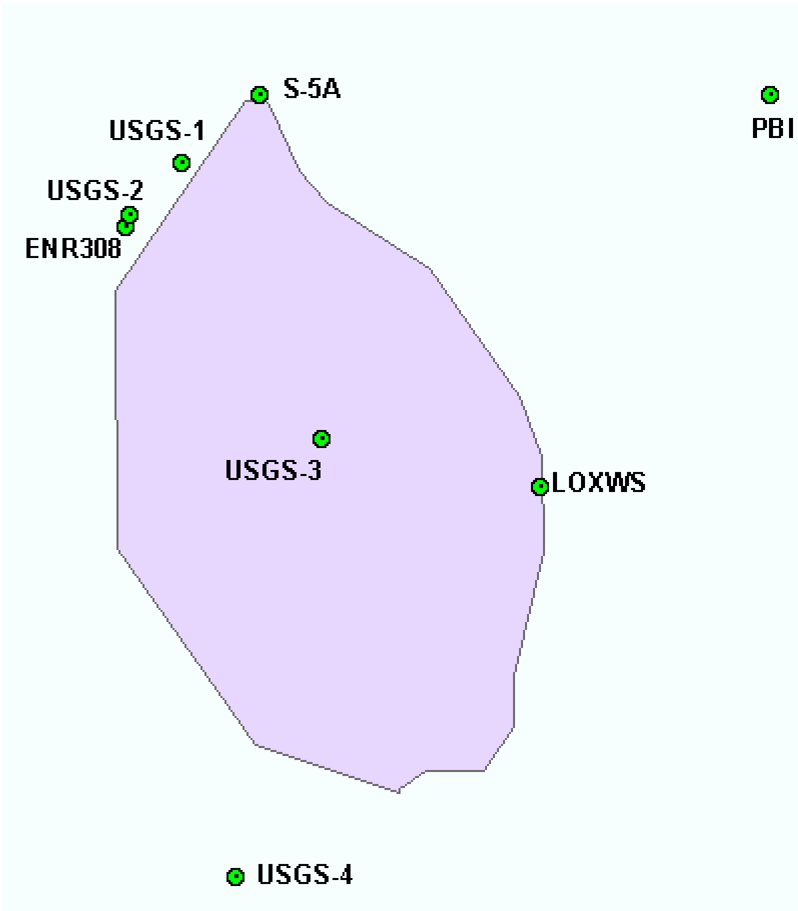

Figure 15. Location of Wind Stations

9. Procurement and Quality Assurance of Water Quality Data

9.1 Water Quality Data

Water quality data for the Loxahatchee Refuge are available from five different sources: 1) the Everglades Protection Area (EVPA) water quality monitoring sites, 2) the "Enhanced" water quality monitoring sites, 3) the District Transect monitoring sites or XYZ data, 4) the water quality monitoring sites located at the hydraulic structures, and 5) additional independent monitoring sites. Water quality data for groups 1, 2, 4 and 5 can be downloaded from the SFWMD's DBHYDRO database, and the XYZ data can be requested from the SFWMD.

There are fourteen Everglades Protection Area (EVPA) water quality monitoring sites inside the Refuge marsh that were active during the period of study. These water quality stations were designed to monitor the physical, chemical and biological quality of the Refuge. Table 20 shows some of the water quality parameters that are measured in the EVPA stations, and Figure 16 shows the location of these monitoring sites. Most of the water quality variables are sampled and reported monthly; however, not all the parameters are measured at the same frequency. The sampling frequency of water quality monitoring stations is irregular. The current SFWMD monitoring programs are described by Germain (1998). According to Weaver and Payne (2004) the sampling frequency in the SFWMD monitoring stations varies by site depending on site classification, variable group, and hydrologic conditions. More than ten years of water quality data can be retrieved from the SFWMD's DBHYDRO database. It should be noted that water quality data at inflow and outflow control structures are typically sampled biweekly when flowing and monthly otherwise.

Table 20. DBHYDRO Variable Names and Description for Water Quality Parameters Measured at e EVPA Water Quality Monitoring Site.

Variable	Description	Variable	Description
ALKA	ALKALINITY, TOT, CACO3	SIO2	SILICA
APA	ALKALINE PHOSPHATASE	SO4	SULFATE
CA	CALCIUM	TDKN	KJELDAHL NITROGEN, DIS
CL	CHLORIDE	TDORC	CARBON, DISSOLVED ORGANIC
COLOR	COLOR	TDPO4	PHOSPHATE, DISSOLVED AS P
DO	DISSOLVED OXYGEN	TDS	TOTAL DISSOLVED SOLIDS
HARD	HARDNESS AS CACO3	TEMP	TEMP
LCOND	SP CONDUCTIVITY, LAB	TORGC	CARBON, TOTAL ORGANIC
MG	MAGNESIUM	TOTAL	ALUMINUM, TOTAL
NH4	AMMONIA-N	TOTCD	CADMIUM, TOTAL
NO2	NITRITE-N	TOTCU	COPPER, TOTAL
NO3	NITRATE-N	TOTHG	MERCURY, TOTAL
OPO4	PHOSPHATE, ORTHO AS P	TOTZN	ZINC, TOTAL
PH	PH, FIELD	TPO4	PHOSPHATE, TOTAL AS P
SALIN	SALINITY	TSS	TOTAL SUSPENDED SOLIDS
SCOND	SP CONDUCTIVITY, FIELD	TURBI	TURBIDITY

It is important to note that care must be taken while interpreting some of the variable names and descriptions in DBHYDRO. TPO4 and TDPO4, for example, are respectively total phosphorus and total dissolved phosphorus as mg/L of phosphorus (not simply phosphate and not as phosphate mass).

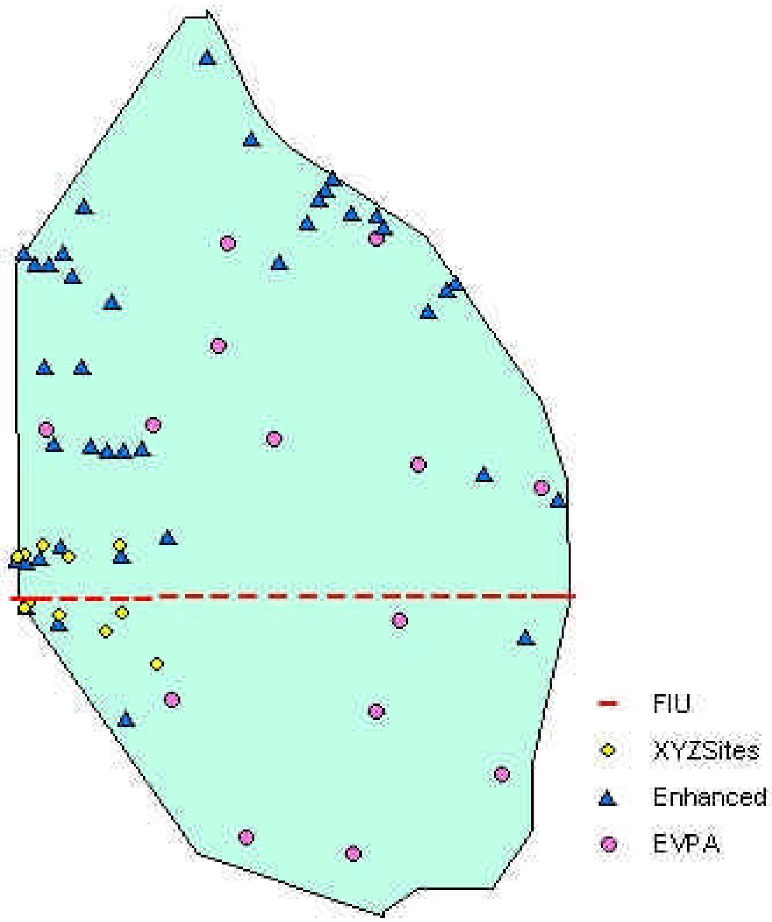

Figure 16. Location of Water Quality Monitoring Sites Inside the Refuge.

9.2 Total Phosphorus Data – EVPA Stations

Based on the selected POR, total phosphorus (TP), and chloride (Cl) were retrieved from the DBHYDRO database for the 14 EVPA monitoring sites, i.e., stations LOX3 to LOX16. Figure 17 shows the location of the EVPA stations. The TP time series for each station are included in Appendix F1. For the POR, the sample size (number of data points available) varies between 65 and 122, the arithmetic averages of measured TP concentrations vary between 7.3 and 11.8 μg/L, and the geometric means between 6.6

and 10.1 μg/L. The TP mean concentration for all the EVPA sites together is between 9.2 and 9.0 μg/L (the uncertainty in this estimate is due to several values that were reported to be less than the limit-of-detection). Table 21 indicates, for each EVPA site, the arithmetic average, the geometric mean, the maximum and the minimum reported value, the sample size, and the start and end dates of the available data (all this information is according to the selected POR). This table also summarizes the major observations to the data and the modifications it underwent after the quality assurance checks.

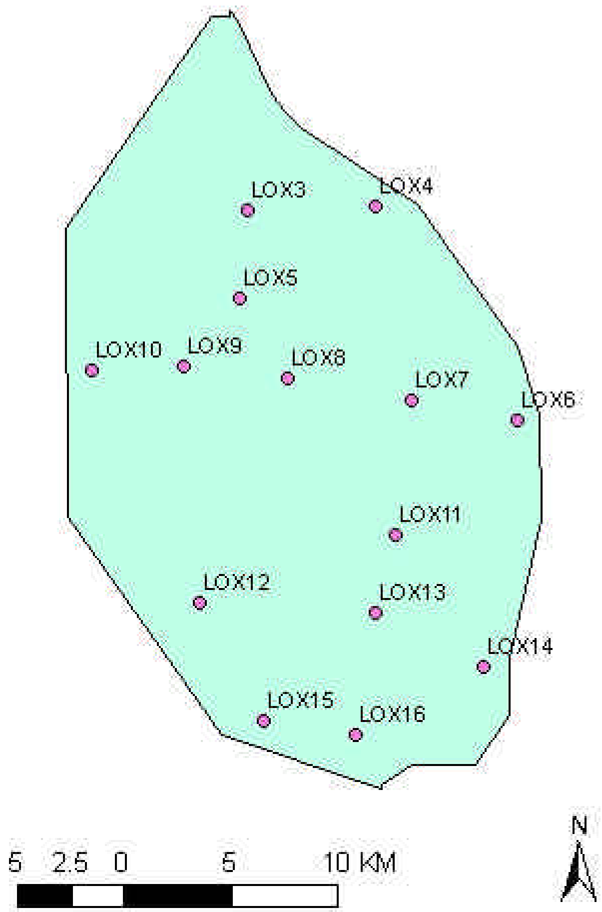

Figure 17. Location of the EVPA Water Quality Monitoring Sites

Table 21. Summary of Total Phosphorus Data Information for the EVPA Stations

Station	Available Data		Study Period		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End	Start	End			Average*	Geometric Mean*	Maximum	Minimum	
LOX3	1/11/1995	12/13/2004	1/1/1995	12/31/2004	65	Irregular	11.8 - 11.7	10.1-9.9	50.0	4.0	Two values were reported to be less than the limit-of-detection (LOD). These values were reported equal to -4µg/L on 11/13/95 and 1/10/96. The geometric mean of measured P concentrations for this station equals the total phosphorus criterion (10 µg/L). This station reports the highest arithmetic average and geometric mean of measured P concentrations
LOX4	1/11/1995	12/13/2004	1/1/1995	12/31/2004	80	Irregular	11.2	9.9-9.8	54.0	4.0	A value was reported to be less than the LOD. This value was reported equal to -4µg/L reported on 11/12/96. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX5	1/11/1995	11/15/2004	1/1/1995	12/31/2004	80	Irregular	10.7-10.6	9.3-9	80.0	5.0	Four values were reported to be less than the LOD. These values were reported equal to -4µg/L on 10/16/95, 6/10/96, 7/8/96 and 11/12/96. The maximum value equal to 80 µg/L is particularly high, it corresponds to an "extreme event" that occurred on 2/8/95. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX6	1/11/1995	12/14/2004	1/1/1995	12/31/2004	112	Irregular	8.1-7.9	7.3-7.0	44.0	4.0	Eight values were reported to be less than the LOD. These values were reported as -4µg/L. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX7	1/11/1995	12/13/2004	1/1/1995	12/31/2004	110	Irregular	8.9-8.8	8.4-8.1	19.0	4.0	Four values were reported to be less than the LOD. These values were reported as -4µg/L on 11/13/95, 4/15/96, 3/3/97 and 6/10/97. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX8	1/11/1995	12/13/2004	1/1/1995	12/31/2004	113	Irregular	9.1-9.0	8.4-8.1	26.0	4.0	Six values were reported to be less than the LOD. These values were reported as -4µg/L. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX9	1/11/1995	12/13/2004	1/1/1995	12/31/2004	88	Irregular	8.8-8.7	8.1-7.9	25.0	4.0	Four values were reported to be less than the LOD. These values were reported as -4µg/L on 9/18/95, 11/13/95, 6/10/96 and 7/8/96. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)

For these stations all the samples were collected as grab samples

*The upper limits of the average and geometric means were calculated replacing the negative values in the time series by the limit-of-detection (LOD), and the lower limits were calculated replacing the negative values by half the LOD. A negative value is the convention used by the SFWMD to report values when are less than the LOD. The LOD is the absolute value of the number reported.

Cont. Table 21. Summary of Total Phosphorus Data Information for the EVPA Stations

Station	Available Data Start	Available Data End	Study Period Start	Study Period End	Sample Size (number)	Sampling Frequency	Data Information (µg/L) Average*	Geometric Mean*	Maximum	Minimum	Observations/Modifications to Data
LOX10	1/11/1995	12/13/2004	1/1/1995	12/31/2004	79	Irregular	9.4-9.3	8.7-8.5	23.0	4.0	Two values were reported to be less than the LOD. These values were reported as -4µg/L on 6/10/96 and 3/3/97. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX11	1/12/1995	12/14/2004	1/1/1995	12/31/2004	108	Irregular	9.5	8.9-8.7	22.0	4.0	Three values were reported to be less than the LOD. These values were reported as -4µg/L on 12/122/95, 7/9/96 and 3/4/97. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX12	1/12/1995	12/14/2004	1/1/1995	12/31/2004	122	Irregular	8.6-8.5	7.7-7.5	47.0	4.0	Four values were reported to be less than the LOD. These values were reported as -4µg/L on 10/18/95, 12/12/95, 2/6/96 and 2/4/97. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX13	1/12/1995	12/14/2004	1/1/1995	12/31/2004	104	Irregular	9.6-9.5	8.7-8.5	35.0	4.0	Four values were reported to be less than the LOD. These values were reported as -4µg/L on 9/19/95, 12/12/95, 11/12/96 and 3/4/97. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX14	1/12/1995	12/14/2004	1/1/1995	12/31/2004	116	Irregular	8.2-8.1	7.6-7.5	20.0	4.0	Three values were reported to be less than the LOD. These values were reported as -4µg/L on 10/16/96, 3/4/97 and 2/4/98; and a value was reported as -2 µg/L on 11/6/01. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
LOX15	1/12/1995	12/14/2004	1/1/1995	12/31/2004	118	Irregular	7.4-7.3	6.9-6.6	35.0	2.0	Seven values were reported to be less than the LOD. These values were reported as -4µg/L. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 µg/L). This station reports the lowest arithmetic average and geometric mean of measured P concentrations
LOX16	1/12/1995	12/14/2004	1/1/1995	12/31/2004	113	Irregular	9.5	8.5-8.4	78.0	4.0	Two values were reported to be less than the LOD. These values were reported as -4µg/L on 1/12/95 and 12/14/04. The maximum value equal to 78 µg/L is particularly high, it correspond to an "extreme event" that occurred on 5/16/95. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion

For these stations all the samples were collected as grab samples

*The upper limits of the average and geometric means were calculated replacing the negative values in the time series by the limit-of-detection (LOD), and the lower limits were calculated replacing the negative values by half the LOD. A negative value is the convention used by the SFWMD to report values when are less than the LOD. The LOD is the absolute value of the number reported.

9.3 Total Phosphorus Data – "ENHANCED" Stations

There are thirty nine "Enhanced" stations inside the Loxahatchee Refuge. However, data for these stations are only available after June 2004, and the number of data points available for TP varies between just 4 and 7. The location of the "Enhanced" monitoring sites is shown in Figure 18. The arithmetic averages for the enhanced sites range from 7.8 to 188.4 μg/L, and the geometric means from 7.4 to 138 μg/L. The TP mean concentration for all the enhanced sites together is 49.9 μg/L. The high values of the means and their wide ranges are related to the fact that some of the sites are located close to the rim canal, and are affected by the penetration of canal water into the marsh. Table 22 shows a summary of the TP data for the enhanced sites, and also the major observations and modifications to these data.

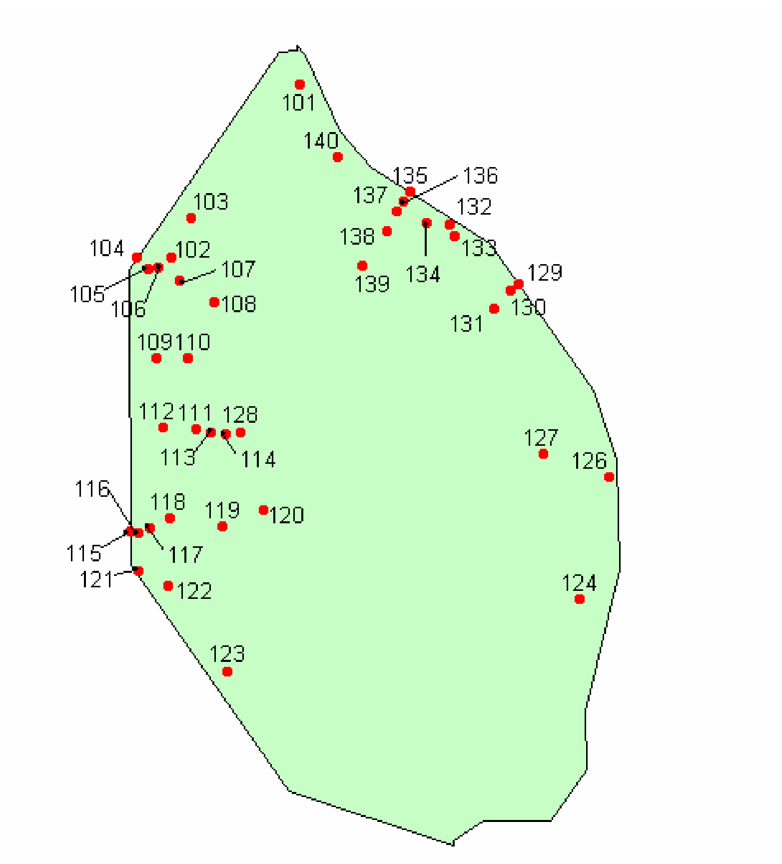

Figure 18. Location of the "Enhanced" Water Quality Monitoring Sites

Table 22. Summary of Total Phosphorus Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA101	9/15/2004	12/7/2004	4	Irregular	23.3	26.8	53.0	14.0	This station is located about 1.5 miles south of S5A pump station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA102	9/15/2004	12/7/2004	4	Irregular	13.0	12.8	15.0	10.0	This station is located about 1.5 miles northeast of G310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA103	9/15/2004	12/7/2004	4	Irregular	13.0	12.5	19.0	9.0	This station is located about 2 miles northeast of G310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA104	6/8/2004	12/9/2004	7	Irregular	103.3	71.1	237.0	22.0	This station is located in the L-7 Canal, about 0.5 mile north of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA105	9/15/2004	12/9/2004	4	Irregular	84.5	52.7	232.0	23.0	This station is located close to the L-7 Canal, about 0.5 mile northeast of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA106	9/15/2004	12/9/2004	4	Irregular	20.0	15.1	48.0	7.0	This station is located close to the L-7 Canal, about 0.6 mile east of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA107	8/3/2004	12/8/2004	5	Irregular	10.8	10.4	16.0	7.0	This station is located about 1.5 miles southeast of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA108	8/2/2004	12/7/2004	5	Irregular	10.6	10.0	17.0	6.0	This station is located about 3.0 miles southeast of G 310 pumping station. The geometric mean of measured P concentrations for this station equals the total phosphorus criterion (10 µg/L).
LOXA109	8/3/2004	12/8/2004	5	Irregular	12.4	11.5	22.0	8.0	This station is located about 3.0 miles south-southeast of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA110	8/3/2004	12/8/2004	5	Irregular	11.8	11.2	17.0	7.0	This station is located about 3.1 miles south-southeast of G 310 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).

For these stations all the samples were collected as grab samples

Cont. Table 22. Summary of Total Phosphorus Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA111	8/3/2004	12/8/2004	5	Irregular	9.0	8.7	13.0	6.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 mg/L).
LOXA112	8/3/2004	12/8/2004	5	Irregular	11.6	11.3	15.0	8.0	This station is located between LOXA111 and the L-7 canal. the geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 mg/L).
LOXA113	6/8/2004	12/8/2004	6	Irregular	9.0	8.7	14.0	7.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion (10 mg/L).
LOXA114	6/8/2004	12/8/2004	7	Irregular	13.9	11.9	33.0	6.0	This is an interior station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 mg/L).
LOXA115	6/8/2004	12/9/2004	7	Irregular	88.1	66.6	200.0	26.0	This station is located in the L-7 Canal, about 1 mile north of S-6 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA116	8/3/2004	12/9/2004	5	Irregular	85.0	70.7	199.0	38.0	This station is located close to the L-7 Canal, about 1.2 miles north of S-6 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA117	8/3/2004	12/9/2004	5	Irregular	17.4	17.1	22.0	13.0	This station is located close to the L-7 Canal, about 1.3 miles northeast of S-6 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA118	6/8/2004	12/9/2004	6	Irregular	8.8	8.1	18.0	6.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion
LOXA119	6/8/2004	12/9/2004	7	Irregular	10.1	9.4	19.0	6.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion
LOXA120	6/8/2004	12/9/2004	6	Irregular	9.0	8.5	16.0	6.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion

For these stations all the samples were collected as grab samples

Cont. Table 22. Summary of Total Phosphorus Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA121	8/3/2004	12/9/2004	4	Irregular	106.8	88.9	179.0	32.0	This station is located close to L-39 canal, about 0.5 mile south of the S-6 pumping stations. The geometric mean of measured P concentrations greatly exceeds the TP criterion
LOXA122	8/3/2004	12/9/2004	5	Irregular	12.4	12.1	17.0	10.0	This station is located 1 mile southeast of S-6 pumping station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion
LOXA123	8/3/2004	12/9/2004	5	Irregular	15.0	14.1	25.0	8.0	This station is located 3 miles northwest of S-10D structure. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion
LOXA124	9/14/2004	12/7/2004	4	Irregular	62.5	39.1	151.0	15.0	This station is located close to the L-40 canal, about 1 mile northwest of the G-94A structure. The geometric mean of measured P concentrations greatly exceeds the TP criterion
LOXA125	---	---	---	---	---	---	---	---	---
LOXA126	8/2/2004	12/7/2004	5	Irregular	13.4	10.9	33.0	6.0	This station is located close to the L-40 canal, about 0.3 miles west of the Refuge boat ramp. The geometric mean of measured P concentrations for this station exceeds the TP criterion
LOXA127	8/2/2004	12/7/2004	5	Irregular	13.0	11.2	27.0	6.0	This station is located about 1.2 miles west of the Refuge boat ramp. The geometric mean of measured P concentrations for this station exceeds the TP criterion
LOXA128	8/3/2004	12/9/2004	5	Irregular	12.4	11.3	21.0	7.0	This is an interior station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA129	6/7/2004	12/7/2004	7	Irregular	158.1	112.9	499.0	58.0	This station is located in the L-40 canal, about 1 mile south ACME 2 pumping stations. The geometric mean of measured P concentrations for this station greatly exceeds the TP criterion
LOXA130	9/14/2004	12/7/2004	4	Irregular	73.5	39.0	212.0	11.0	This station is located close to the L-40 canal, about 2.7 miles northwest of the G-94C structure. The geometric mean of measured P concentrations for this station greatly exceeds the TP criterion

For these stations all the samples were collected as grab samples

Cont. Table 22. Summary of Total Phosphorus Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA131	9/14/2004	12/7/2004	4	Irregular	7.8	7.4	10.0	5.0	This is an interior station. The geometric mean of measured P concentrations for this station does not exceed the total phosphorus criterion
LOXA132	6/7/2004	12/7/2004	7	Irregular	170.4	116.1	574.0	64.0	This station is located in the L-40 canal, below the ACME 1 pump station. This station shows the second highest geometric mean of measured P concentrations (116.1 µg/L)
LOXA133	9/14/2004	12/7/2004	4	Irregular	165.5	138.0	322.0	65.0	This station is located close to the L-40 canal, 0.5 miles southwest of the ACME 1 pump station.
LOXA134	9/14/2004	12/7/2004	4	Irregular	72.3	42.0	216.0	23.0	This station is located 1 mile west of the ACME 1 pump station, close to L-40 canal
LOXA135	6/7/2004	12/8/2004	7	Irregular	188.4	127.6	653.0	53.0	This station is located in the L-40 canal, about 1 mile northwest of the ACME 1 pump station. This station shows the highest geometric mean of measured P concentrations (127.6 µg/L) and the maximum measured value for all the stations (653 µg/L).
LOXA136	9/14/2004	12/8/2004	4	Irregular	108.3	86.3	238.0	40.0	This station is located close to the L-40 canal, about 1.2 miles northwest of the ACME 1 pump station.
LOXA137	9/14/2004	12/8/2004	4	Irregular	30.5	26.8	57.0	14.0	This station is located 1.4 miles northwest of the ACME 1 pump station.
LOXA138	9/14/2004	12/8/2004	4	Irregular	13.0	12.6	18.0	10.0	This is an interior station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA139	9/14/2004	12/8/2004	4	Irregular	12.0	11.7	14.0	8.0	This is an interior station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).
LOXA140	9/15/2004	12/8/2004	4	Irregular	21.8	19.9	31.0	13.0	This station is located close to the L-40 canal, about 4 miles southeast of the S-5A pump station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 µg/L).

For these stations all the samples were collected as grab samples

9.4 Total Phosphorus Data – XYZ Stations

There are eleven "XYZ" stations associated with the Loxahatchee Refuge, two canal stations (X0 and Z0) and nine marsh stations (X1, X2, X3, X4, Y4, Z1, Z2, Z3, Z4). The location of the "XYZ" stations is shown in Figure 19, and the TP time series for each station are included in Appendix F2. According to the SFWMD (2000) these stations were established along a nutrient gradient in the southwestern corner of the Refuge (see Figure 19) for biological and chemical sampling. Data for these stations are available from April 1996. The sample size for these sites varies between 107 and 142 values per site, for the POR. Arithmetic means of TP concentrations during the period of record range between 9.0 and 56.5 μg/L, and the geometric means vary between 8.1 and 49.9 μg/L. The highest concentration values correspond to canal water, and it declines as the distance from the rim canal increases. Figure 20 and 21 shows the variation in the TP arithmetic and geometric means, respectively, with respect to the distance from the rim canal. In both cases, the TP concentration steadily decreases as the distance from the canal increases until about 1.5 Km, where the TP values become almost constant at about 10 μg/L and independent of the distance from the canal.

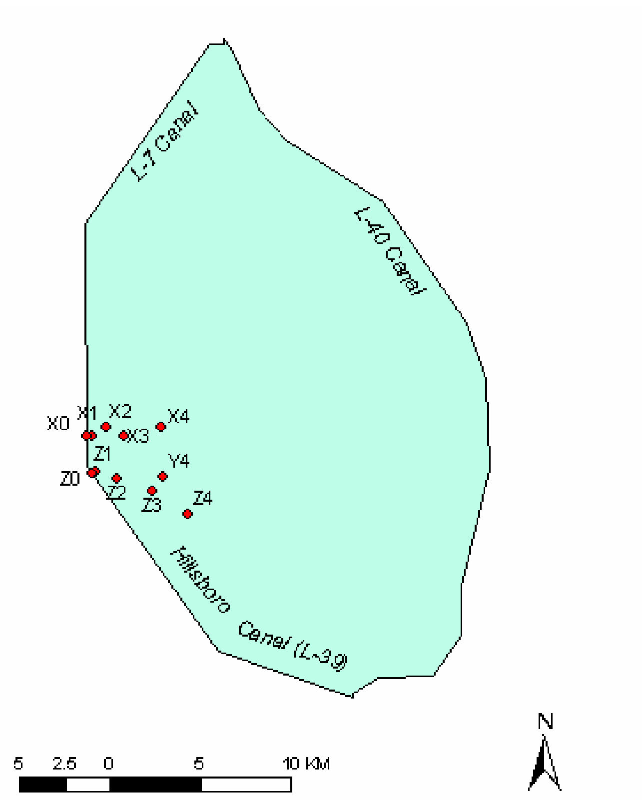

Figure 19. Location of the "XYZ" Water Quality Monitoring Sites

Table 23 shows a summary of the TP data for the "XYZ" sites, and also the major observation and modifications to these data.

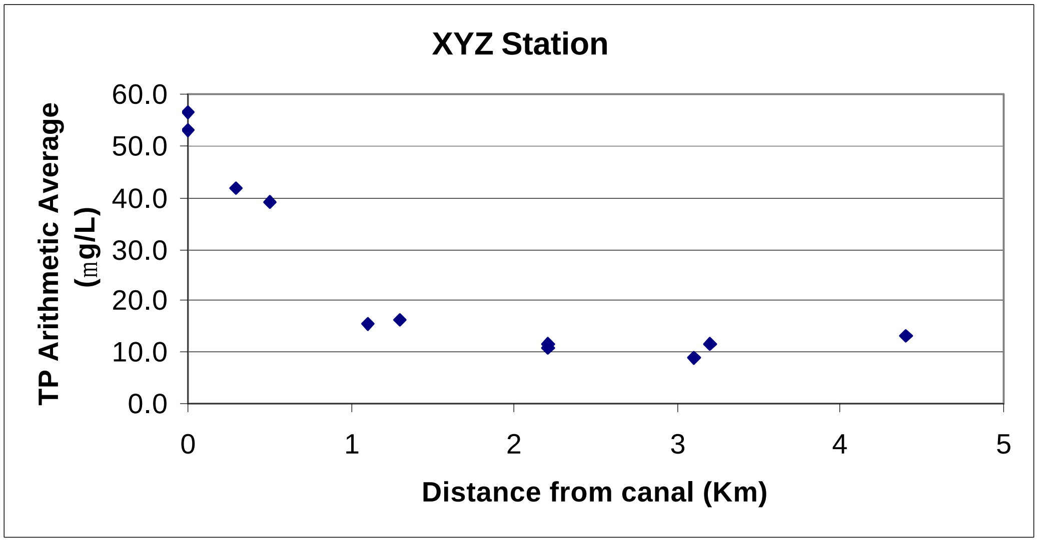

Figure 20. TP Arithmetic Means at Refuge Transect Stations with Increasing Distance from the Rim Canal

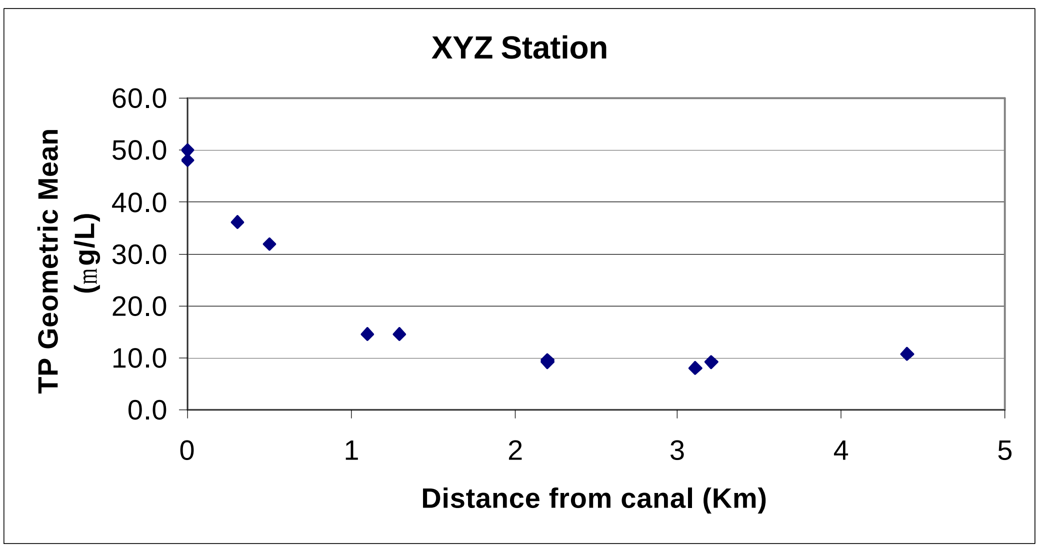

Figure 21. TP Geometric Means at Refuge Transect Stations with Increasing Distance from the Rim Canal

Table 23. Summary of Total Phosphorus Data Information for the District Transect Monitoring Sites ("XYZ" Stations)

Station	Available Data*		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
X0	5/9/1996	12/14/2004	107	Irregular	53.0	48.0	230.0	22.0	This location is located in the L-7 canal, about 1.4 Km north of the S-6 pump station. The maximum value equal to 230 µg/L corresponds to an "extreme event" on 10/19/99. Besides this value, the maximum measured TP concentration is 140 µg/L.
X1	4/24/1996	12/14/2004	122	Irregular	39.0	32.0	200.0	6.0	This station is located 0.5 Km from the L-7 canal, about 1.59 Km north of the S-6 pump station. The geometric mean of measured TP concentrations for this station exceeds the total phosphorus criterion (10 µg/L)
X2	4/24/1996	12/14/2004	127	Irregular	16.3	14.7	78.0	4.0	This station is located 1.3 Km from the L-7 canal, about 2.26 Km north-northeast of the S-6 pump station. The geometric mean of measured TP concentrations for this station exceeds the total phosphorus criterion (10 µg/L)
X3	4/24/1996	12/14/2004	124	Irregular	11.5	9.8	74.0	4.0	This station is located 2.2 Km from the L-7 canal, about 2.59 Km northeast of the S-6 pump station. The geometric mean of measured TP concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
X4	4/24/1996	12/14/2004	136	Irregular	13.1	10.9	130.0	5.0	This station is located 4.4 Km from the L-7 canal, about 4.69 Km northeast of the S-6 pump station. The maximum measured TP concentration reported as 130 mg/L corresponds to an "extreme event" on 3/25/97. Besides this value, the maximum TP concentration is 41 mg/L. The geometric mean of measured TP concentrations for this station exceeds the total phosphorus criterion
Y4	4/25/1996	12/14/2004	133	Irregular	11.8	9.3	110.0	4.0	This station is located 3.2 Km from the L-7 canal, about 4.38 Km east of the S-6 pump station. The geometric mean of measured TP concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)

For these stations all the samples were collected as grab samples

*There are not data reported between 10/15/2002 and 5/13/2003

Cont. Table 23. Summary of Total Phosphorus Data Information for the District Transect Monitoring Sites ("XYZ" Stations)

Station	Available Data*		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
Z0	5/9/1996	12/14/2004	121	Irregular	56.5	49.9	290.0	19.0	This location is located in the L-39 canal, about 0.69 Km east-southeast of the S-6 pump station. The maximum value equal to 290 µg/L corresponds to an "extreme event" on 10/19/99. Besides this value, the maximum measured TP concentration is 150 µg/L.
Z1	4/25/1996	12/14/2004	132	Irregular	41.8	36.2	180.0	11.0	This station is located 0.3 Km from the L-39 canal, about 0.69 Km east-southeast of the S-6 pump station. The maximum value equal to 180 µg/L corresponds to an "extreme event" on 6/15/04. The geometric mean of measured TP concentrations for this station exceeds the total phosphorus criterion (10 µg/L)
Z2	4/25/1996	12/14/2004	119	Irregular	15.5	14.5	44.0	6.0	This station is located 1.1 Km from the L-39 canal, about 1.94 Km east-southeast of the S-6 pump station. The geometric mean of measured TP concentrations for this station exceeds the total phosphorus criterion (10 µg/L)
Z3	4/25/1996	12/14/2004	137	Irregular	10.8	9.2	64.0	4.0	This station is located 2.2 Km from the L-39 canal, about 4.0 Km east-southeast of the S-6 pump station. The geometric mean of measured TP concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)
Z4	4/25/1996	12/14/2004	142	Irregular	9.0	8.1	39.0	4.0	This station is located 3.1 Km from the L-39 canal, about 6.38 Km east-southeast of the S-6 pump station. The geometric mean of measured TP concentrations for this station does not exceed the total phosphorus criterion (10 µg/L)

For these stations all the samples were collected as grab samples

*There are not data reported between 10/15/2002 and 5/13/2003

9.5 Total Phosphorus Data – Hydraulic Structure Stations

As indicated in a previous section, for the POR that goes from 1995 to 2004, there are 19 hydraulic structures associated with the Refuge. Water quality Data are available from 15 of these sites (for the complete POR); only the structures G-251, G-338, S-362 and G-94A (see Figure 10) do not have data available, and structure G-94C presents data for only three single days. The data for the G-251 have been requested to the SFWMD. Stations S-5A, G-310 and S-6 have grab samples and composite samples. The rest of the stations have only grab samples. For the data that was gathered as "grab sample", and excluding station G-94C, the sample size for the period of record ranges between 81 and 534 samples per site, with a mean equal to 177 samples per station. The TP time series for these stations are included in Appendix F3. The TP arithmetic means vary between 35.2 and 127.4 μg/L, and the geometric means vary between 30.7 and 113.1 μg/L (excluding station G-94C). The arithmetic mean for all these sites together is equal to 80.9 μg/L. Table 24A summarizes the information regarding "grab" TP measurements at these stations, and indicates the major observations and modifications to the data after the quality assurance checks. The composite data are for a 7-days period, and the date reported is the last day of the composite. The samples were composite either by time or by flow. Table 24B summarizes the information about the composite TP measurements at stations S-5A, G-310 and S-6. For the data gathered as "composite sample" the sample size for the POR ranges between 160 and 314 samples per site. The TP arithmetic means vary between 55.2 and 141.5 μg/L, and the geometric means vary between 44.2 and 124.0 μg/L. The TP time series for these stations are also included in Appendix F3

9.6 Total Phosphorus Data – Additional Stations

Besides the data described in the previous sections, the DBHYDRO database includes data for other five stations associated with the Refuge. These stations are known as S5AD, S6D, L40-1, L40-2 and ACME1DS. Site S5AD and S-6D are downstream of the S-5A and S-6 pumping stations, respectively, and L40-1 and L40-2 are monitoring stations on the downstream side of ACME 1 and ACME 2. The site ACME1DS is located in the L-40 Canal. According to Waldon (2005) when the pump (ACME-1) is flowing this site may not be representative of the L-40 Canal because the sampling point is in the discharge from the gated culverts. For these additional stations, the sample size varies between 56 and 119 samples per site. The TP arithmetic means range between 57.8 and 117.5 μg/L, and the geometric means range between 51.9 and 101.8 μg/L. The arithmetic mean for the four sites together is equal to 86.0 μg/L. Table 25 summarizes the information regarding TP measurements at these stations, and indicates the major observations and modifications to the data after the quality assurance checks. The TP time series for these additional stations are included in Appendix F.

Table 24A. Summary of Total Phosphorus Data Information for Monitoring Sites Located at the Hydraulic Structure Locations (Grab Samples)

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S-5A	1/5/1995	12/28/2004	471	Irregular	125.3	110.7	822.0	30.0	Composite samples were also taken in this station (see Table 24B). The maximum value equal to 822 µg/L corresponds to an "extreme event" on 8/10/04. Besides this value, the maximum measured TP concentration is 435 µg/L. This station was sampled at depths of 0 and 0.5 m
S-5AS	1/30/1995	11/22/2004	102	Irregular	101.0	88.6	272.0	29.0	The average TP concentration for this station is 23% lower than the average value for S-5A. For this station all samples were taken at a 0.5 m depth
G-300	5/3/2000	7/8/2004	111	Irregular	107.4	94.1	240.0	24.0	This station is located in a diversion structure to the L-40 canal. The structure started operating on November 1999. For this station all samples were taken at a 0.5 m depth
G-301	4/28/2000	7/8/2004	112	Irregular	127.4	113.1	305.0	27.0	This station is located in a diversion structure to the L-7 canal. The structure started operating on August 1999. For this station all samples were taken at a 0.5 m depth
G-310	6/1/2000	12/28/2004	247	Irregular	43.8	35.1	273.0	12.0	Composite samples were also taken in this station (see Table 24B). This station is located at the outflow pump station of STA-1W. This station was sampled at depths of 0 and 0.5 m.
G251	---	---							No water quality data is available for this site
S-6	1/5/1995	12/29/2004	534	Irregular	66.2	51.1	799.0	13.0	Composite samples were also taken in this station (see Table 24B). This station is located upstream of the S-6 pump station. The maximum value equal to 799 µg/L corresponds to an "extreme event" on 9/7/99. This station was sampled at depths of 0 and 0.5 m. The S-6 pump station discharge was diverted away from the Refuge on May 2001
S-10E	1/5/1995	12/22/2004	123	Irregular	67.4	58.4	200.0	22.0	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth
S-10D	1/5/1995	12/22/2004	140	Irregular	67.6	56.1	306.0	17.0	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth

Cont. Table 24A. Summary of Total Phosphorus Data Information for Monitoring Sites Located at the Hydraulic Structure Locations (Grab Samples)

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S-10C	1/5/1995	10/11/2004	81	Irregular	51.9	42.4	159.0	11.0	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth
S-10A	1/5/1995	10/11/2004	85	Irregular	38.3	31.5	166.0	10.0	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth
S-39	1/5/1995	12/22/2004	170	Irregular	35.2	30.7	148.0	6.0	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth
ACME-1	2/5/1997	12/22/2004	106	Irregular	76.0	66.8	348.0	27.0	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94D	2/5/1997	12/22/2004	109	Irregular	96.4	83.4	305.0	21.0	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94C	3/19/2001	4/10/2001	3	Irregular	478.3	398.3	898.0	227.0	This station is located on the L-40 canal. Only three values are reported for this station. This station shows the maximum TP measured concentration for the structure sites and also in general (898 µg/L)
G-94B	8/25/1997	12/22/2004	87	Irregular	89.5	62.6	495.0	18.0	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94A	---	---							No water quality data is available for this site

Table 24B. Summary of Total Phosphorus Data Information for Monitoring Sites Located at the Hydraulic Structure Locations (Composite Samples)

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S-5A	5/23/1995	12/28/2004	314	Irregular	141.5	124.0	460.0	4.0	The 314 samples were taken as flow composite samples (ACF). Grab samples were also taken in this station. A value reported as -4µg/L on 4/4/95 was replaced by 4µg/L. A negative values is the convention used by the SFWMD to report values when they are less than the detection limit. The detection limit is the absolute value of the number reported.
G-310	7/18/2000	12/28/2004	160	Irregular	55.2	44.2	493.0	14.0	From the 160 composite samples 19 are time composite samples (ACT) and 141 are flow composite samples. Grab samples were also taken in this station (see Table 24A). This station is located at the outflow pump station of STA-1W. The maximum value equal to 493 µg/L corresponds to an "extreme event" on 3/11/03.
S-6	2/21/1995	12/29/2004	312	Irregular	80.9	68.9	722.0	16.0	The 312 samples were taken as flow composite samples (ACF). Grab samples were also taken in this station. The maximum value equal to 722 µg/L corresponds to an extreme envent on 3/18/97. Besides this value, the maximum measured TP concentration is 341 µg/L. The S-6 pump station discharge was diverted away from the Refuge on May 2001

Table 25. Summary of Total Phosphorus Data Information for Additional Monitoring Sites Associated with the Refuge

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (µg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S5AD	1/11/1995	12/13/2004	119	Irregular	117.5	101.8	817.0	19.0	This station is downstream of the S-5A pump and was inside of the Refuge until roughly 1999 when the S-5A was isolated from the Refuge (Waldon, 2005) The maximum value equal to 817 µg/L corresponds to an "extreme event" on 8/9/04. This station was sampled at depths of 0 and 0.5 m.
S6D	1/12/1995	12/4/2001	84	Irregular	57.8	51.9	210.0	20.0	This station is downstream of the S-6 pump station. This site was not collected after December 2001. This station was sampled at depths of 0 and 0.5 m
L40-1	1/5/1995	1/4/1999	59	Irregular	80.6	68.8	410.0	28.0	This station is located on the downstream side of the ACME 1 structure in the L-40 canal. All samples were taken at a 0.5 m depth
L40-2	1/5/1995	1/4/1999	56	Irregular	85.7	71.7	383.0	24.0	This station is located on the downstream side of the ACME 2 structure in the L-40 canal. All samples were taken at a 0.5 m depth
ACME1DS	2/5/1997	12/22/2004	106	Irregular	76.0	66.8	348.0	27.0	This station is located in the L-40 canal. All samples were taken at a 0.5 m depth

9.7 Chloride Data – EVPA Stations

Ten years (1995 to 2004) of chloride (Cl) data were retrieved from the DBHYDRO database for the fourteen EVPA monitoring sites (see Figure 17). The sample size for Cl varies between 41 and 112 data points per site for the POR. The Cl arithmetic means range between 13.5 and 67.6 mg/L and the geometric means between 12.7 and 58.0 mg/L (see Table 26). The arithmetic mean for all the EVPA Cl measurements during the POR is equal to 31.8 mg/L. Table 26 indicates, for each EVPA site, the arithmetic average, the geometric mean, the maximum and the minimum reported value, the sample size, and the start and end dates of the available chloride data (all this information is according to the selected POR). This table also summarizes the major observations to the data and the modifications it underwent after the quality assurance checks. The time series for chloride are shown in Appendix F5. The relationship between TP and Cl arithmetic and geometry means can be observed in Figures 22 and 23, respectively. There is virtually no correlation between TP and Cl averages for the EVPA stations.

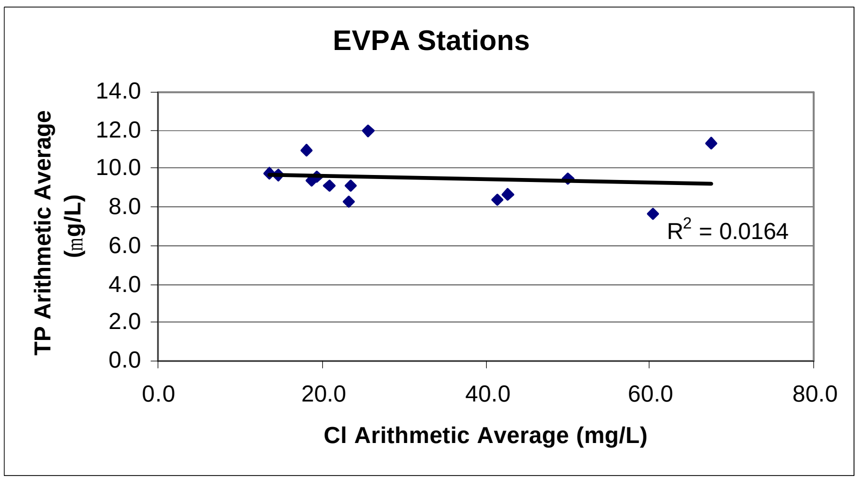

Figure 22. TP vs. Cl Arithmetic Means at EVPA Stations

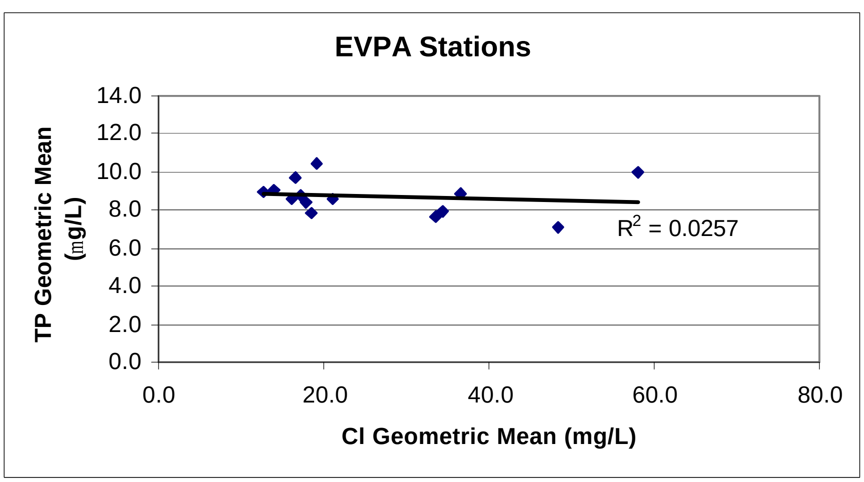

Figure 23. TP vs. Cl Geometric Means at EVPA Stations

Table 26. Summary of Chloride Data Information for the EVPA Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data*
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOX3	1/11/1995	10/18/2004	41	Irregular	25.6	19.1	96.0	8.1	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly decreases as the depth increases. The data show a period of high concentration (mean equal to 87 mg/L) between 11/13/95 and 4/15/96
LOX4	1/11/1995	12/13/2004	66	Irregular	67.6	58.0	170.0	12.0	This station is located close to the L-40 canal. It was sampled at different depths. The graph Cl vs Depth shows no correlation. This station shows the highest arithmetic average and geometric mean for the measured Cl values
LOX5	1/11/1995	10/18/2004	55	Irregular	18.2	16.5	48.0	6.1	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly decreases as the depth increases.
LOX6	1/11/1995	12/14/2004	95	Irregular	41.3	33.6	120.0	1.8	This station is located close to the L-40 canal. It was sampled at different depths. The graph Cl vs Depth shows no correlation, however, Cl slighlty increases as the Depth increases. The data for this station is highly variable (standard deviation equal to 25.6 mg/L)
LOX7	1/11/1995	12/13/2004	87	Irregular	23.4	21.0	55.0	5.4	This station was sampled at different depths. The graph Cl vs Depth shows no correlation
LOX8	1/11/1995	12/13/2004	94	Irregular	18.8	17.2	46.0	4.8	This station was sampled at different depths. The graph Cl vs Depth shows no correlation
LOX9	1/11/1995	10/18/2004	65	Irregular	21.0	17.9	93.0	6.7	This station was sampled at different depths. The graph Cl vs Depth shows no correlation. The maximum value equal to 93 mg/L corresponds to an "extreme event" on 11/6/2000
LOX10	1/11/1995	11/15/2004	66	Irregular	50.0	36.5	150.0	10.6	This station is located close to the L-7 canal. It was sampled at different depths. The graph Cl vs Depth shows no correlation. The data for this station is highly variable (standard deviation equal to 40.7 mg/L)
LOX11	1/12/1995	12/14/2004	86	Irregular	14.7	13.9	27.3	5.5	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly increases as the depth increases.

Cont. Table 26. Summary of Chloride Data Information for the EVPA Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data*
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOX12	1/12/1995	12/14/2004	112	Irregular	42.8	34.5	124.3	5.5	This station is located close to the L-39 canal. It was sampled at different depths. The graph Cl vs Depth shows no correlation. The data for this station is highly variable (standard deviation equal to 30.4 mg/L)
LOX13	1/12/1995	12/14/2004	83	Irregular	13.5	12.7	34.3	4.5	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly increases as the depth increases. This station shows the lowest arithmetic average and geometric mean for the measured Cl values
LOX14	1/12/1995	12/14/2004	101	Irregular	23.2	18.4	115.0	6.3	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly increases as the depth increases. The maximum value equal to 115 mg/L corresponds to an "extreme event" on 9/9/03
LOX15	1/12/1995	12/14/2004	109	Irregular	60.4	48.3	140.0	6.5	This station is located close to the L-39 canal. It was sampled at different depths. The graph Cl vs Depth shows no correlation, however, Cl sligthly increases as the depth increases. The data for this station is highly variable (standard deviation equal to 37.3 mg/L)
LOX16	1/12/1995	12/14/2004	103	Irregular	19.5	16.1	97.2	0.2	This station was sampled at different depths. The graph Cl vs Depth shows almost no correlation, however, Cl sligthly increases as the depth increases. The maximum value equal to 97.2 mg/L corresponds to an "extreme event" on 8/10/04

* See Chloride time series for EVPA Stations

All the Cl samples for the EVPA stations were collected as grab samples.

9.8 Chloride Data – "Enhanced" Stations

As indicated before, there are 39 "Enhanced" stations inside the Loxahatchee Refuge, but data for these stations are only available after June 2004 (see Figure 18). The number of data points available for Cl varies between just 3 and 7. All the CL samples at the "Enhanced" stations were collected as grab samples. The Cl arithmetic averages for the enhanced sites range from 16.9 and 114.0 mg/L, and the geometric means from 16.2 to 110.2 mg/L. The Cl mean concentration for all the enhanced sites together is 58.7 mg/L. As in the case of the total phosphorus, the high values of the means and their wide ranges are related to the fact that some of the sites are located close to the rim canal, and are affected by the penetration of canal water into the marsh. Table 27 shows a summary of the Cl data for the enhanced sites, and also the major observations and modifications to these data. Figure 24 and 25 show the relationship between the means of TP and Cl for the enhanced stations. These figures show that the TP means tend to increase as the Cl means increases, however a poor correlation is observed between the variables.

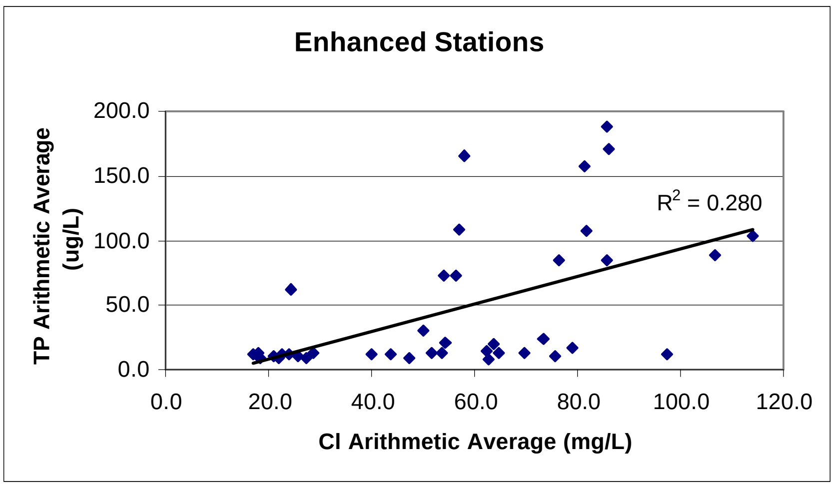

Figure 24. TP vs. Cl Arithmetic Means at "Enhanced" Stations

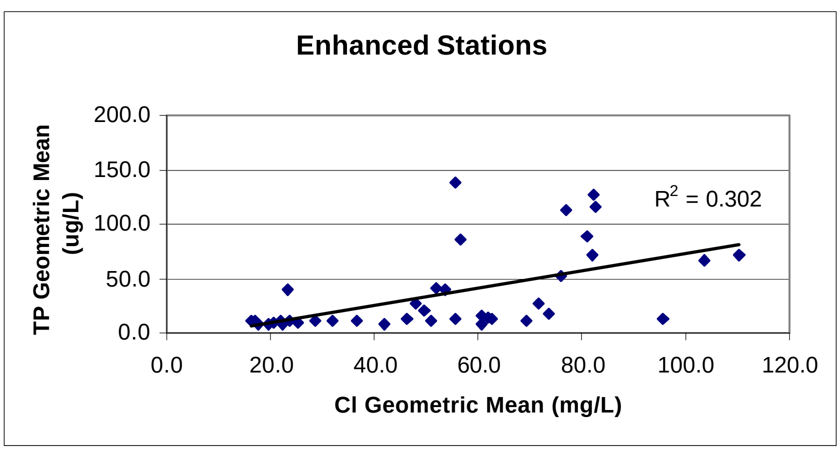

Figure 25. TP vs. Cl Geometric Means at "Enhanced" Stations

Table 27. Summary of Chloride Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA101	9/15/2004	12/7/2004	4	Irregular	73.4	71.7	85.3	49.2	This station is located about 1.5 miles south of S5A pump station.
LOXA102	9/15/2004	12/7/2004	4	Irregular	64.6	55.7	127.0	32.7	This station is located about 1.5 miles northeast of G310 pumping station.
LOXA103	9/15/2004	12/7/2004	4	Irregular	69.6	62.8	118.0	37.0	This station is located about 2 miles northeast of G310 pumping station.
LOXA104	6/8/2004	12/9/2004	7	Irregular	114.0	110.2	175.0	80.1	This station is located in the L-7 Canal, about 0.5 mile north of G 310 pumping station.
LOXA105	9/15/2004	12/9/2004	4	Irregular	76.2	75.9	84.0	65.2	This station is located close to the L-7 Canal, about 0.5 mile northeast of G 310 pumping station. This station shows the highest arithmetic average and geometric mean of observed Cl concentrations for the Enhanced stations.
LOXA106	9/15/2004	12/9/2004	4	Irregular	63.6	60.8	97.5	44.9	This station is located close to the L-7 Canal, about 0.6 mile east of G 310 pumping station.
LOXA107	9/15/2004	12/8/2004	3	Irregular	75.5	69.2	95.9	36.8	This station is located about 1.5 miles southeast of G 310 pumping station.
LOXA108	9/15/2004	12/7/2004	4	Irregular	25.8	25.2	33.4	19.2	This station is located about 3.0 miles southeast of G 310 pumping station.
LOXA109	9/15/2004	12/8/2004	4	Irregular	43.5	36.5	88.7	20.1	This station is located about 3.0 miles south-southeast of G 310 pumping station.
LOXA110	9/15/2004	12/8/2004	4	Irregular	22.8	22.1	31.8	16.6	This station is located about 3.1 miles south-southeast of G 310 pumping station.
LOXA111	9/15/2004	12/8/2004	4	Irregular	27.3	22.4	59.4	12.7	This is an interior station.
LOXA112	9/15/2004	12/8/2004	4	Irregular	39.9	31.9	92.1	19.2	This station is located between LOXA111 and the L-7 canal.
LOXA113	9/15/2004	12/8/2004	4	Irregular	22.0	19.5	40.6	11.4	This is an interior station.

Cont. Table 27. Summary of Chloride Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA114	9/15/2004	12/8/2004	4	Irregular	17.9	17.0	25.4	10.8	This is an interior station.
LOXA115	6/8/2004	12/9/2004	7	Irregular	106.5	103.6	148.0	71.4	This station is located in the L-7 Canal, about 1 mile north of S-6 pumping station.
LOXA116	8/3/2004	12/9/2004	5	Irregular	85.8	81.9	135.0	57.0	This station is located close to the L-7 Canal, about 1.2 miles north of S-6 pumping station.
LOXA117	9/16/2004	12/9/2004	4	Irregular	78.9	73.5	123.0	51.3	This station is located close to the L-7 Canal, about 1.3 miles northeast of S-6 pumping station.
LOXA118	9/16/2004	12/9/2004	4	Irregular	47.4	41.9	87.1	26.2	This is an interior station.
LOXA119	6/8/2004	12/9/2004	6	Irregular	21.0	20.5	30.6	15.9	This is an interior station.
LOXA120	8/3/2004	12/9/2004	5	Irregular	18.3	17.8	23.5	11.8	This is an interior station.
LOXA121	8/3/2004	12/9/2004	4	Irregular	81.6	81.1	95.0	70.8	This station is located close to L-39 canal, about 0.5 mile south of the S-6 pumping stations.
LOXA122	9/16/2004	12/9/2004	4	Irregular	97.3	95.8	123.0	78.7	This station is located 1 mile southeast of S-6 pumping station.
LOXA123	9/16/2004	12/9/2004	4	Irregular	62.2	62.1	66.7	59.6	This station is located 3 miles northwest of S-10D structure.
LOXA124	9/14/2004	12/7/2004	4	Irregular	24.4	23.3	37.8	17.7	This station is located close to the L-40 canal, about 1 mile northwest of the G-94A structure.
LOXA125	---	---	---	---	---	---	---	---	---
LOXA126	9/14/2004	12/7/2004	4	Irregular	53.8	51.0	86.5	40.9	This station is located close to the L-40 canal, about 0.3 miles west of the Refuge boat ramp.
LOXA127	9/14/2004	12/7/2004	4	Irregular	28.8	28.6	34.6	25.1	This station is located about 1.2 miles west of the Refuge boat ramp.

Cont. Table 27. Summary of Chloride Data Information for the "Enhanced" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
LOXA128	9/16/2004	12/9/2004	4	Irregular	16.9	16.2	21.5	10.6	This is an interior station. This station shows the lowest arithmetic average and geometric mean of observed Cl concentrations for the Enhanced stations.
LOXA129	6/7/2004	12/7/2004	7	Irregular	81.3	77.1	130.0	54.0	This station is located in the L-40 canal, about 1 mile south ACME 2 pumping stations.
LOXA130	9/14/2004	12/7/2004	4	Irregular	56.3	53.8	66.6	30.7	This station is located close to the L-40 canal, about 2.7 miles northwest of the G-94C structure.
LOXA131	9/14/2004	12/7/2004	4	Irregular	62.5	60.6	87.5	45.3	This is an interior station. This stations showed the lowest arithmetic average and geometric mean of measured TP concentrations, however, the Cl concentrations are relatively high
LOXA132	6/7/2004	12/7/2004	7	Irregular	86.1	82.6	124.0	50.0	This station is located in the L-40 canal, below the ACME 1 pump station.
LOXA133	9/14/2004	12/7/2004	4	Irregular	58.0	55.7	69.7	33.2	This station is located close to the L-40 canal, 0.5 miles southwest of the ACME 1 pump station.
LOXA134	9/14/2004	12/7/2004	4	Irregular	54.0	52.0	65.3	32.1	This station is located 1 mile west of the ACME 1 pump station, close to L-40 canal
LOXA135	6/7/2004	12/8/2004	7	Irregular	85.5	82.3	122.0	59.6	This station is located in the L-40 canal, about 1 mile northwest of the ACME 1 pump station.
LOXA136	9/14/2004	12/8/2004	4	Irregular	57.0	56.5	64.4	48.3	This station is located close to the L-40 canal, about 1.2 miles northwest of the ACME 1 pump station.
LOXA137	9/14/2004	12/8/2004	4	Irregular	49.9	47.9	72.8	35.5	This station is located 1.4 miles northwest of the ACME 1 pump station.
LOXA138	9/14/2004	12/8/2004	4	Irregular	51.7	46.2	84.8	26.2	This is an interior station.
LOXA139	9/14/2004	12/8/2004	4	Irregular	24.1	23.6	31.4	17.7	This is an interior station.
LOXA140	9/15/2004	12/8/2004	4	Irregular	54.4	49.5	96.3	30.2	This station is located close to the L-40 canal, about 4 miles southeast of the S-5A pump station. The geometric mean of measured P concentrations for this station exceeds the total phosphorus criterion (10 μg/L).

9.9 Chloride Data – XYZ Stations

As indicated before, there are eleven “XYZ” stations associated with the Loxahatchee Refuge, two canal stations and nine marsh stations (see Figure 19). Chloride data for these stations are available from April 1996. For this period of record, the sample size varies between 103 and 121 data points per station. The Cl arithmetic means vary between 40.4 and 148.6 mg/L, and the geometric means range between 34.1 and 138.7 mg/L. The arithmetic mean of all the Cl measurements during the period of record is equal to 92.7 mg/L. As in the case of TP, the Cl concentration exhibits a gradient of decreasing concentrations as the distance from the rim canal increases (see Figures 26 and 27). However, as shown in Figure 26, the gradient for the TP is steeper and the concentrations decrease to a fairly constant value (about 10 μg/L) within the first 1.5 Km. The Cl concentration decreases less rapidly and it seems to drop to a relative constant-interior value (about 50 mg/L) within 3.2 Km of the rim canal. The relationship between TP and Cl means for these stations are shown in Figures 28 and 29. The data in these Figures can be grouped into two different sets: (a) the stations close to the canal (distance to the canal less than 0.6 Km) that show high values for both TP and Cl, and (b) the stations located in the interior zone (distance to the canal greater than 0.6 Km) that show a almost constant value for the TP (varying between 9.0 and 16.3 μg/L for the arithmetic averages) and a variable Cl concentration (varying between 40.4 and 105.5 mg/L for the arithmetic averages). This tendency is not surprising, since the Cl is a more conservative substance than TP. TP concentrations are affected by biological uptake and other bio-chemical processes in the marsh, while the Cl concentrations basically decline as the result of dilution (SFW*-/MD, 2001). Table 28 summarizes the information for the Cl data at the “XYZ” sites. This Table indicates the major observations to the data. The Cl time series for each site during the period of record are included in Appendix F6.

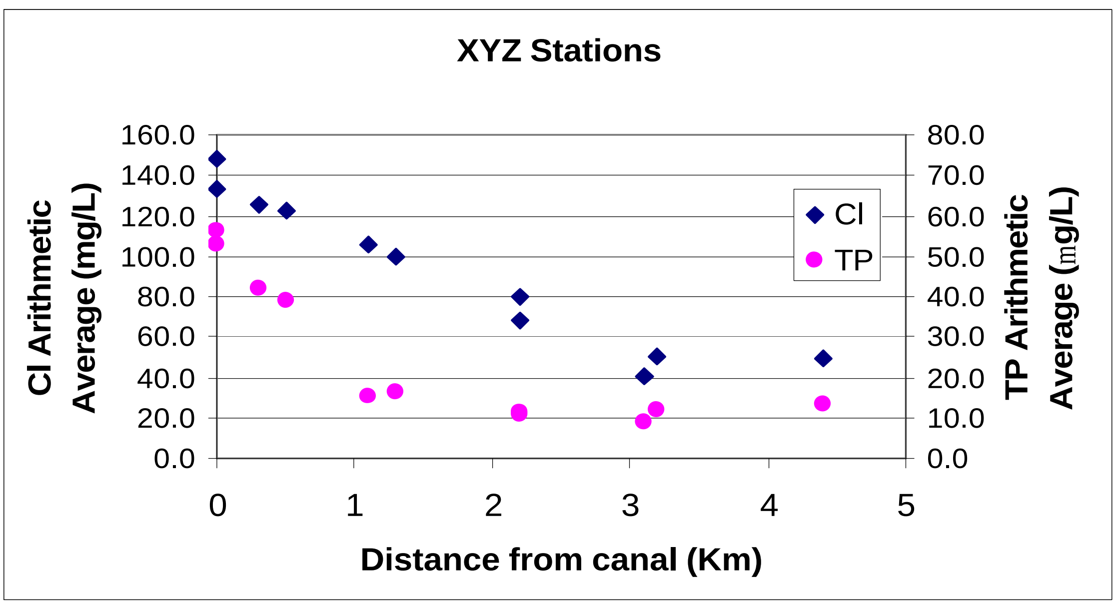

Figure 26. Cl and TP Arithmetic Means at Refuge Transect Stations with Increasing Distance from the Rim Canal

Table 28. Summary of Chloride Data Information for the "XYZ" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
X0	5/9/1996	12/14/2004	107	Irregular	133.0	127.2	230.0	50.0	This location is located in the L-7 canal, about 1.4 Km north of the S-6 pump station. This station was sampled at a 0.5 m depth.
X1	4/24/1996	12/14/2004	105	Irregular	122.9	118.5	190.0	40.0	This station is located 0.5 Km from the L-7 canal, about 1.59 Km north of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows no correlation.
X2	4/24/1996	12/14/2004	109	Irregular	100.0	91.2	170.0	29.0	This station is located 1.3 Km from the L-7 canal, about 2.26 Km north-northeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly increases as the depth increases.
X3	4/24/1996	12/14/2004	106	Irregular	80.2	69.5	160.0	23.0	This station is located 2.2 Km from the L-7 canal, about 2.59 Km northeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly increases as the depth increases.
X4	4/24/1996	12/14/2004	113	Irregular	49.5	39.9	140.0	12.0	This station is located 4.4 Km from the L-7 canal, about 4.69 Km northeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly decreases as the depth increases.
Y4	4/25/1996	12/14/2004	111	Irregular	50.6	40.8	160.0	11.0	This station is located 3.2 Km from the L-7 canal, about 4.38 Km east of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly decreases as the depth increases.

For these stations all the samples were collected as grab samples

*There are not data reported between 10/15/2002 and 5/13/2003

Cont. Table 28. Summary of Chloride Data Information for the "XYZ" Stations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
Z0	5/9/1996	12/14/2004	121	Irregular	148.6	138.7	298.0	47.0	This station is located in the L-39 canal, about 0.69 Km east-southeast of the S-6 pump station. This station was sampled at a 0.5 m depth. The arithmetic average and geometry mean of the data before 10/15/2002 are 131.8 and 125.4 mg/L, respectively. The arithmetic average and geometric mean of the data for the period between 5/13/2003 and 12/14/2004 are 228.6 and 224.3 mg/L, respectively.
Z1	4/25/1996	12/14/2004	112	Irregular	125.8	122.9	190.0	57.0	This station is located 0.3 Km from the L-39 canal, about 0.69 Km east-southeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly decreases as the depth increases.
Z2	4/25/1996	12/14/2004	103	Irregular	105.5	101.5	180.0	38.0	This station is located 1.1 Km from the L-39 canal, about 1.94 Km east-southeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly increases as the depth increases.
Z3	4/25/1996	12/14/2004	119	Irregular	68.3	59.9	170.0	18.0	This station is located 2.2 Km from the L-39 canal, about 4.0 Km east-southeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly increases as the depth increases.
Z4	4/25/1996	12/14/2004	120	Irregular	40.4	34.1	130.0	11.0	This station is located 3.1 Km from the L-39 canal, about 6.38 Km east-southeast of the S-6 pump station. This station was sampled at different depths. The graph Cl vs depth shows almost no correlation, however, Cl slightly decreases as the depth increases.

For these stations all the samples were collected as grab samples

*There are not data reported between 10/15/2002 and 5/13/2003

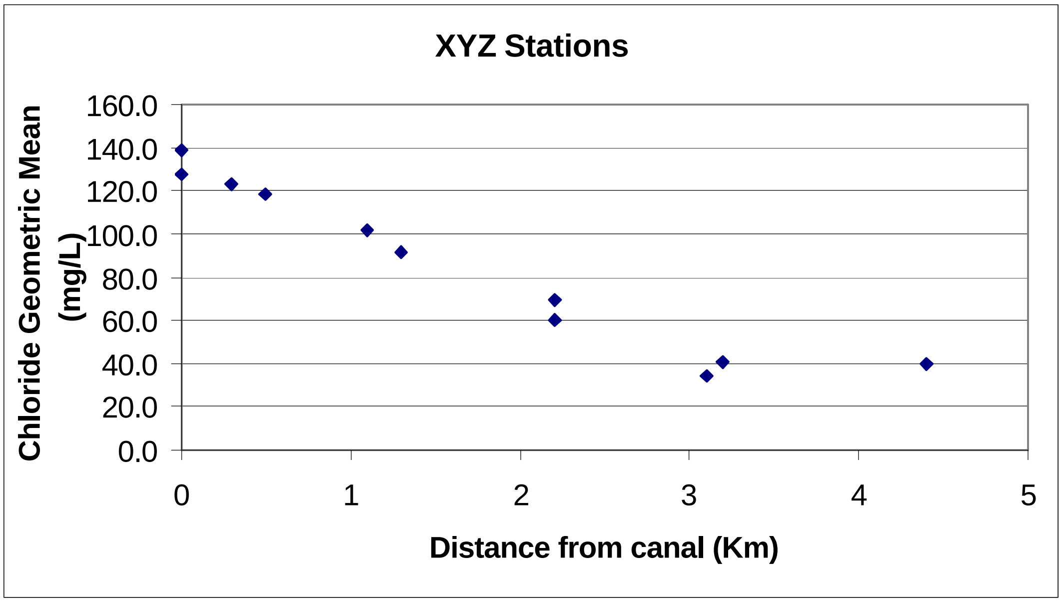

Figure 27. Cl Geometric Means at Refuge Transect Stations with Increasing Distance from the Rim Canal

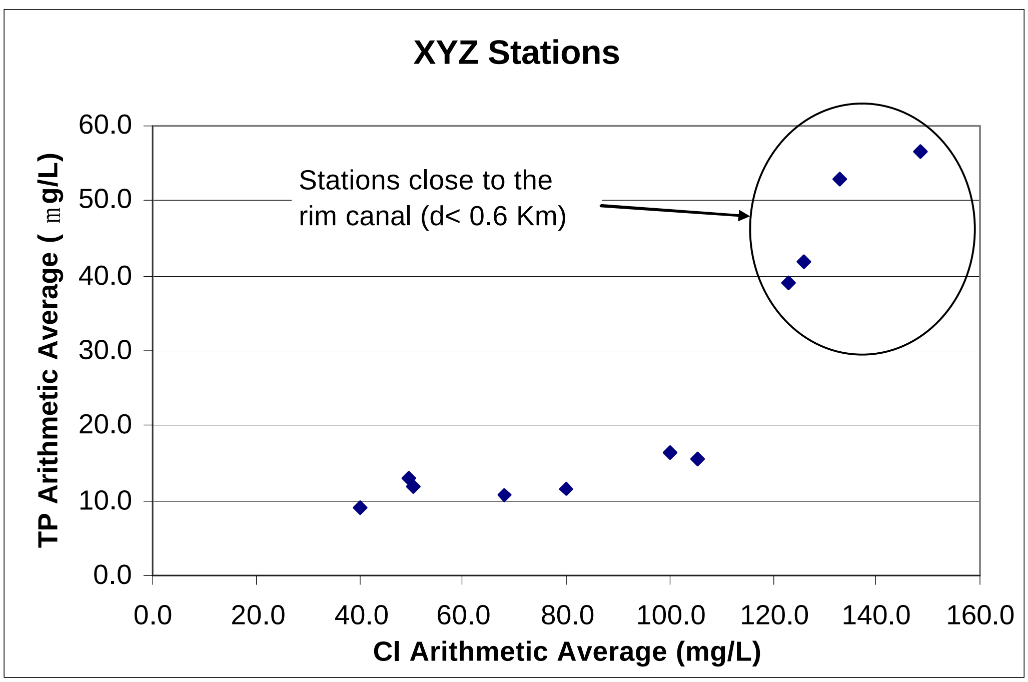

Figure 28. TP vs. Cl Arithmetic Means at “XYZ” Stations

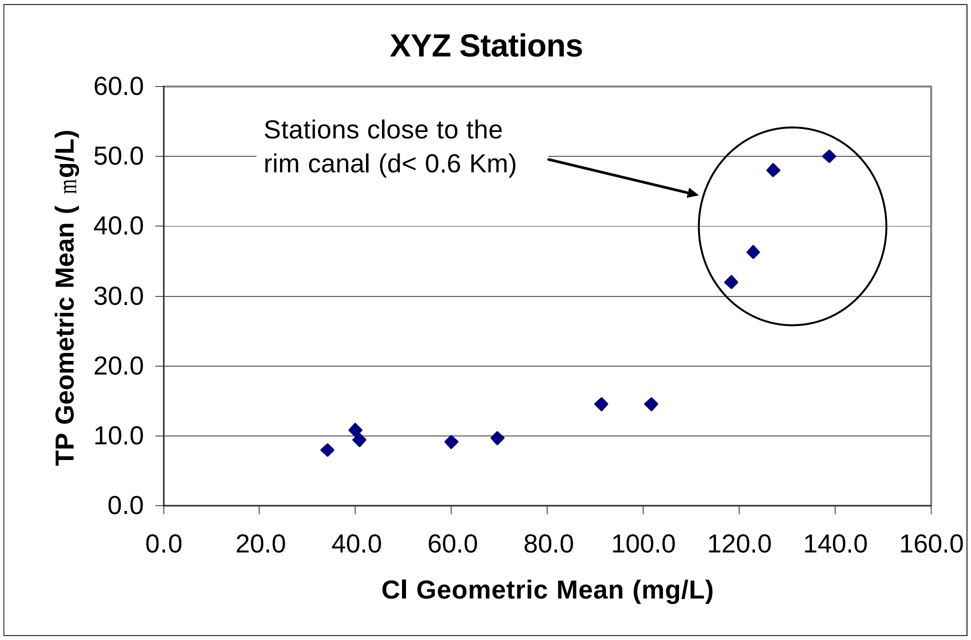

Figure 29. TP vs. Cl Geometric Means at "XYZ" Stations

9.10 Chloride Data – Hydraulic Structure Stations

Chloride Data are available at 13 of 19 hydraulic structure locations around the Refuge for the period that goes form January 1995 to December 2004. Structures G-300, G-301, G-251, G-94A, G-338 and S-362 do not have data available, and the site associated with structure G-94C only presents data for three days (between March and April 2001). However, Cl data for the G-300 and G-301 may be assumed to be equal to the S-5A because of its proximity. Data for the G-251 have been requested from the SFWMD. Excluding station G-94C, the Cl sample size for the period of record ranges between 81 and 218 samples per site, with a mean equal to 129 samples per station. The Cl time series for these stations are included in Appendix F7. The Cl arithmetic means vary between 49.7 and 148.7 mg/L, and the geometric means vary between 49.0 and 144.6 mg/L (excluding station G-94C). The arithmetic mean for all these sites together is equal to 113.2 mg/L. Table 29 summarizes the information regarding Cl measurements at these stations, and indicates the major observations and modifications to the data after the quality assurance checks.

Figures 30 and 31 show the relationships between the TP and Cl arithmetic and geometry means, respectively. For these stations, both the TP and the Cl concentrations are considerably higher than that of the interior stations. However, there is no correlation between the long term average TP and Cl concentrations.

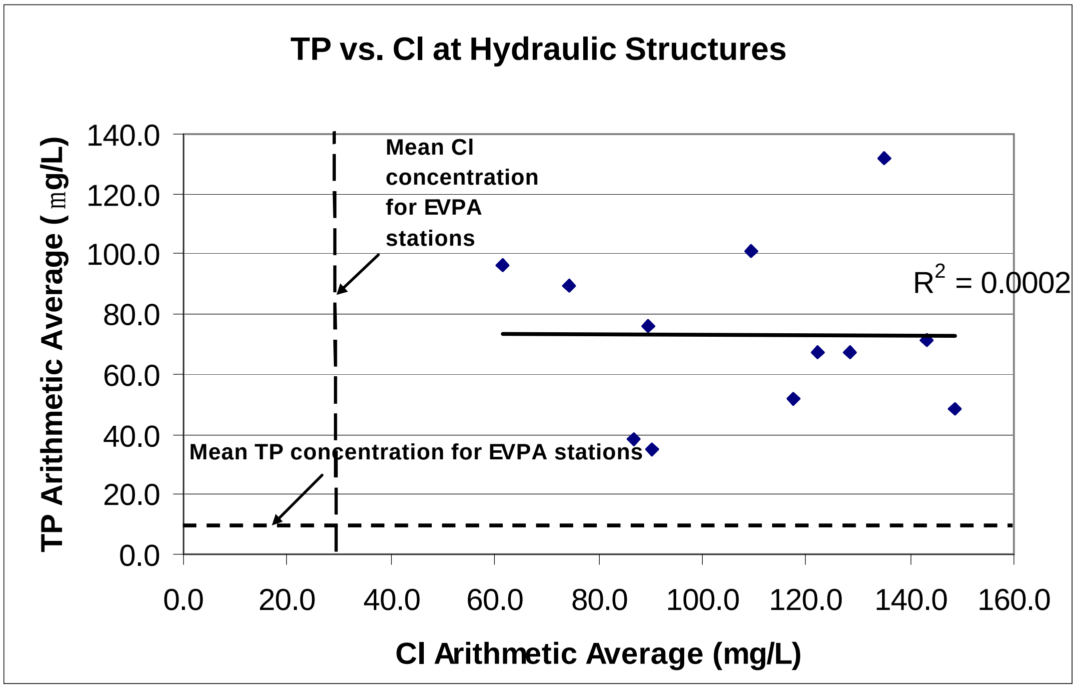

Figure 30. TP vs. Cl Arithmetic Means at Monitoring Sites Associated with the Hydraulic Structures

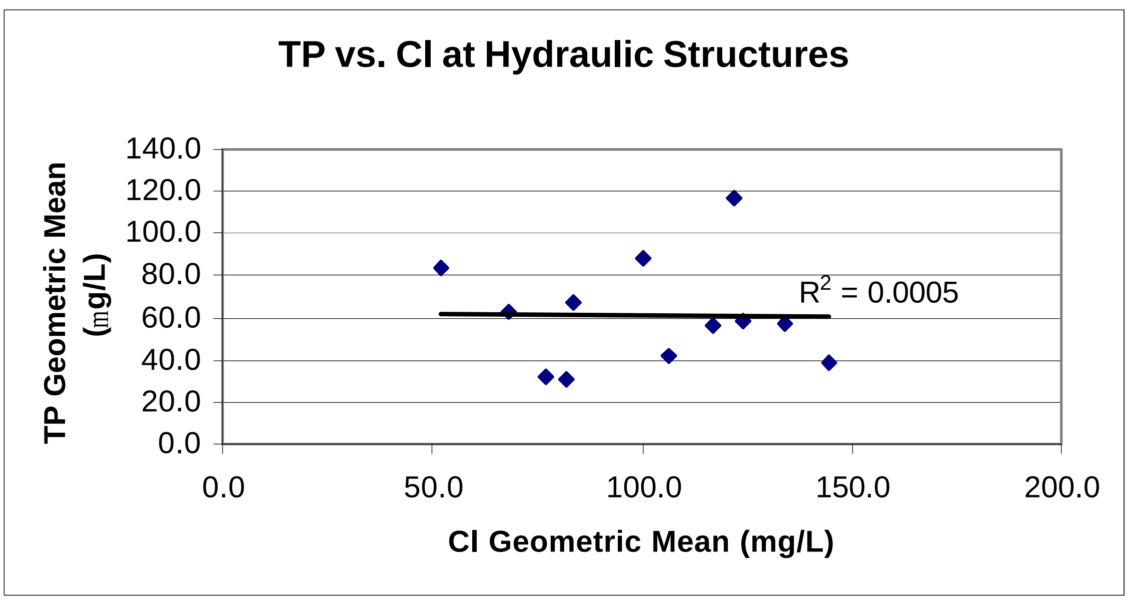

Figure 31. TP vs. Cl Geometric Means at Monitoring Sites Associated with the Hydraulic Structures

Table 29. Summary of Chloride Data Information for the Monitoring Site at Hydraulic Structure Locations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S-5A	1/5/1995	12/28/2004	218	Irregular	135.1	121.9	344.8	37.5	All the Cl samples were taken at a 0.5 m depth. The data for this station is highly variable (standard deviation= 59.3 mg/L). Some of the variability in Cl concentration may result from whether the water source is the Everglades Agricultural Area or discharge from Lake Okeechobee
S-5AS	1/30/1995	12/22/2004	103	Irregular	109.4	100.3	252.3	5.4	The average Cl value for this station is 20% lower than the average value for S-5A. The minimum value equal to 5.4 mg/L corresponds to an "extreme event" on 10/23/95. Besides this value, the minimum value is equal to 39.4 mg/L. The data for this station is highly variable. Flow at this structure is bi-directional, and variability may result from alteration of source water from the Refuge or S-5A pump, or the L-8 Basin runoff (Waldon, 2005). For this station all samples were taken at a 0.5 m depth
G-300	---	---							No chloride data is available for this site
G-301	---	---							No chloride data is available for this site
G-310	7/18/2000	12/28/2004	117	Irregular	148.7	144.6	264.2	77.3	This structure is located at the outflow pump station of STA-1W. Almost all the Cl samples were taken at a 0.5 m depth. This structure started operating on May 1999, approximately 437 days of chloride data are missing. This station shows the highest arithmetic average and geometric mean of measured Cl concentrations.
G251	---	---							No water quality data is available for this site
S-6	1/5/1995	12/21/2004	200	Irregular	143.4	133.9	756.0	42.2	This structure is located at upstream of the S-6 pump station. A value reported equal to -0.1 mg/L on 10/11/99 was removed from the time series. The maximum value equal to 756 mg/L corresponds to an "extreme event" on 7/8/97. Besides this value, the maximum value is equal to 275 mg/L. Almost all the Cl samples were taken at a 0.5 m depth.

All the Cl samples were collected as grab samples.

Cont. Table 29. Summary of Chloride Data Information for the Monitoring Site at Hydraulic Structure Locations

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S-10E	1/5/1995	12/22/2004	126	Irregular	128.4	124.1	197.4	43.3	This station is located on the L-7 canal. For this station all samples were taken at a 0.5 m depth. No data is reported on 7/8/97 (data of "extreme event" for S-6)
S-10D	1/5/1995	12/22/2004	141	Irregular	122.3	117.0	184.1	19.5	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth. The data report a value equal to 101.7 mg/L on 7/8/97, which is not consistent with values reported on the same day for stations S-6 and S-10C.
S-10C	1/5/1995	10/11/2004	81	Irregular	117.4	106.5	633.9	22.0	This station is located on the L-39 canal. The maximum value equal to 633.9 mg/L corresponds to an "extreme event" on 7/8/97. Besides this value, the maximum value is equal to 167.5 mg/L. For this station all samples were taken at a 0.5 m depth
S-10A	1/5/1995	10/11/2004	83	Irregular	86.9	77.0	158.9	13.2	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth. No data is reported on 7/8/97 (data of "extreme event" for S-6)
S-39	1/5/1995	12/22/2004	174	Irregular	90.4	81.9	174.8	14.2	This station is located on the L-39 canal. For this station all samples were taken at a 0.5 m depth. No data is reported on 7/8/97 (data of "extreme event" for S-6)
ACME-1	2/5/1997	12/22/2004	109	Irregular	89.5	83.8	171.0	24.2	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94D	2/5/1997	12/22/2004	112	Irregular	61.5	52.3	156.9	18.3	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94C	3/19/2001	4/10/2001	3	Irregular	49.7	49.0	59.1	40.1	This station is located on the L-40 canal. Only three values are reported for this station
G-94B	8/25/1997	12/22/2004	87	Irregular	74.4	67.9	162.1	19.2	This station is located on the L-40 canal. For this station all samples were taken at a 0.5 m depth
G-94A	---	---							No water quality data is available for this site

All the Cl samples were collected as grab samples.

9.11 Chloride Data – Additional Stations

Chloride data for the S5AD, S6D, L40-1, L40-2 and ACME1DS sites were also retrieved from the DBHYDRO database. For these additional stations, the Cl sample size varies between 60 and 116 samples per site. The Cl arithmetic means range between 42.9 and 128.0 mg/L, and the geometric means range between 37.9 and 117.6 mg/L. The arithmetic mean for the four sites together is equal to 103.0 mg/L. Table 30 summarizes the information regarding Cl measurements at these stations, and indicates the major observations and modifications to the data after the quality assurance checks.

Table 30. Summary of Chloride Data Information for Additional Monitoring Sites Associated with the Refuge

Station	Available Data		Sample Size (number)	Sampling Frequency	Data Information (mg/L)				Observations/Modifications to Data
	Start	End			Average	Geometric Mean	Maximum	Minimum	
S5AD	1/11/1995	12/13/2004	116	Irregular	128.0	117.6	272.0	50.0	This station is downstream of the S-5A pump and was inside of the Refuge until roughly 1999 when the S-5A was isolated from the Refuge (Waldon, 2005). The data for this station is highly variable (standard deviation= 51.8 mg/L). This station was sampled at depths of 0 and 0.5 m.
S6D	1/12/1995	12/4/2001	79	Irregular	128.0	123.8	210.0	67.0	This station is downstream of the S-6 pump station. This site was not collected after December 2001. This station was sampled at depths of 0 and 0.5 m
L40-1	1/5/1995	1/4/1999	61	Irregular	92.1	85.1	201.6	28.9	This station is located on the downstream side of the ACME 1 structure in the L-40 canal. All samples were taken at a 0.5 m depth
L40-2	1/5/1995	1/4/1999	60	Irregular	42.9	37.9	177.1	12.5	This station is located on the downstream side of the ACME 2 structure in the L-40 canal. All samples were taken at a 0.5 m depth
ACME1DS	2/5/1997	12/22/2004	69	Irregular	94.3	87.9	171.0	24.2	This station is located in the L-40 canal. All samples were taken at a 0.5 m depth

For these stations all the samples were collected as grab samples

10. Conclusions and Recommendations

The main goal of this report was to compile and summarize the availability of data to support the Refuge hydrodynamic and water quality modeling effort. TP was selected as the main water quality parameter to be modeled, and chloride was selected as conservative tracer to evaluate the model transport subroutine. Marsh elevations, rim canal cross-sections, water level, discharge, rainfall, temperature, evapotranspiration, wind, TP and Cl data were gathered and evaluated.

Overall, it is concluded that the available data is sufficient to achieve most of the modeling goals. In other words, the available data is sufficient to develop the boundary conditions that will force the hydrodynamic and water quality modules of the model. Data is also available for calibration and validation of the numerical model.

Additional specific conclusions regarding the available field data include:

- Data describing the interaction between surface and ground water is generally unavailable. However, there are estimates and studies that approximate leakage rates through the rim levee, and the recharge to groundwater from the marsh interior. A more detailed discussion about the surface-ground water interaction and the approach to address this issue will be provided in companion reports.

- Wind direction data is only available at the West Palm Beach International Airport (PBI) station for the POR. There are wind-direction data available at three local stations but for only limited time (two years).

- Atmospheric deposition data have not been discussed at this time. These data are currently being collected and evaluated. Even though, there is a good amount of data on both wet and dry deposition in the Everglades, the available time series have significant gaps due to instrumental failures and sample contamination (Ahn, 1999). The initial approach in this modeling effort will be to use a constant "dry" deposition and a constant "wet" rain concentration, and to perform model sensitivity analyses to determine whether or not this approach is adequate.

- It should be noted that there are no velocity measurements in the rim canal or in the interior marsh. Therefore, the transport module of the numerical model will be evaluated only through the ability to reproduce the spatial and temporal distribution of the conservative tracer.

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Appendix A
(Stages Plots)

A1 Interior Stages

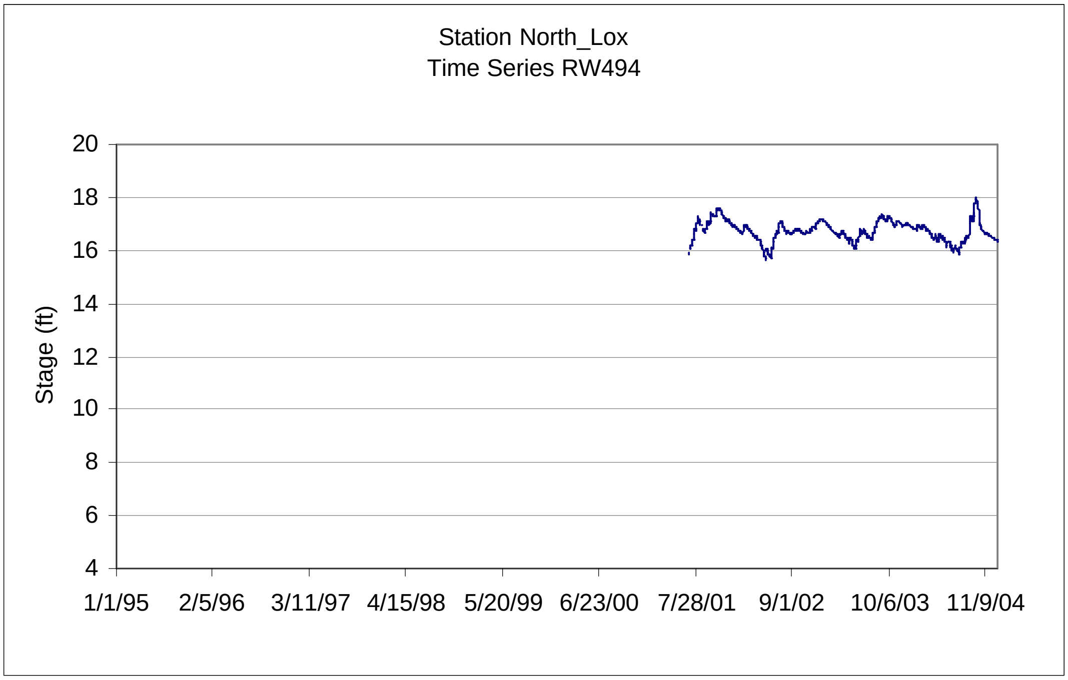


Figure A1.1 North_Lox Stage

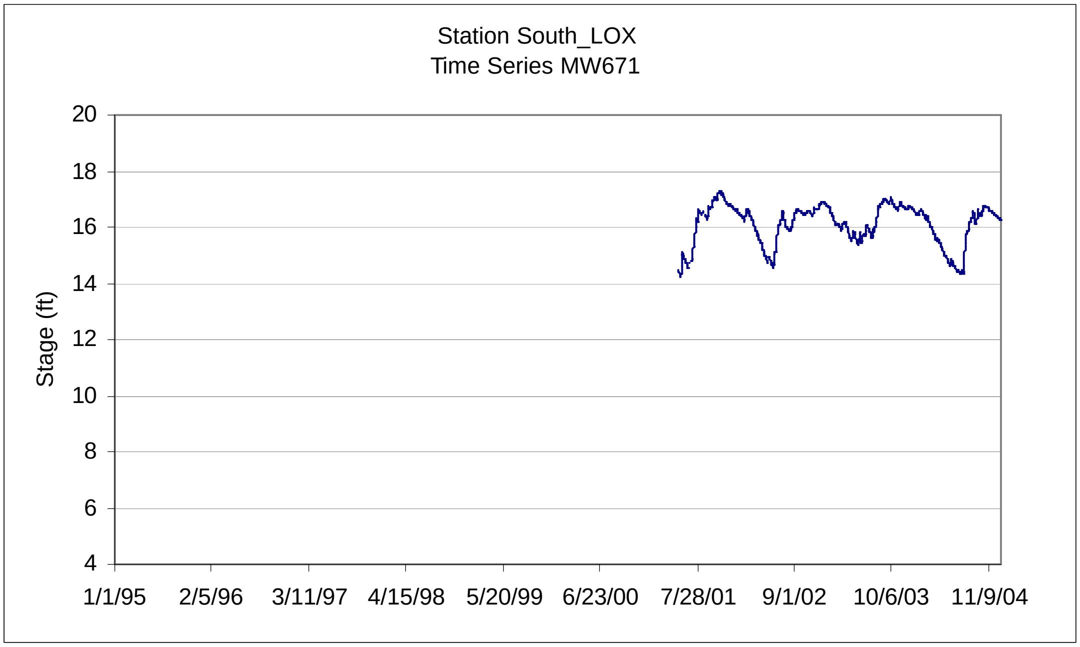


Figure A1.2 South_Lox Stage

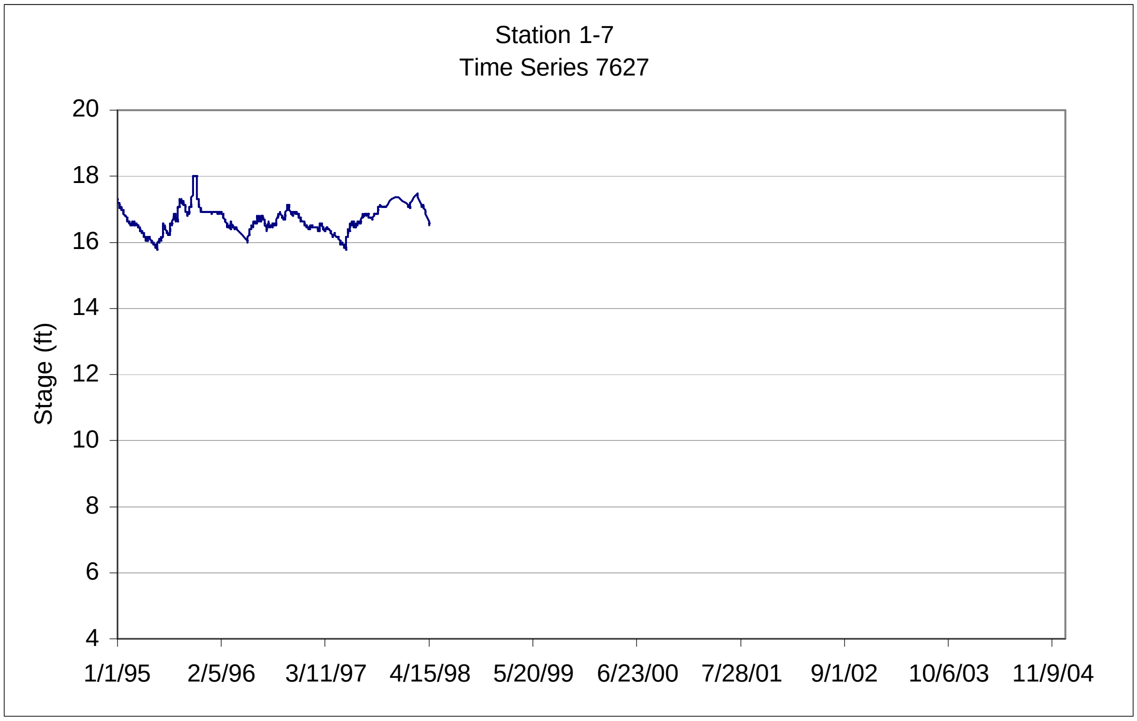
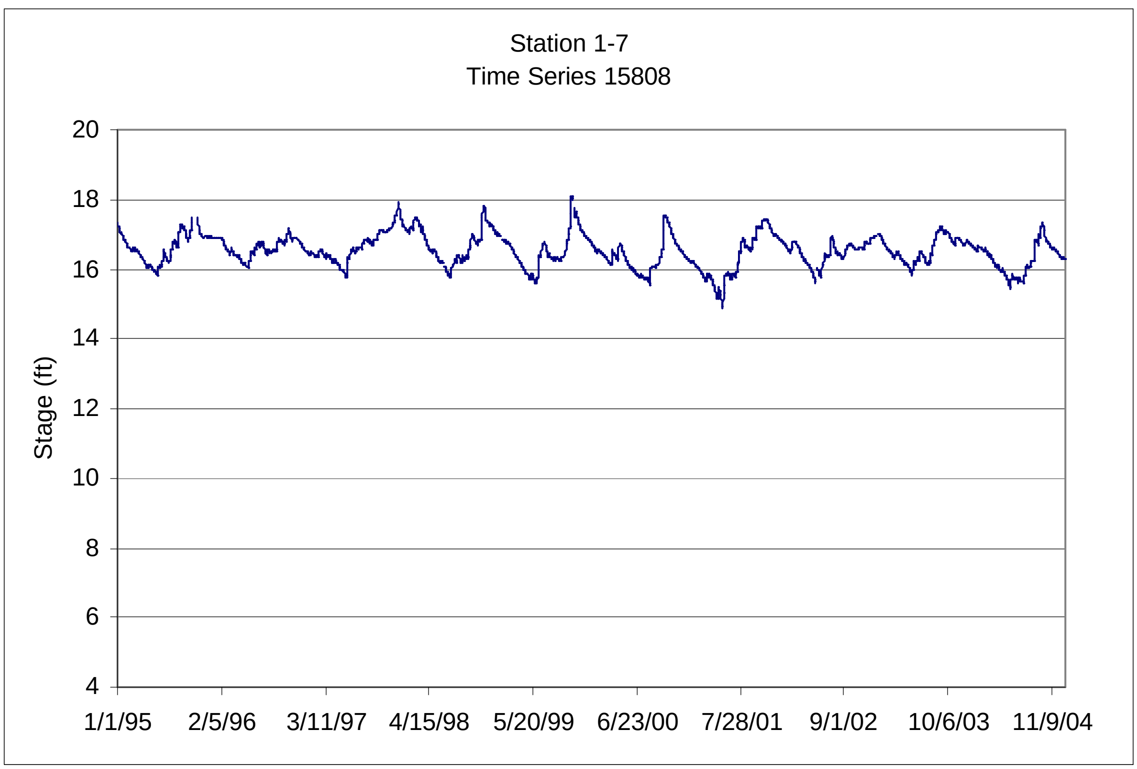


Figure A1.3 Station 1-7 Stage



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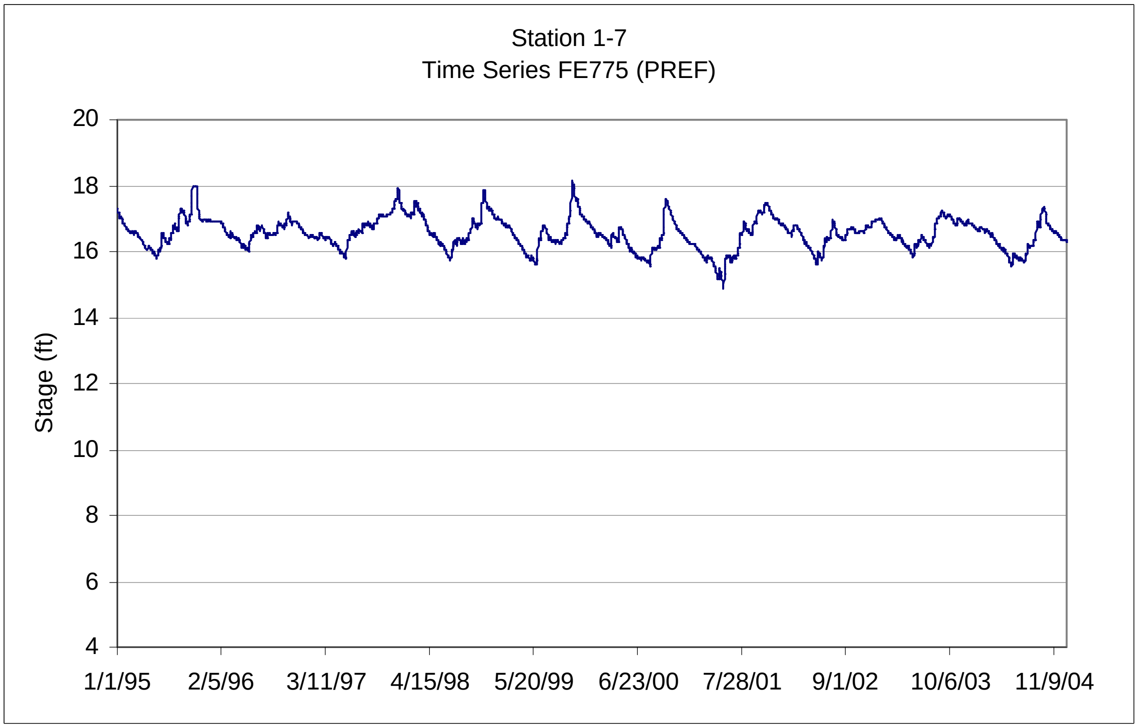


Figure A1.5 Station 1-7 Stage

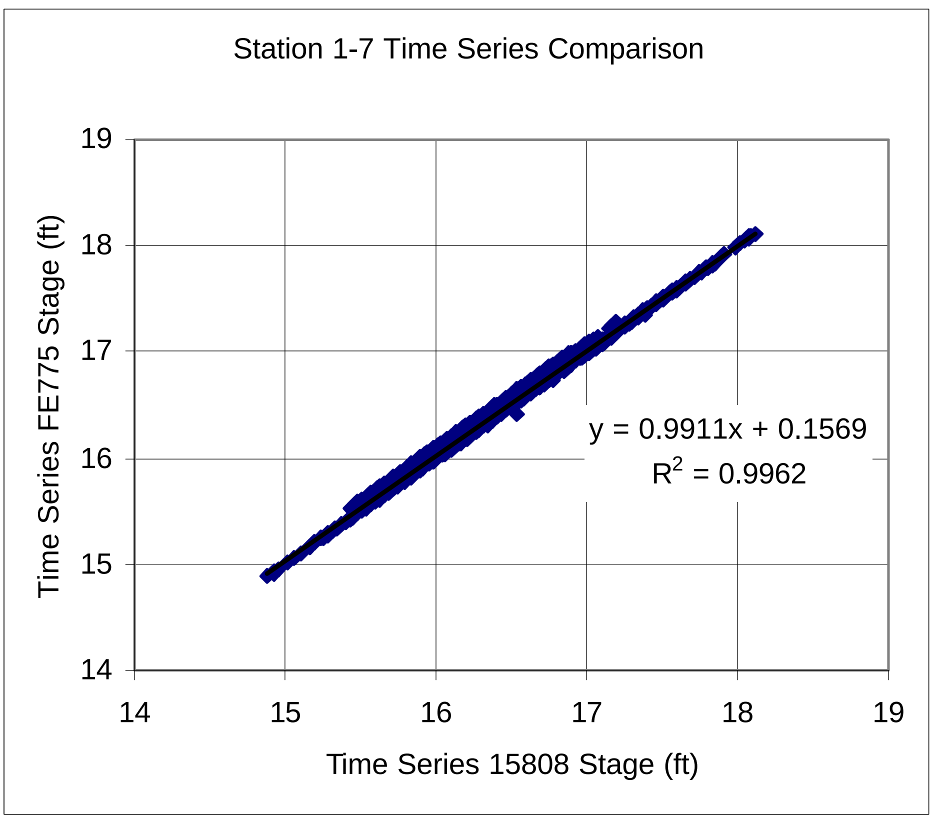
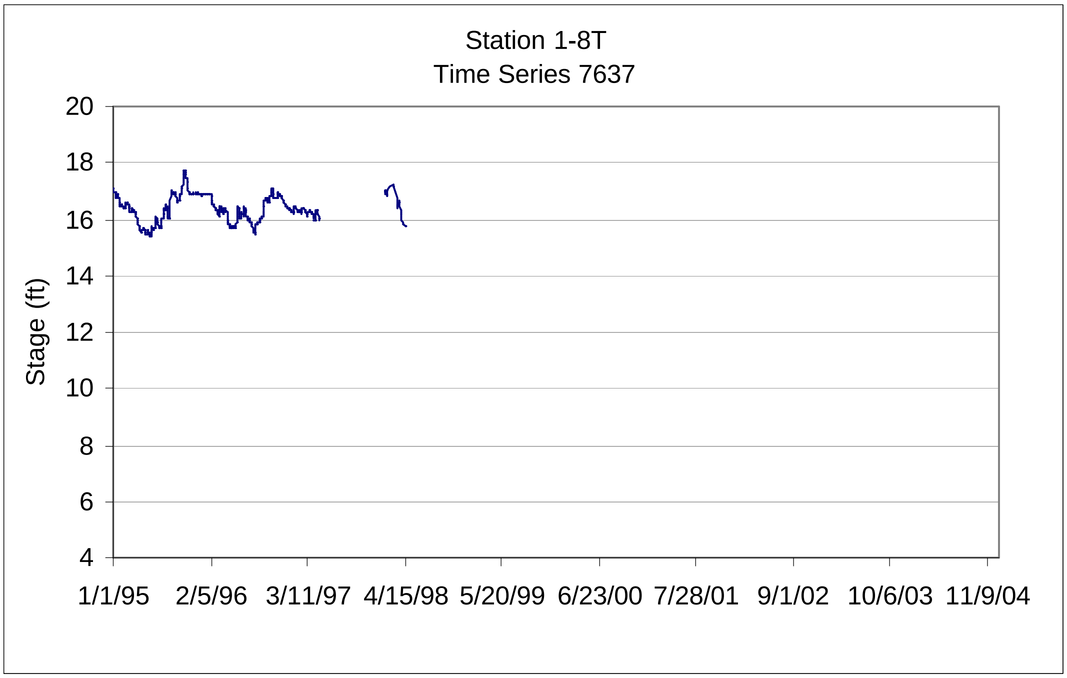


Figure A1.6 Station 1-7 stage time series comparison.



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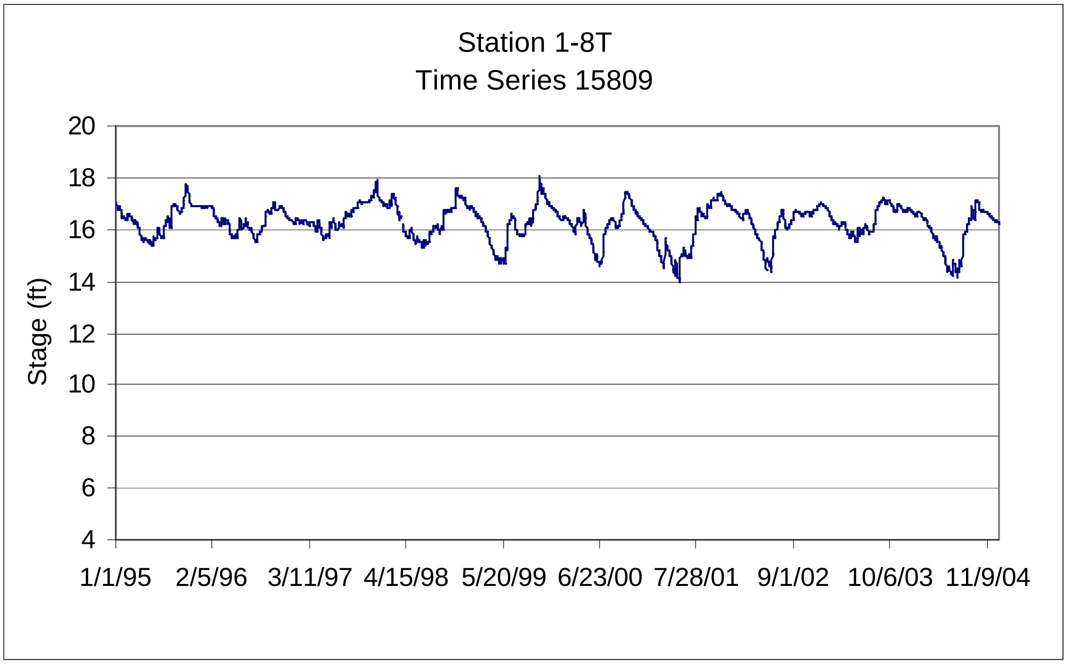

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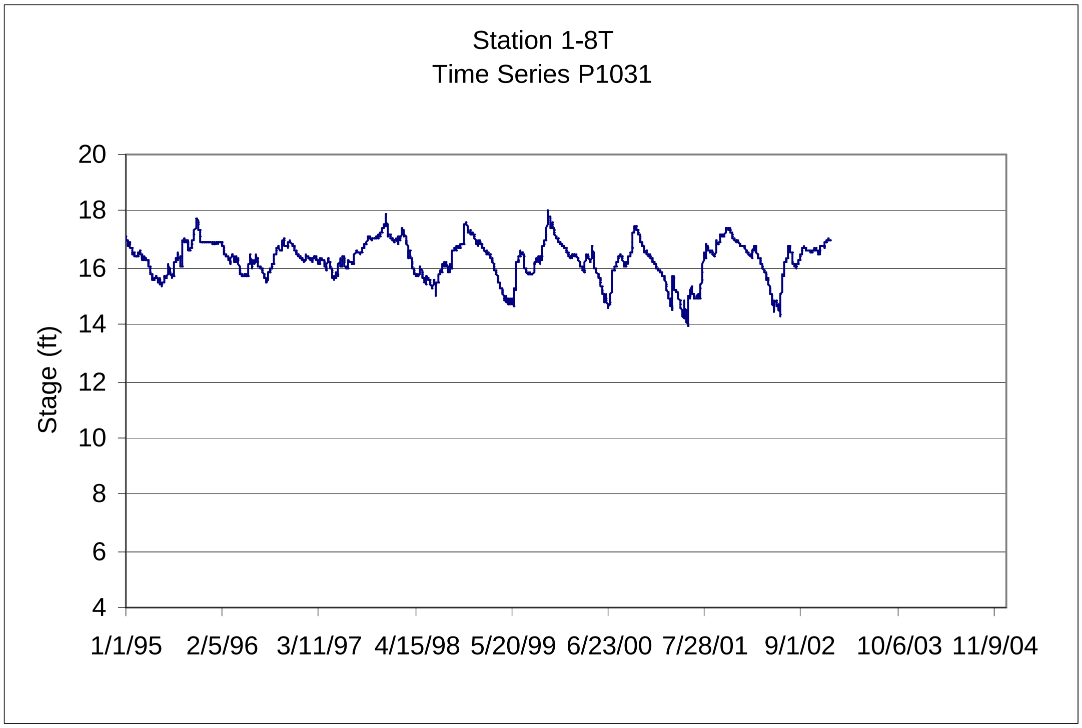

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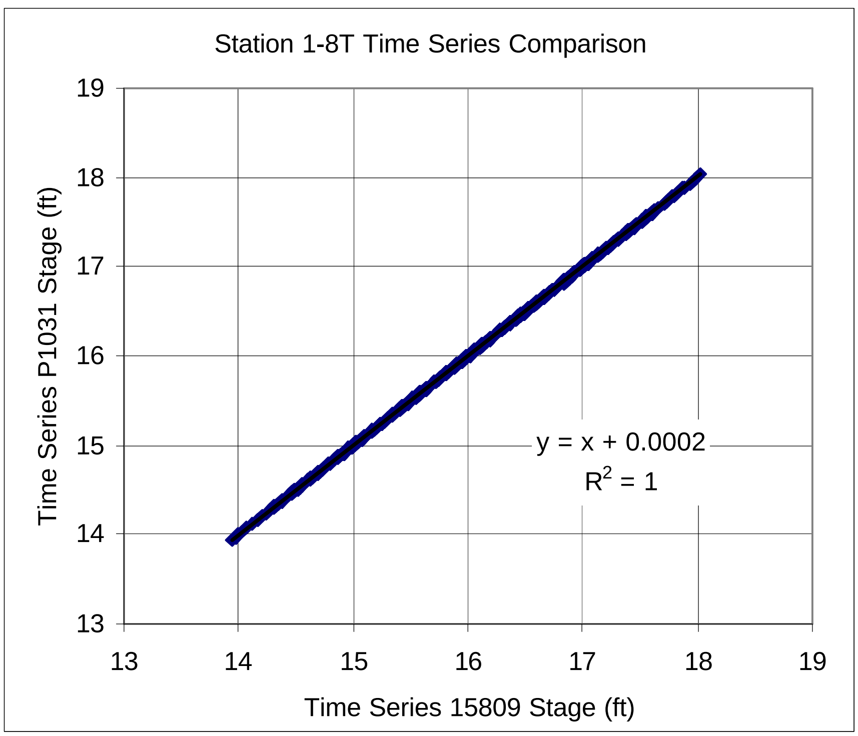
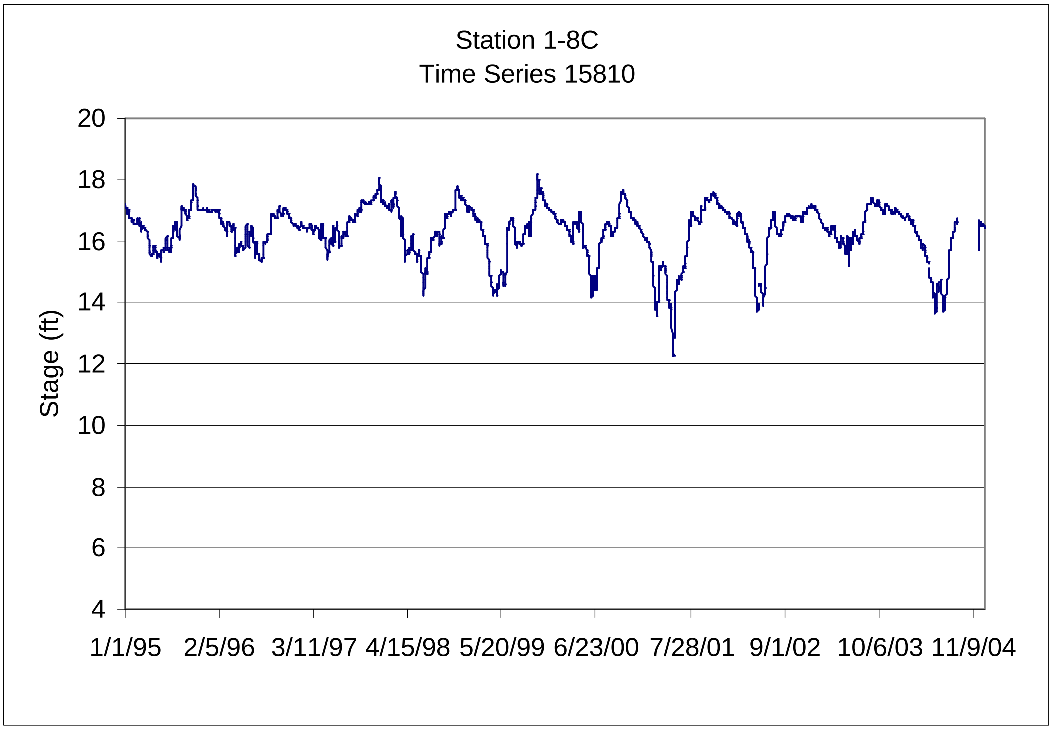


Figure A1.10 Station 1-8T stage time series comparison.



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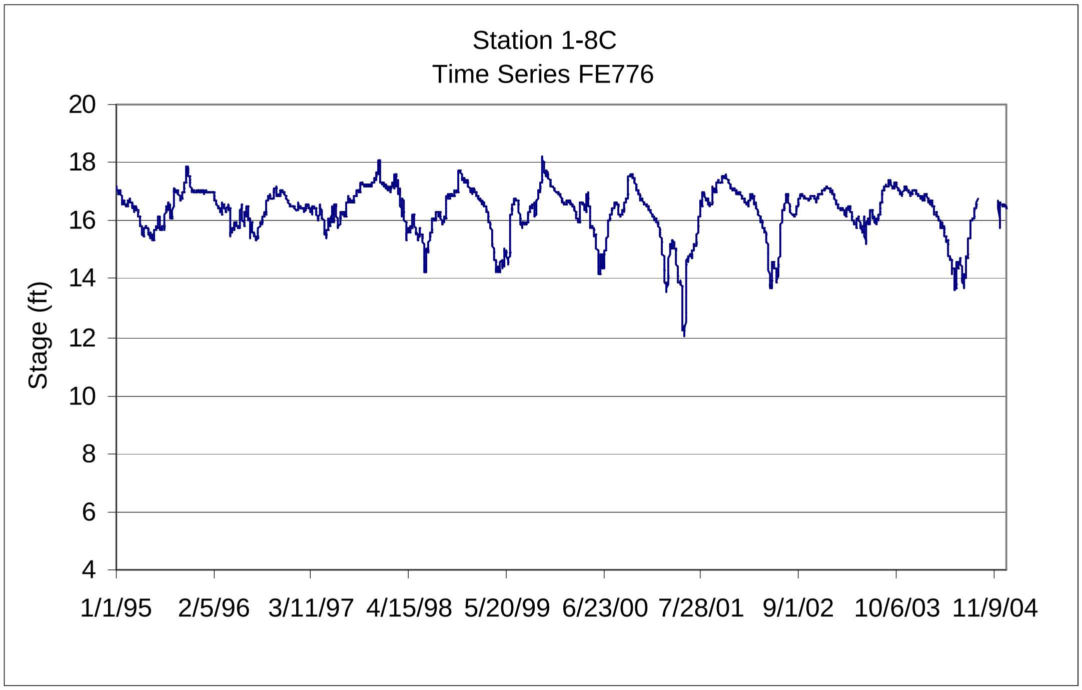

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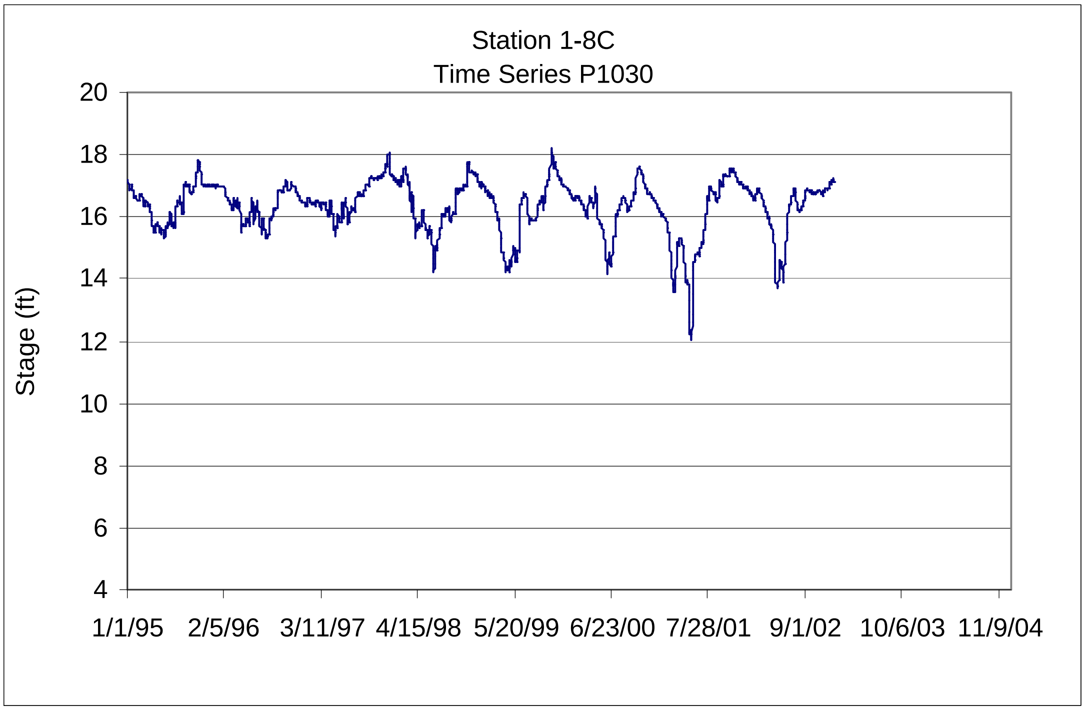

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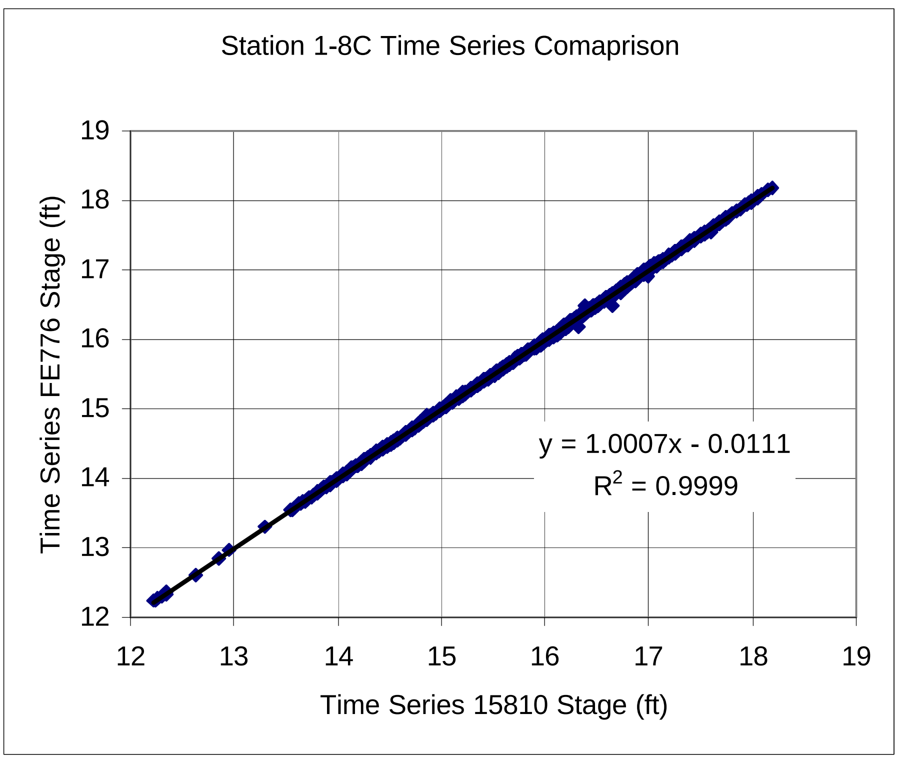
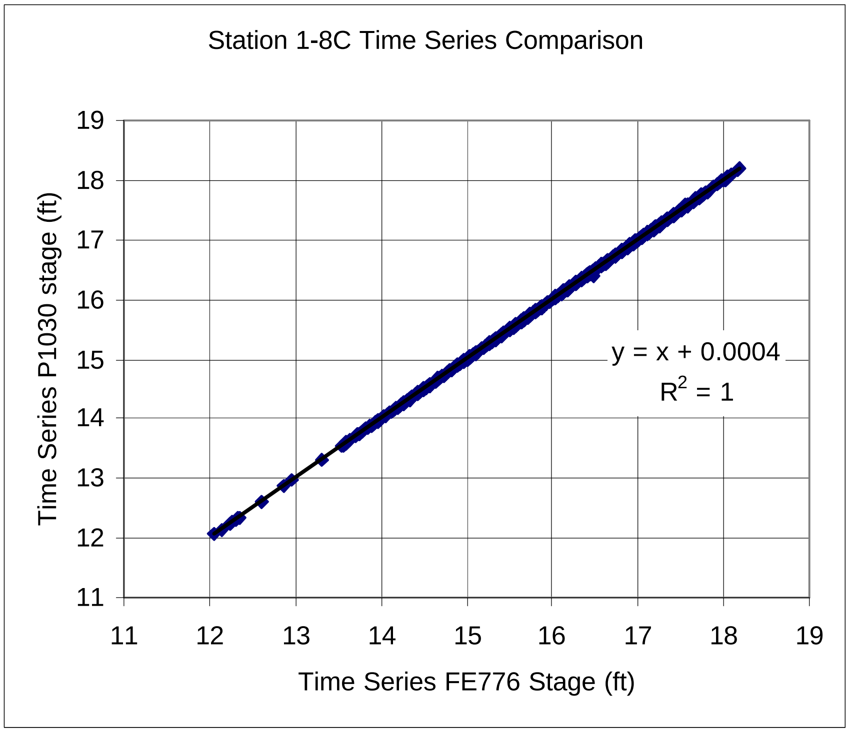


Figure A1.14 Station 1-8C stage time series comparison.



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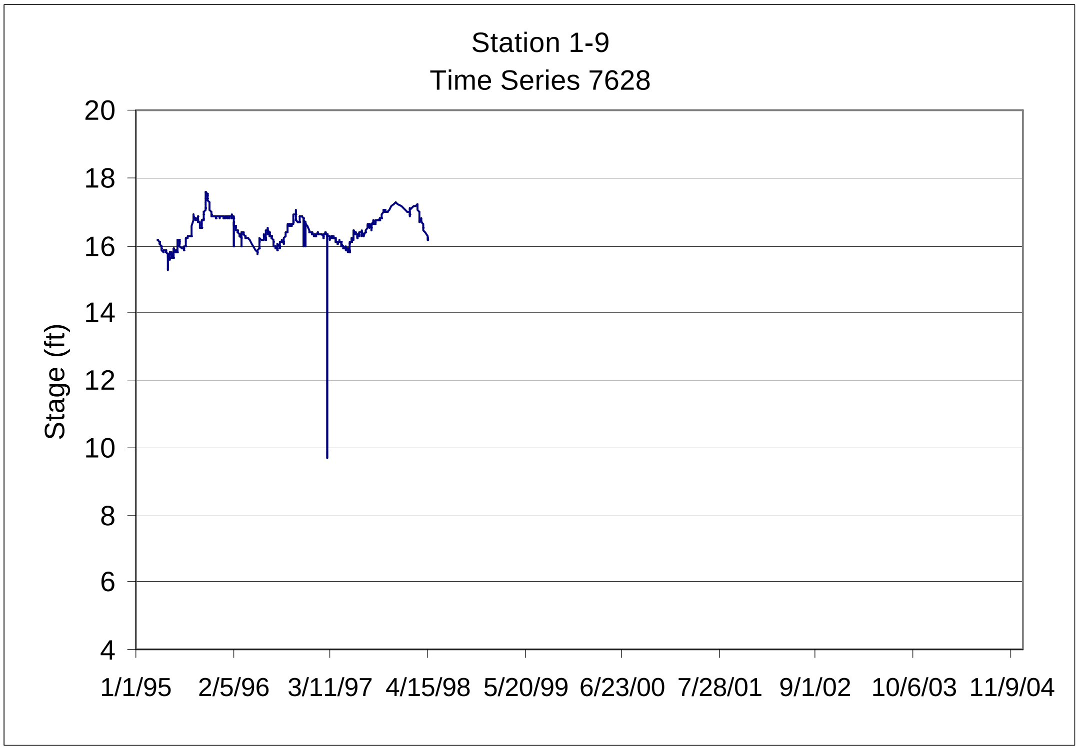

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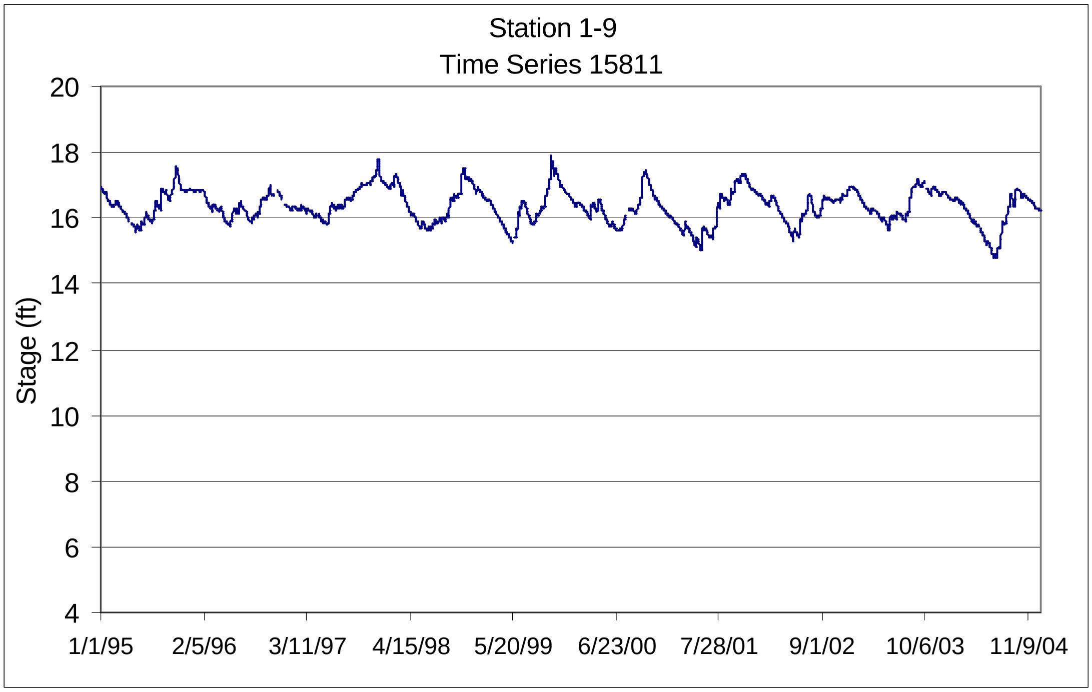

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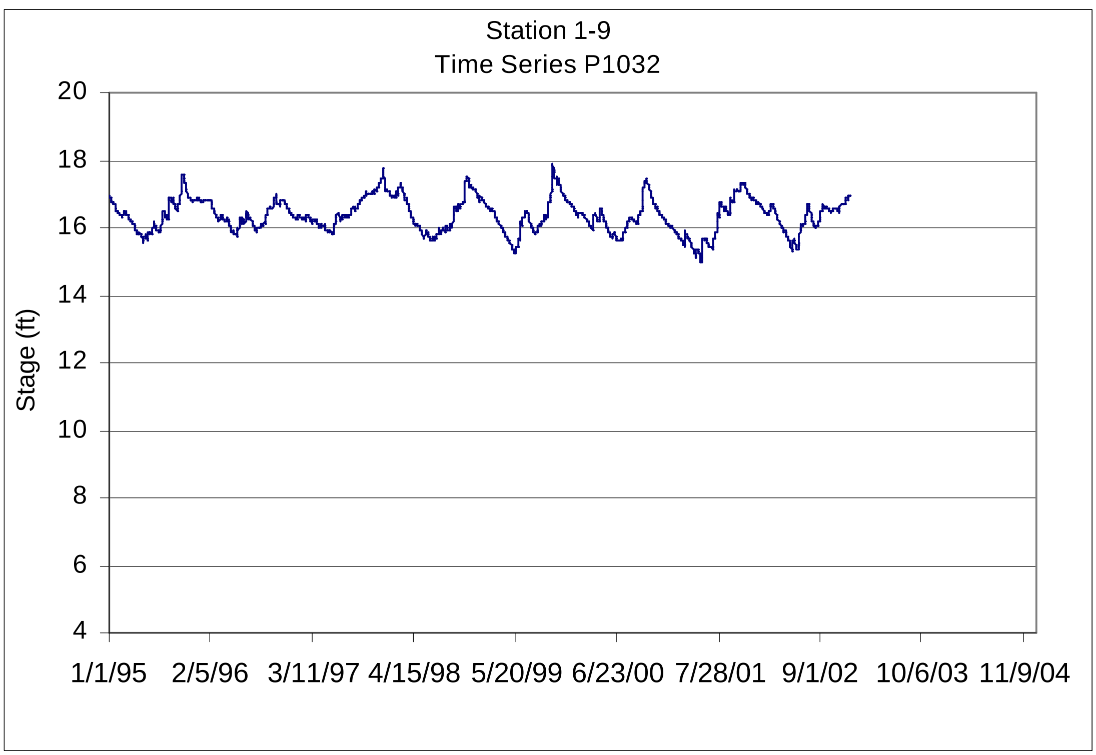

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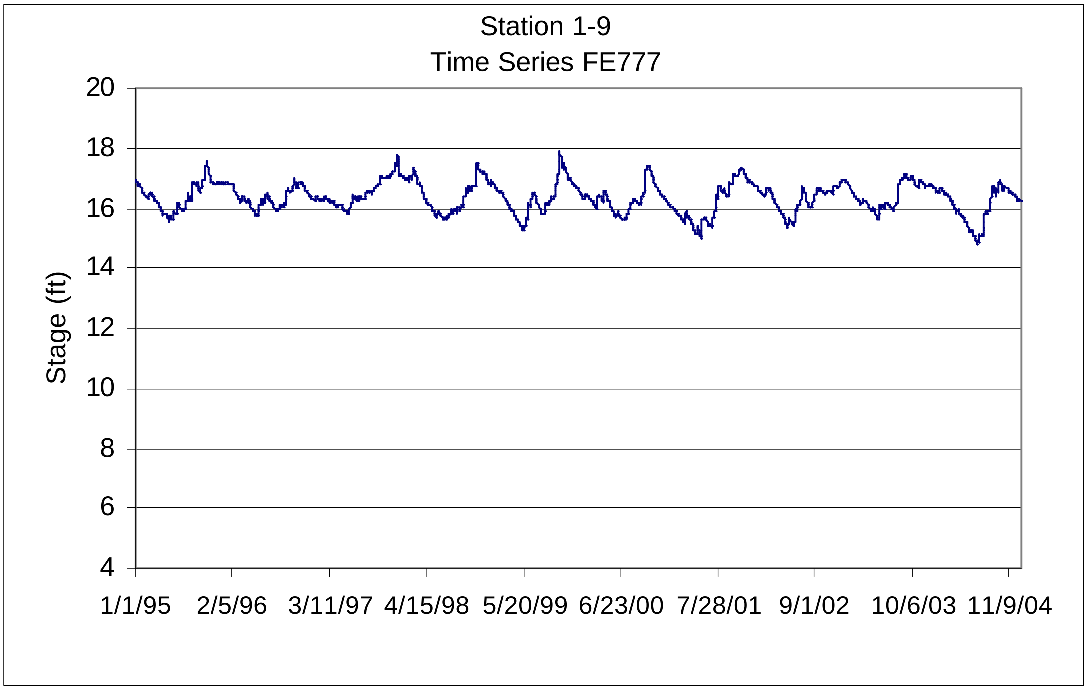

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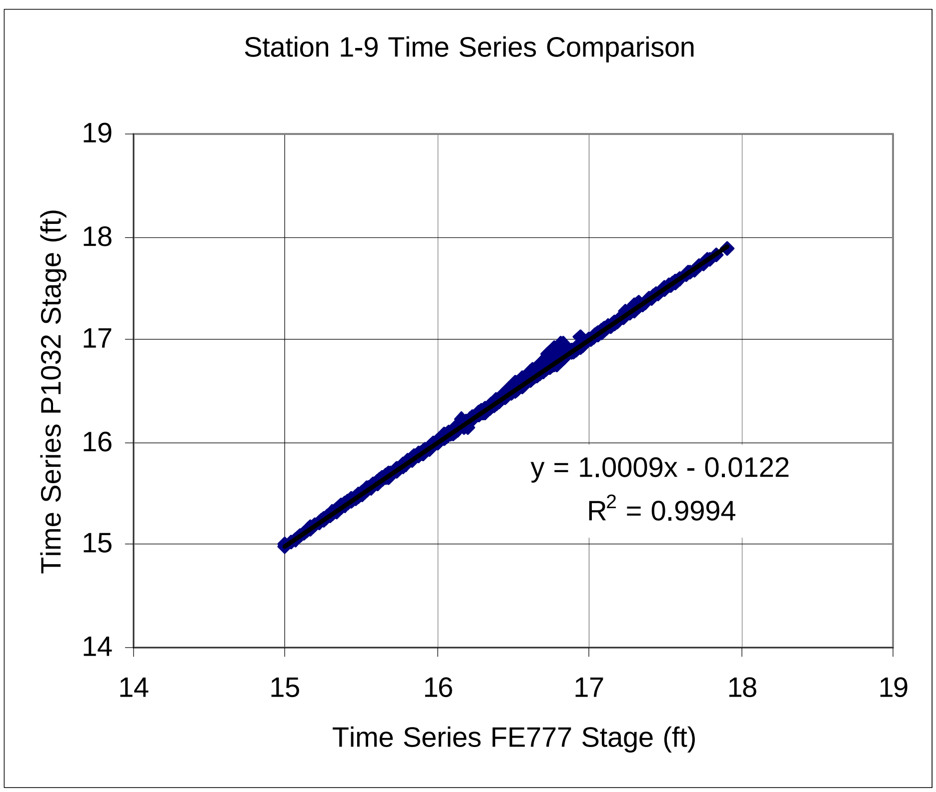


Figure A1.20 Station 1-9 stage time series comparison

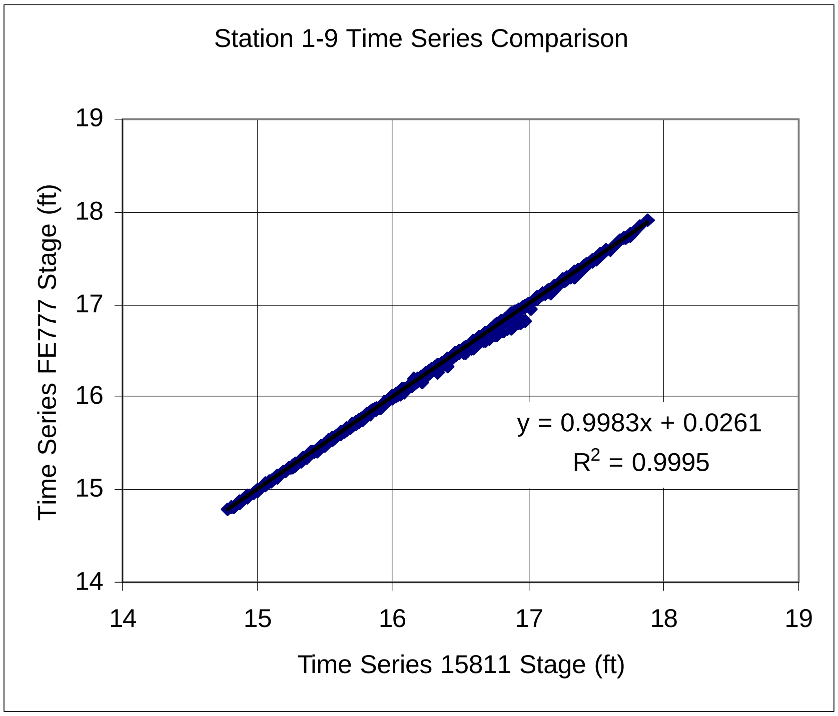


Figure A1.21 Station 1-9 stage time series comparison.

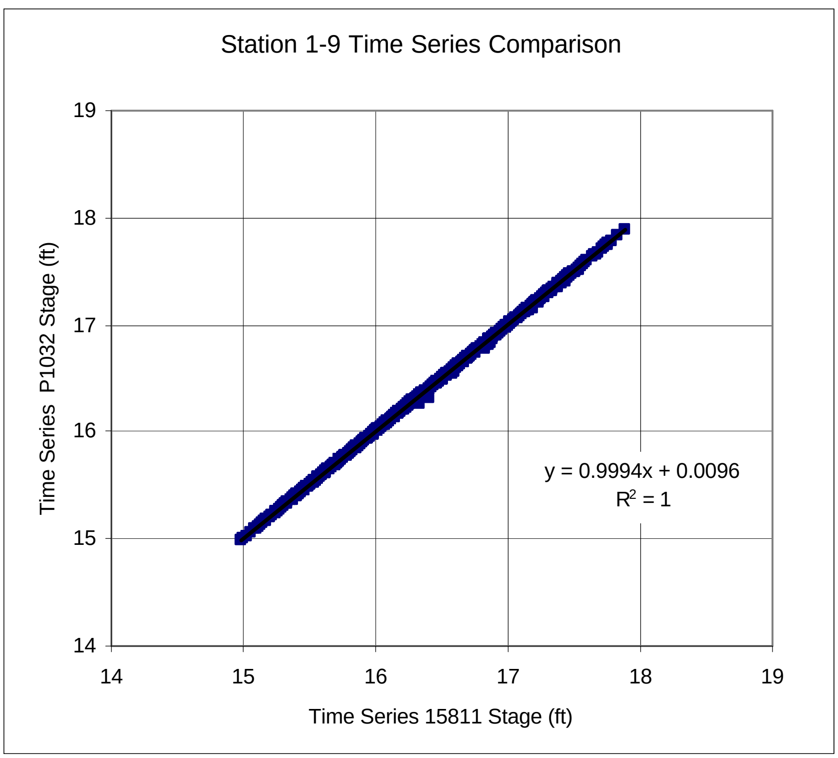


Figure A1.22 Station 1-9 stage time series comparison.

A2 Stages at Flow Control Structures

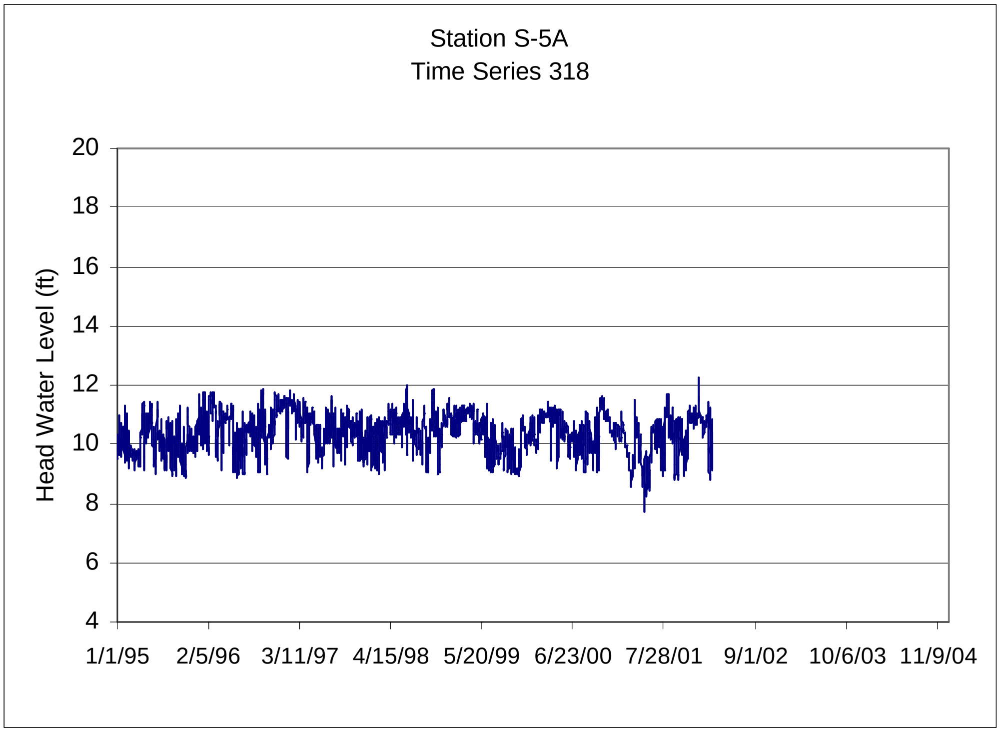
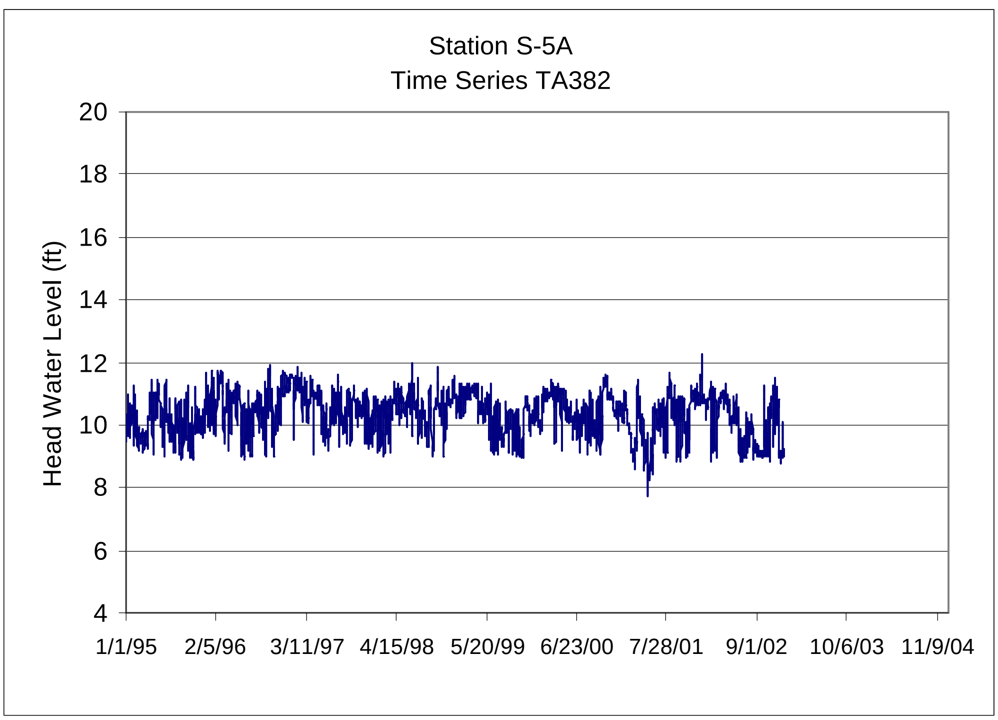


Figure A2.1 Station S-5A Head Water Level



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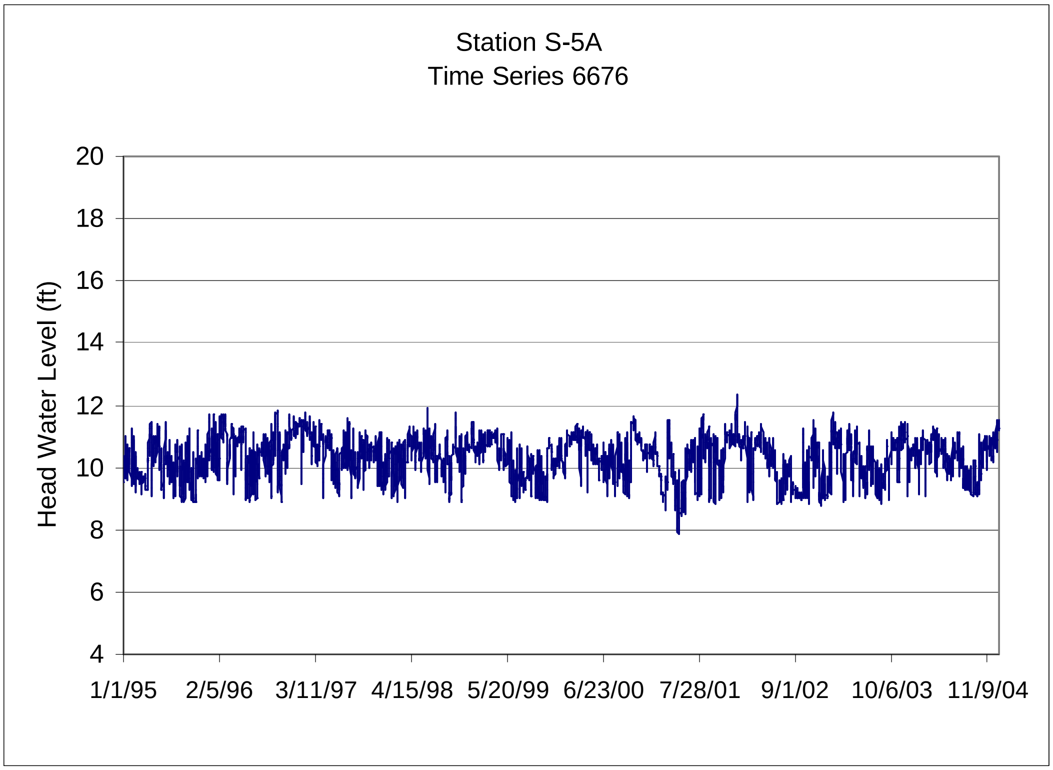

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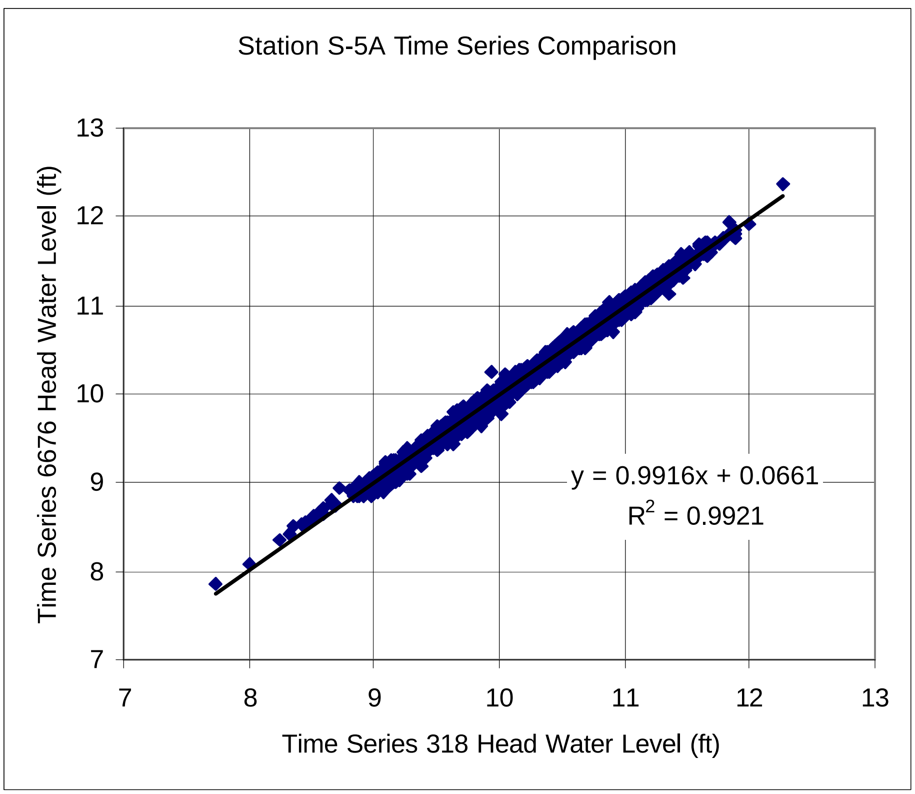

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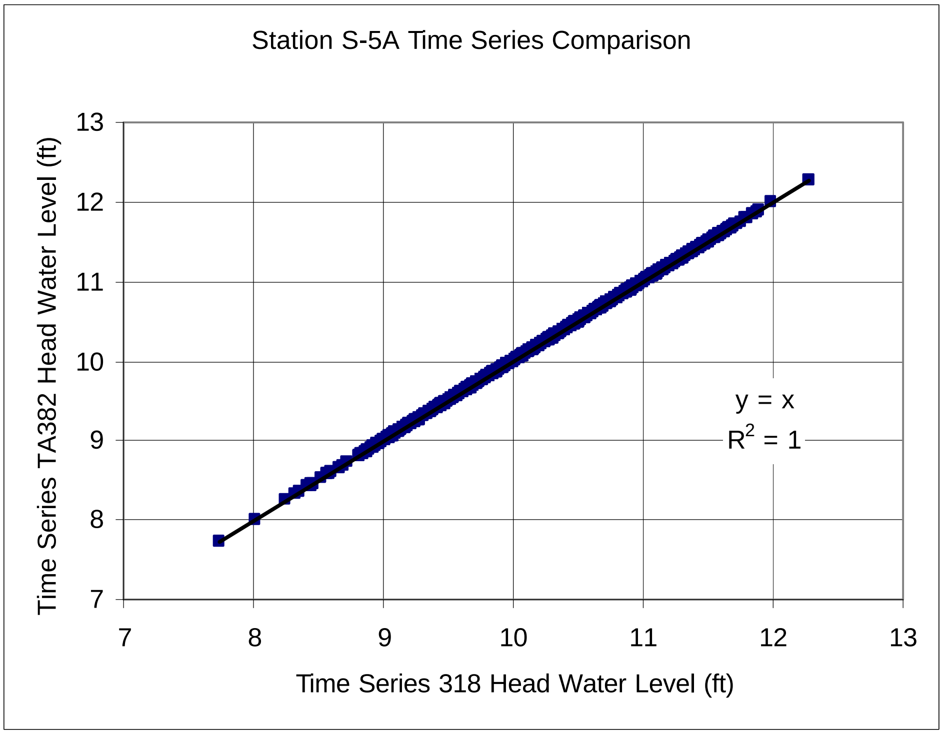

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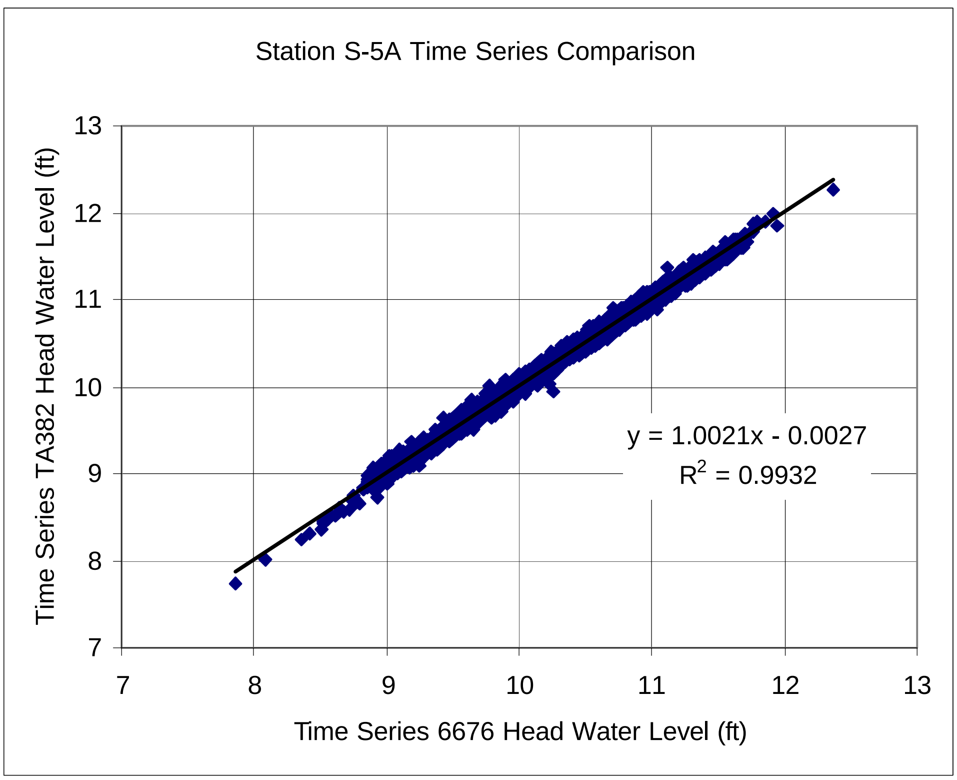


Figure A2.6 Station S-5A head water level time series comparison.

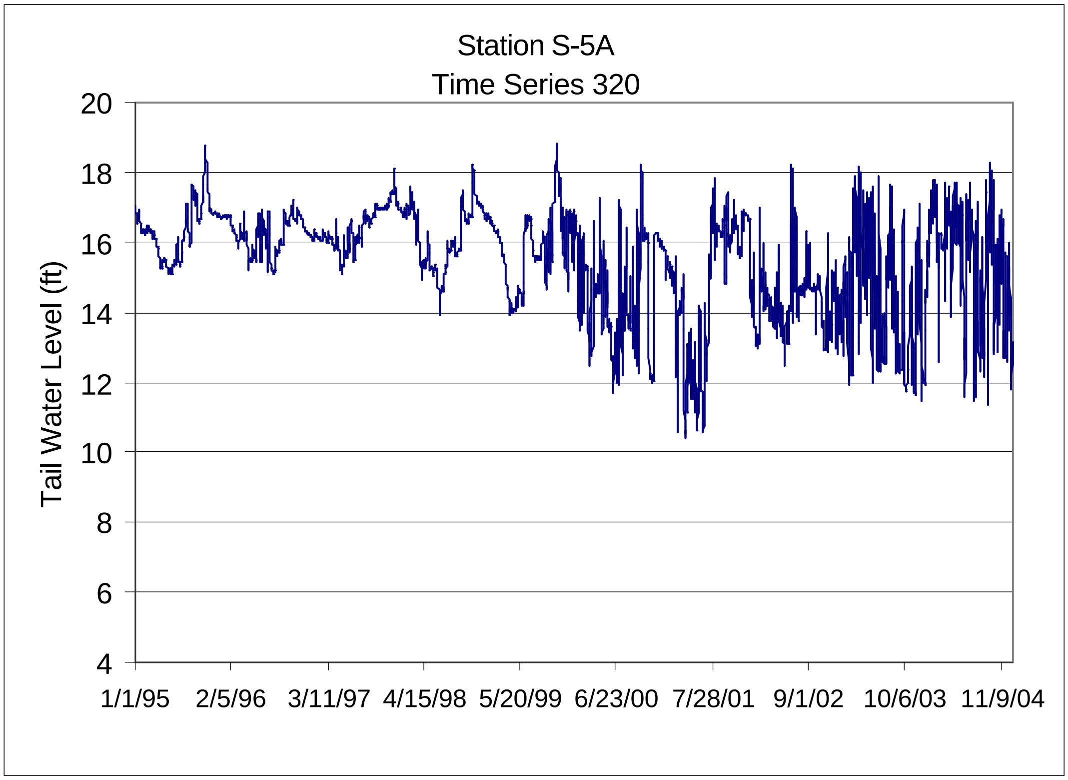


Figure A2.7 Station S-5A Tail Water Level

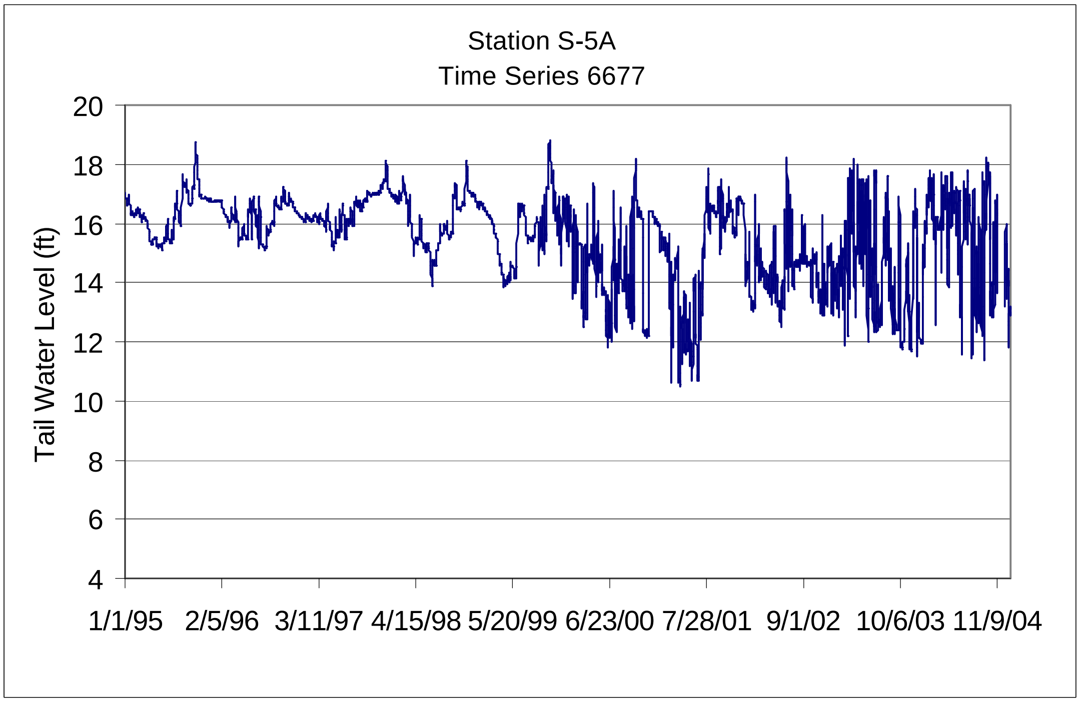
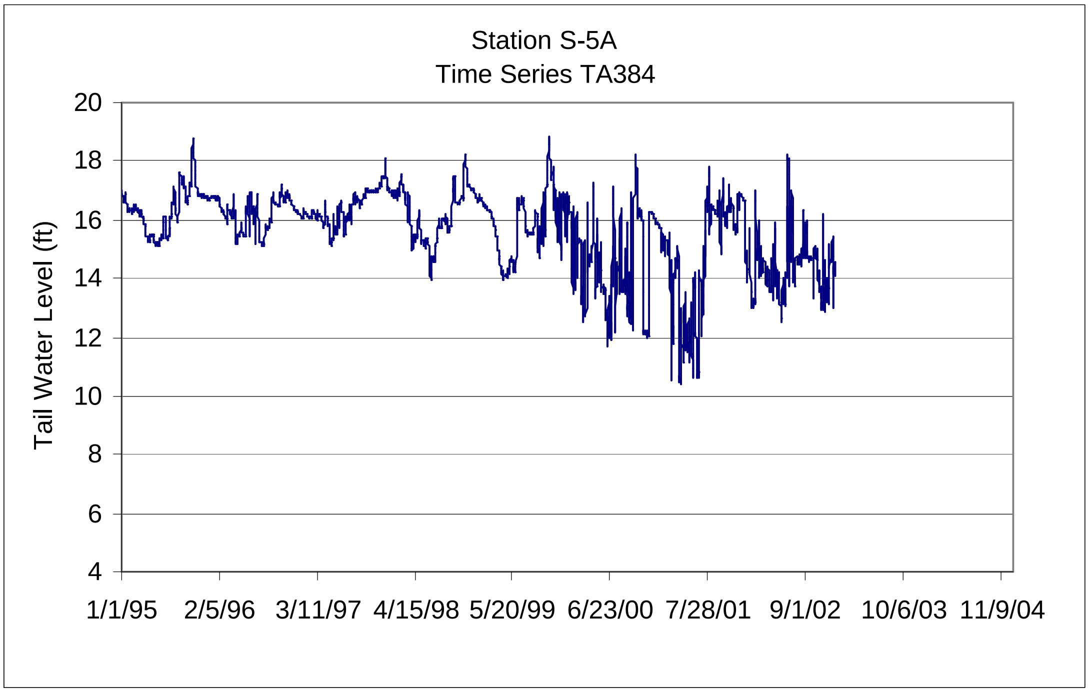


Figure A2.8 Station S-5A Tail Water Level



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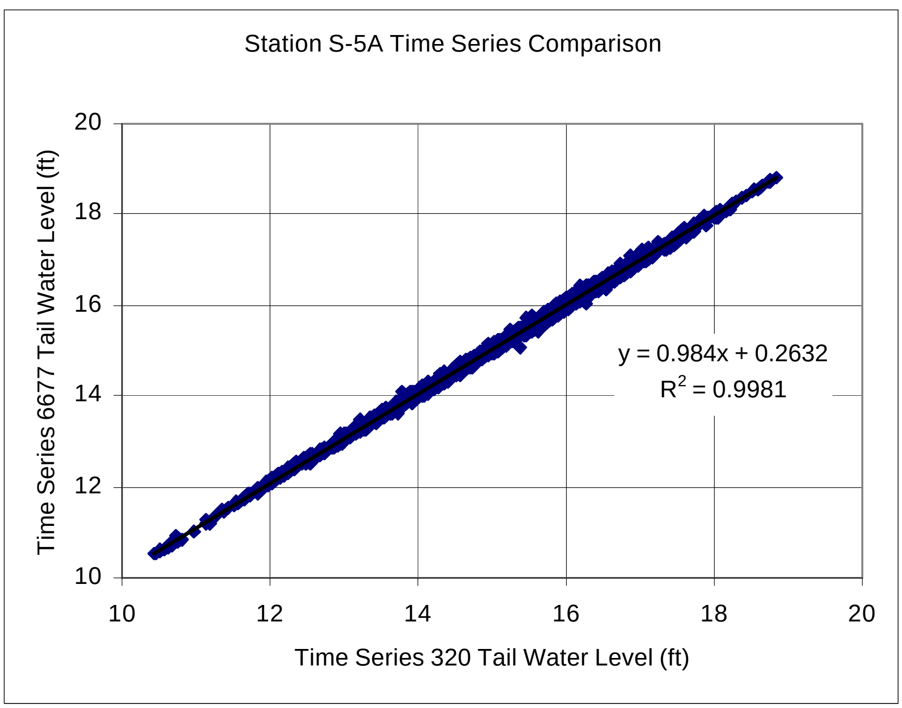
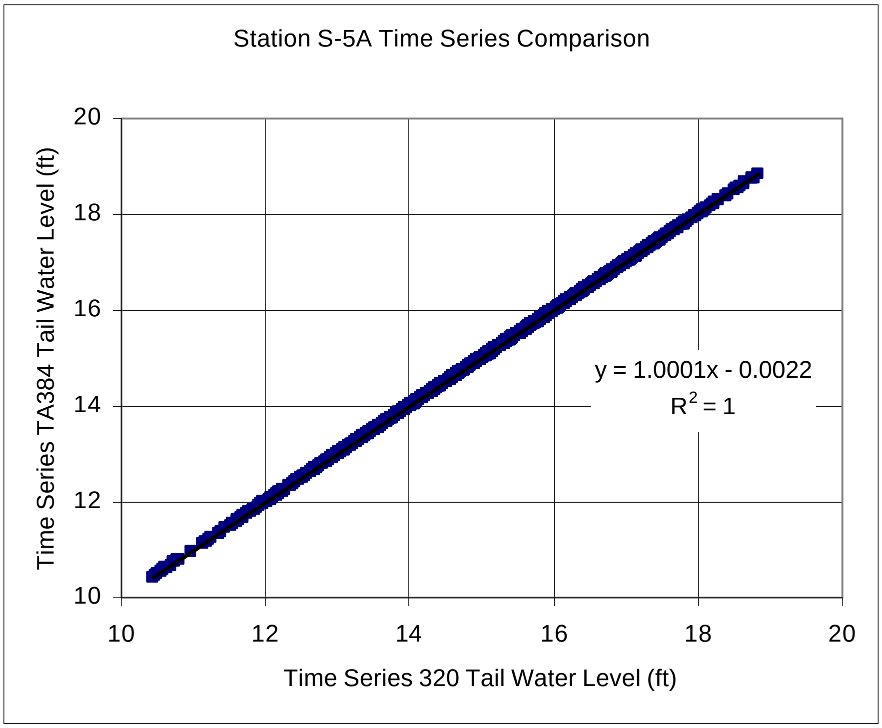


Figure A2.10 Station S-5A tail water level time series comparison.



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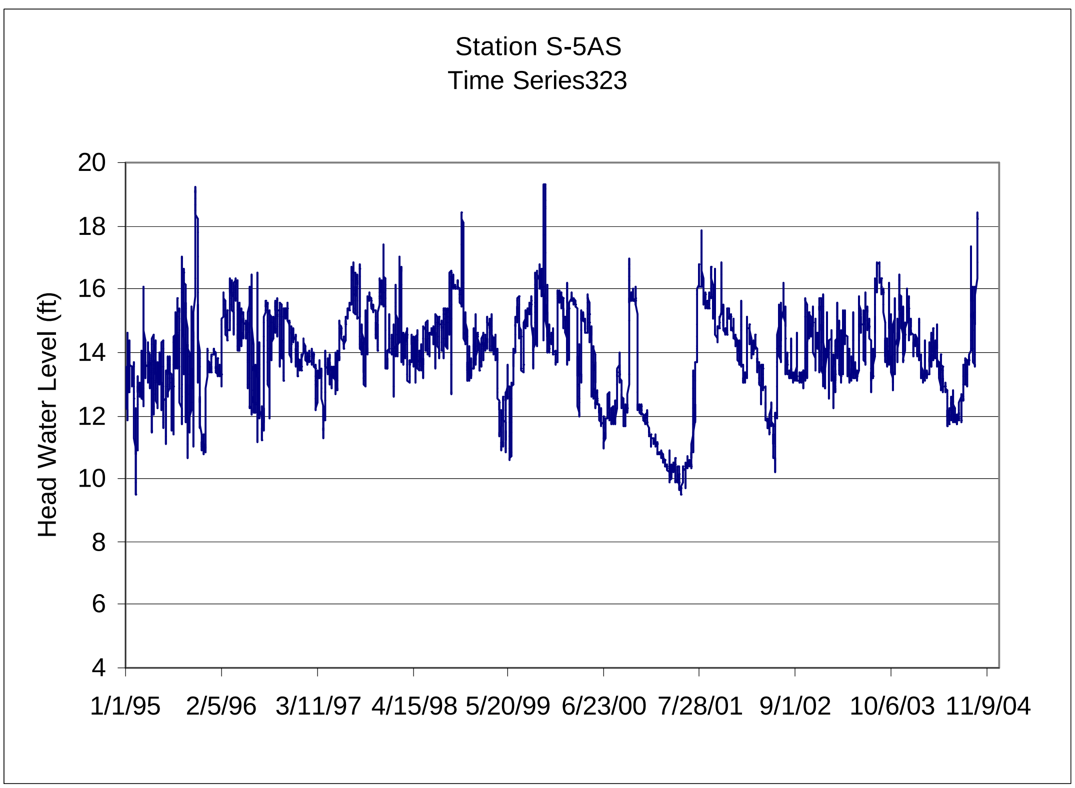

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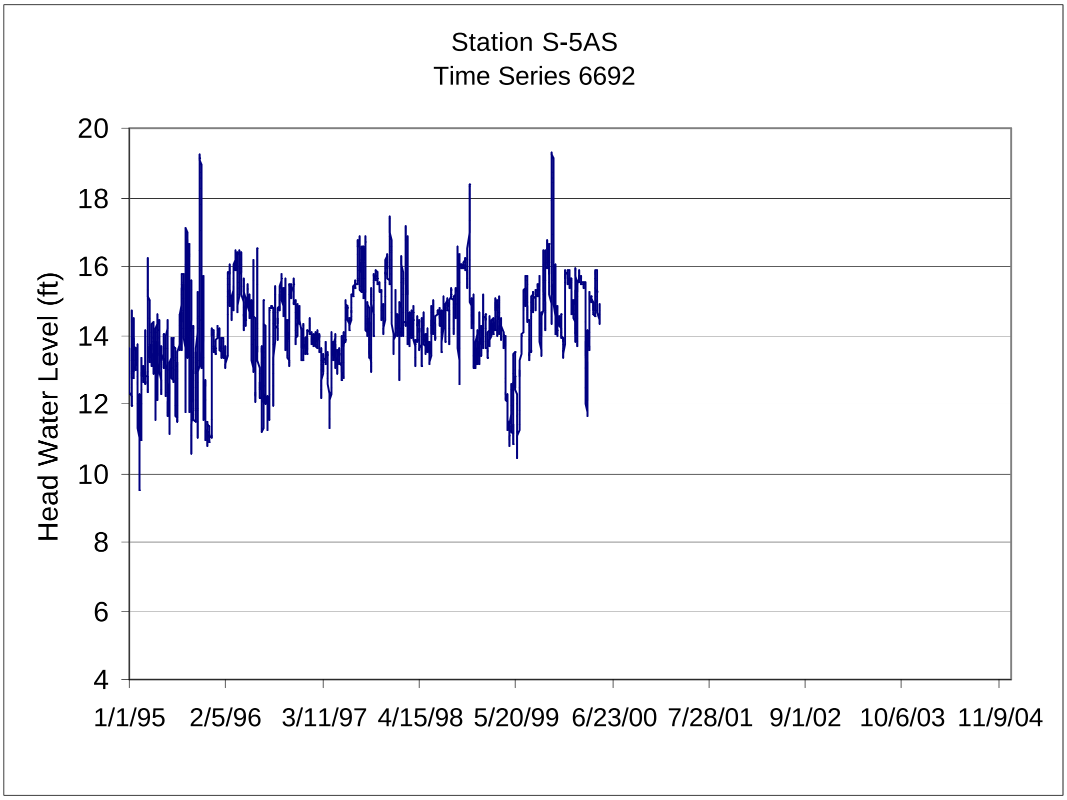

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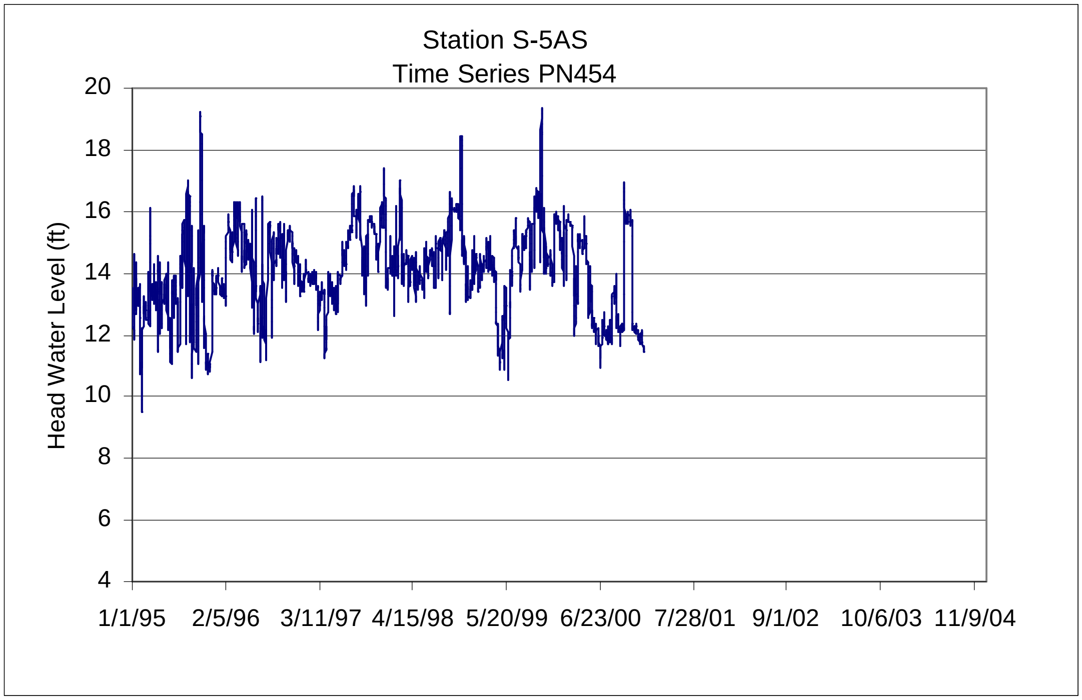

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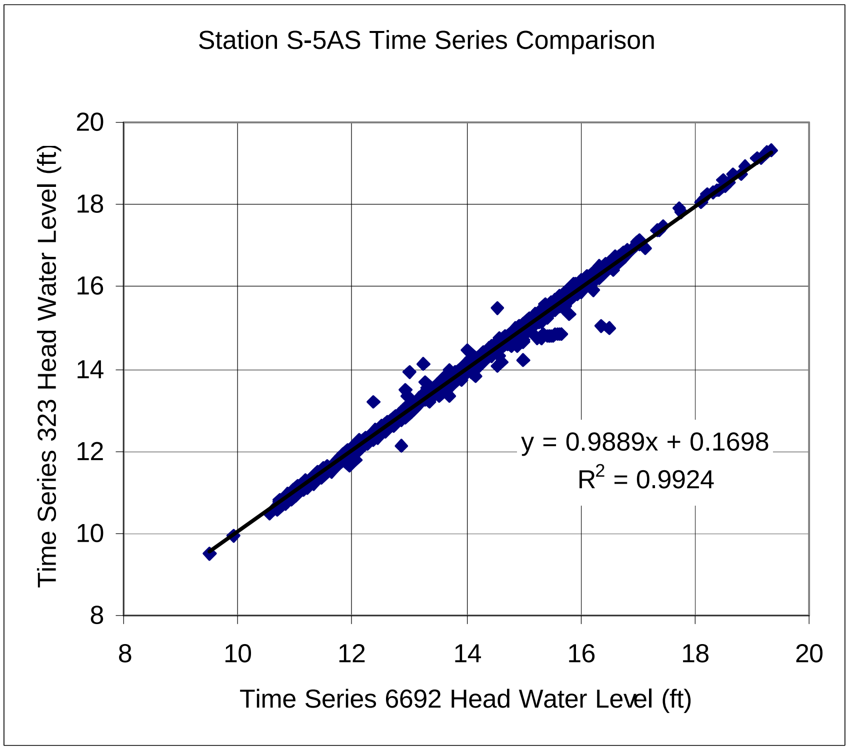

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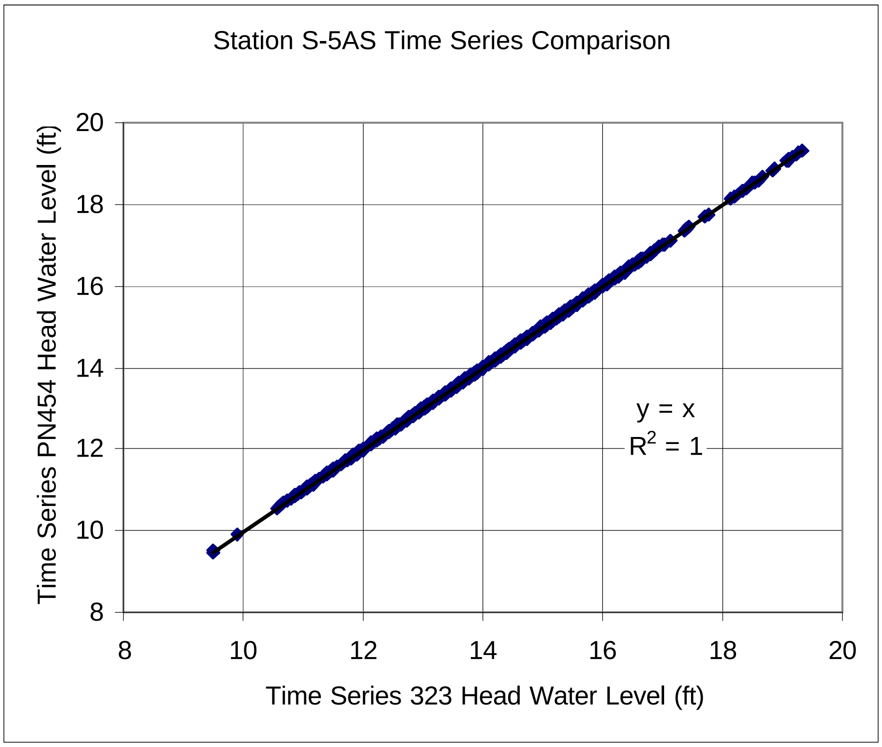

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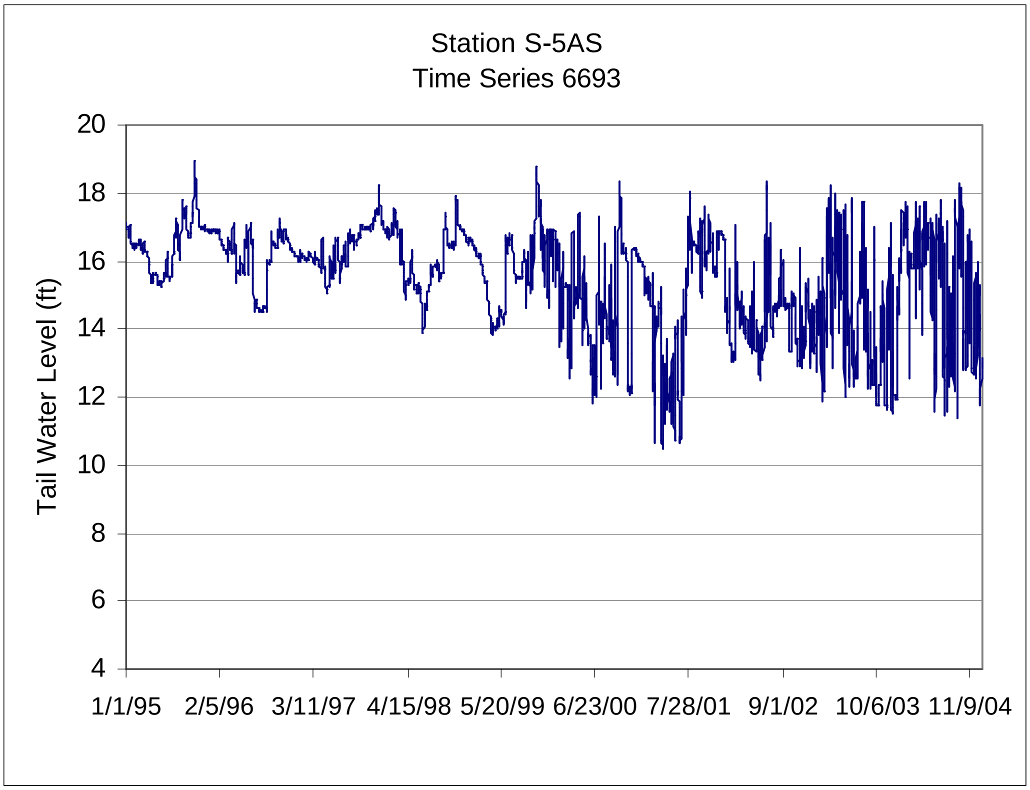
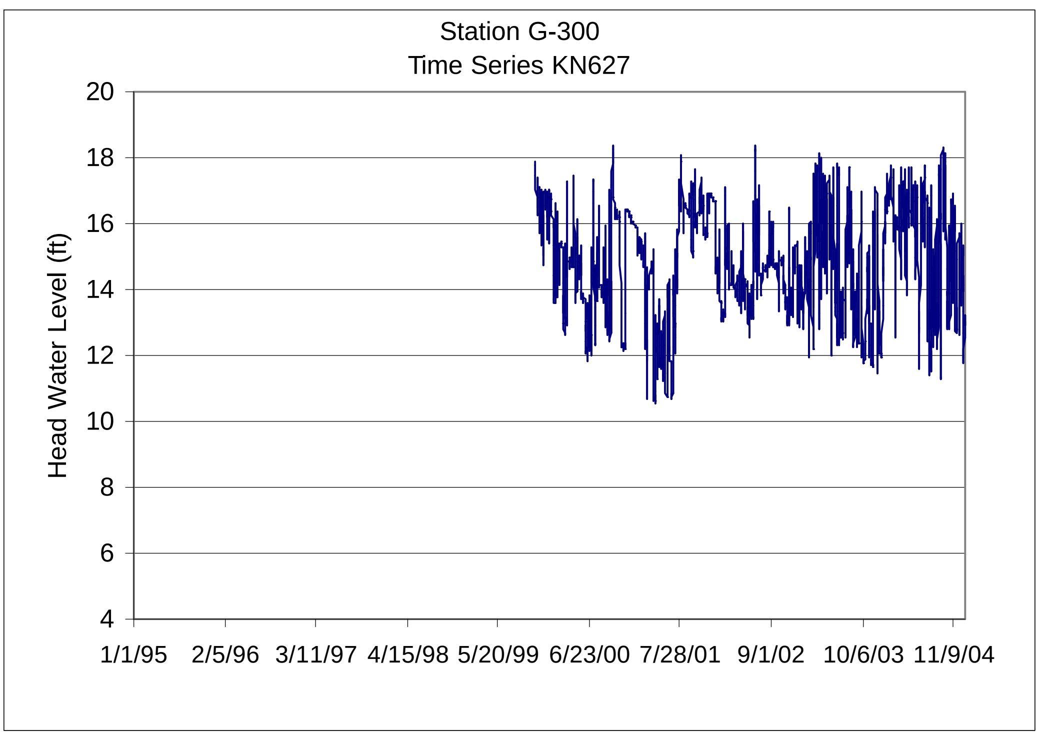


Figure A2.17 Station S-5AS Tail Water Level



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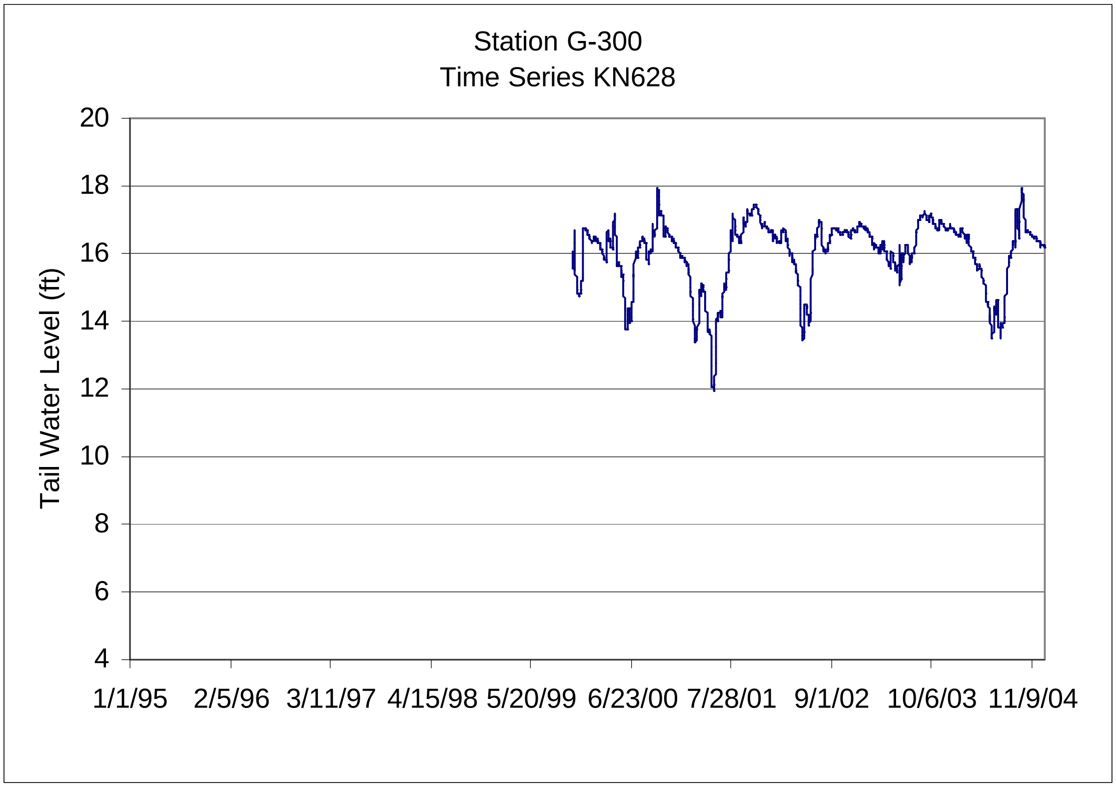

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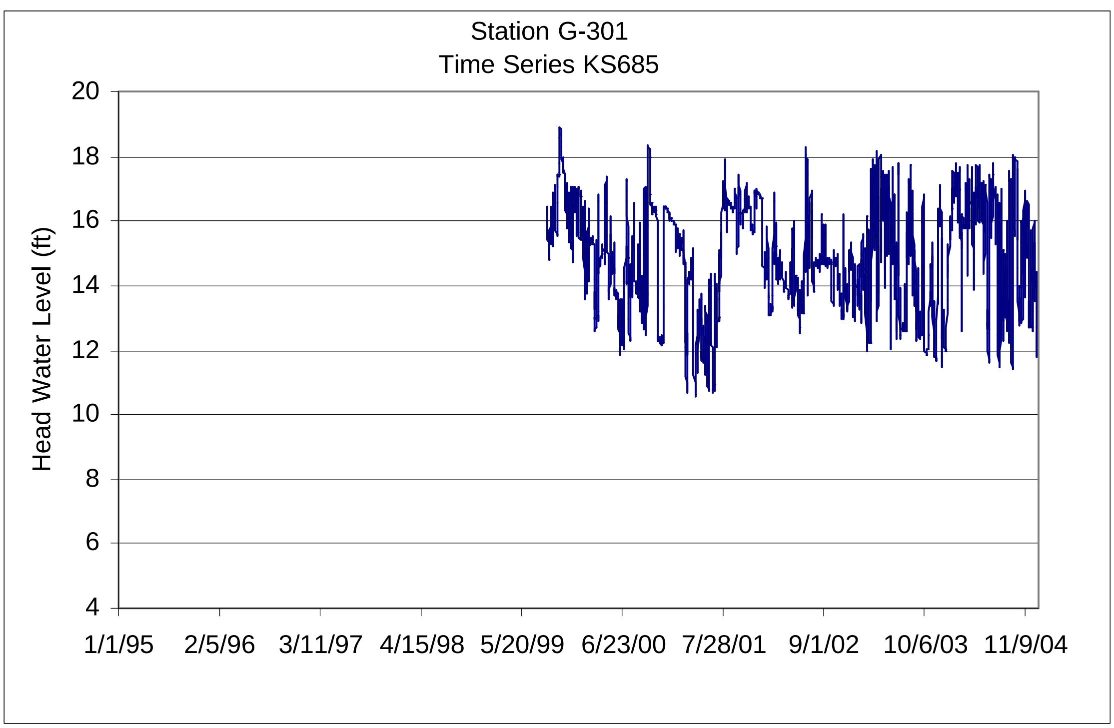

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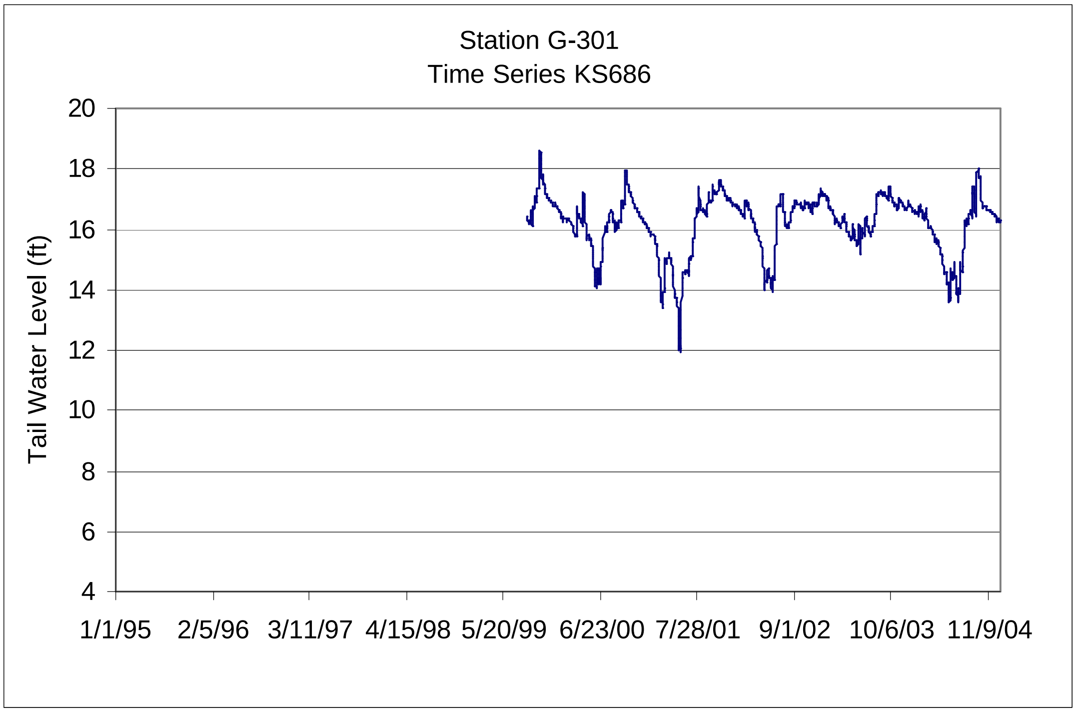

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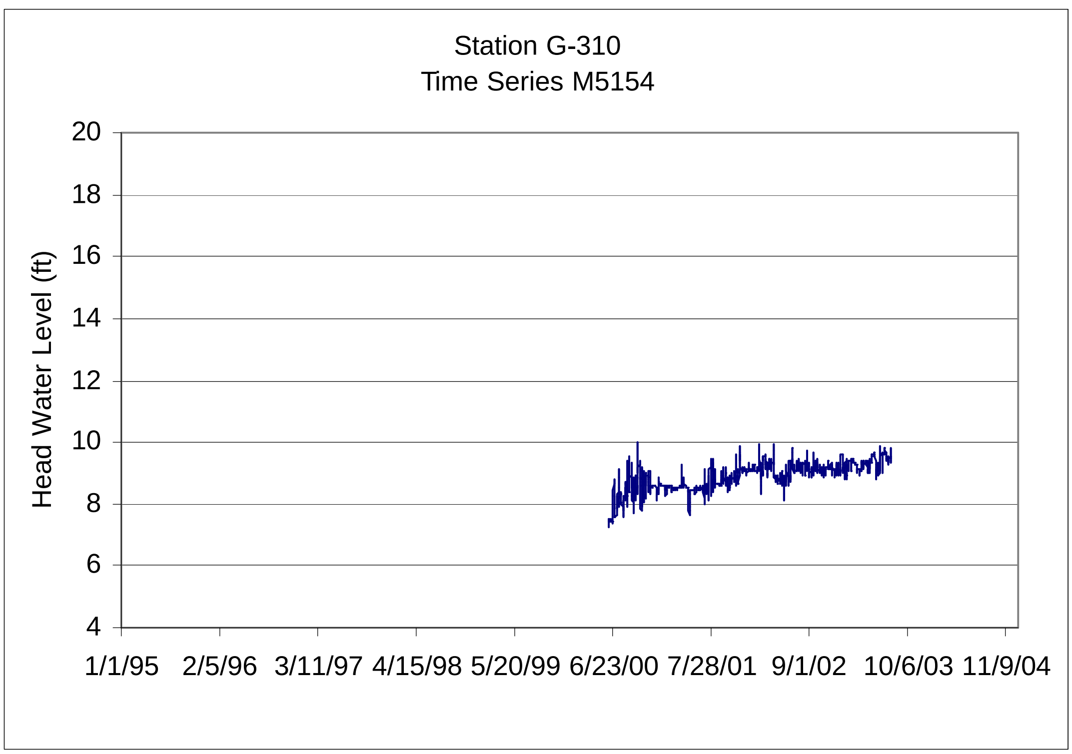

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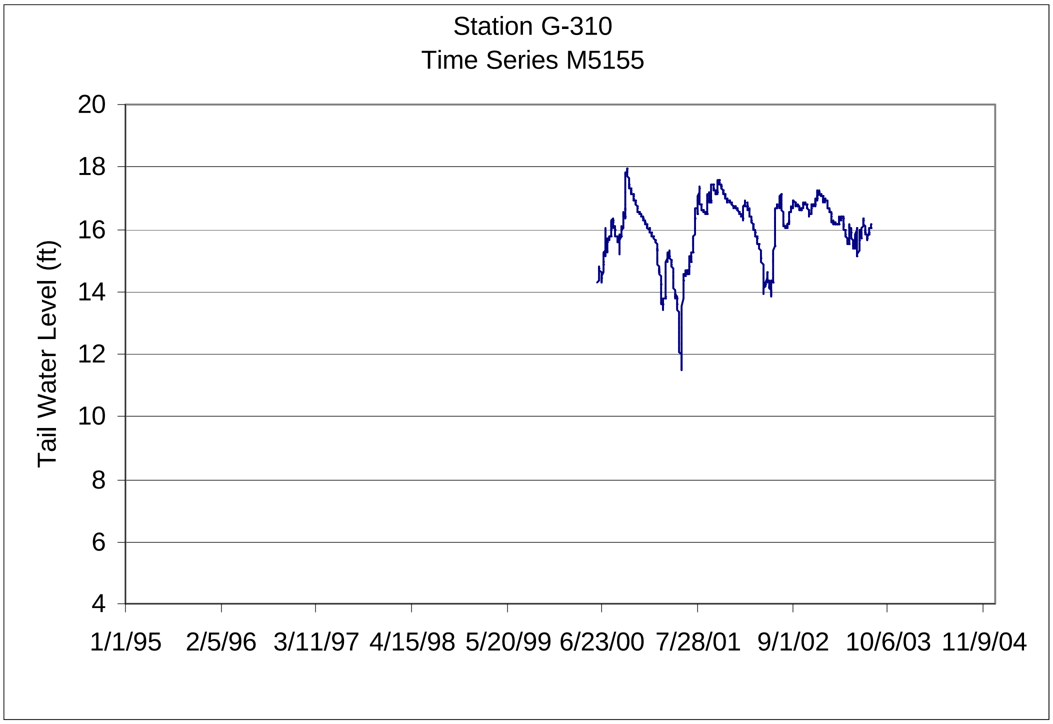

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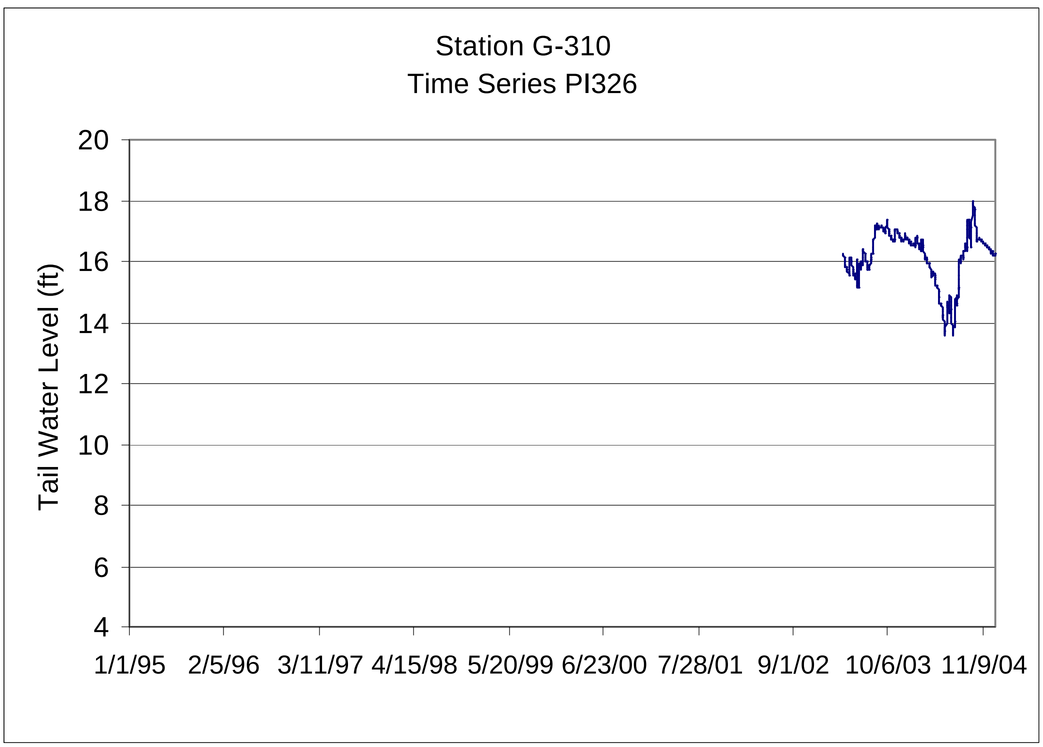

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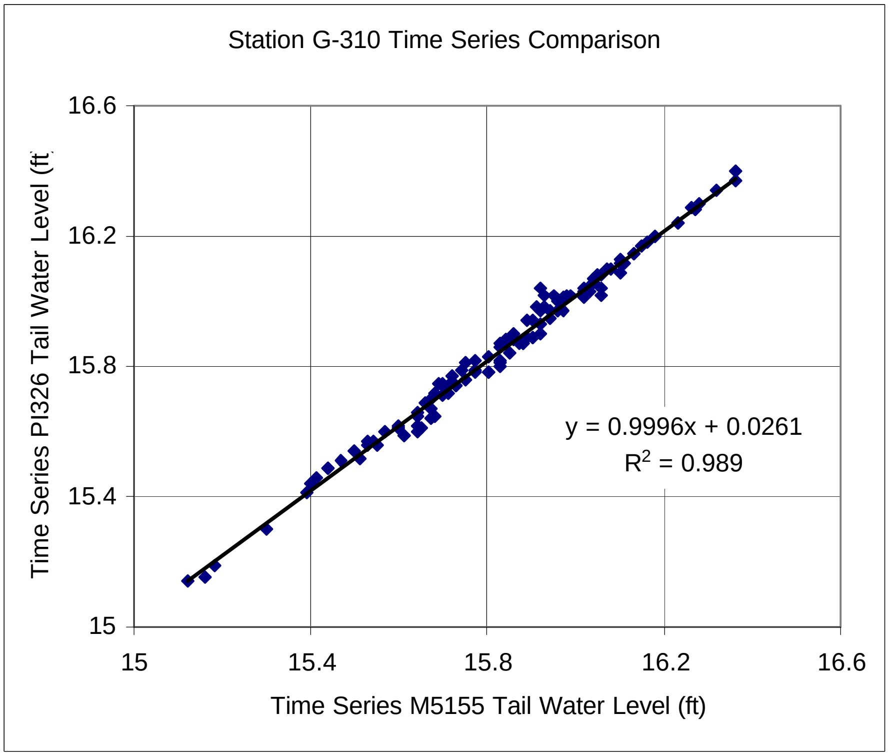


Figure A2.25 Station G-310 tail water level time series comparison.

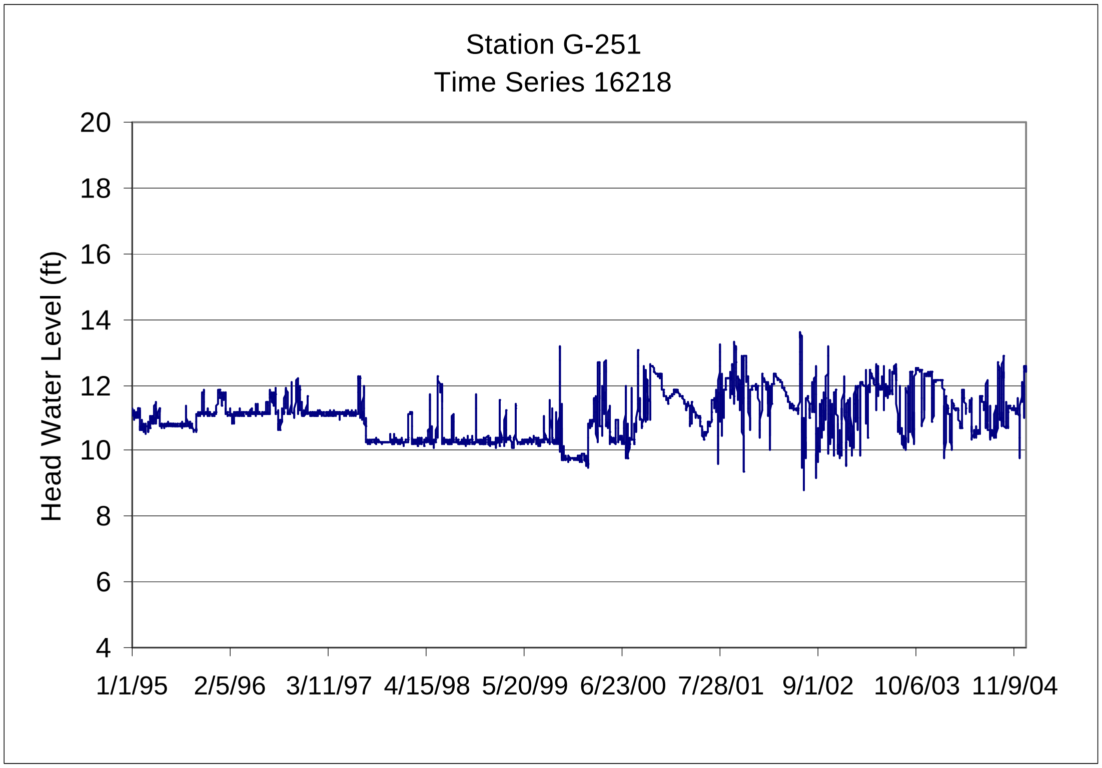
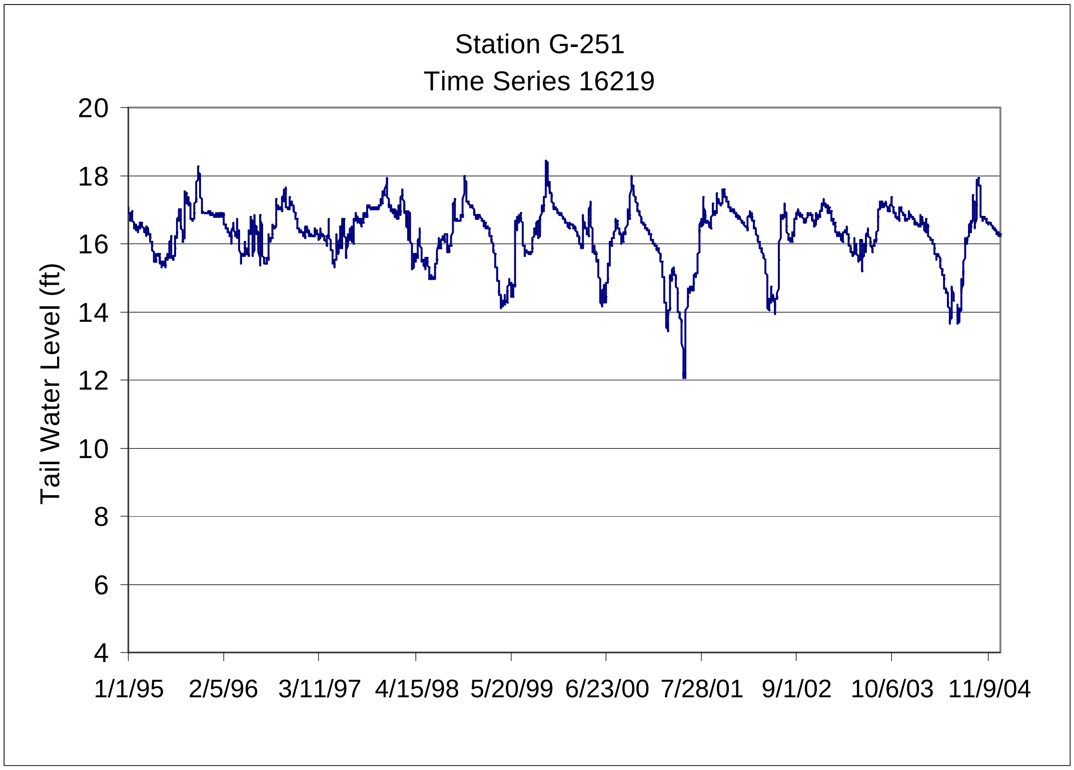


Figure A2.26 Station G-251 Head Water Level



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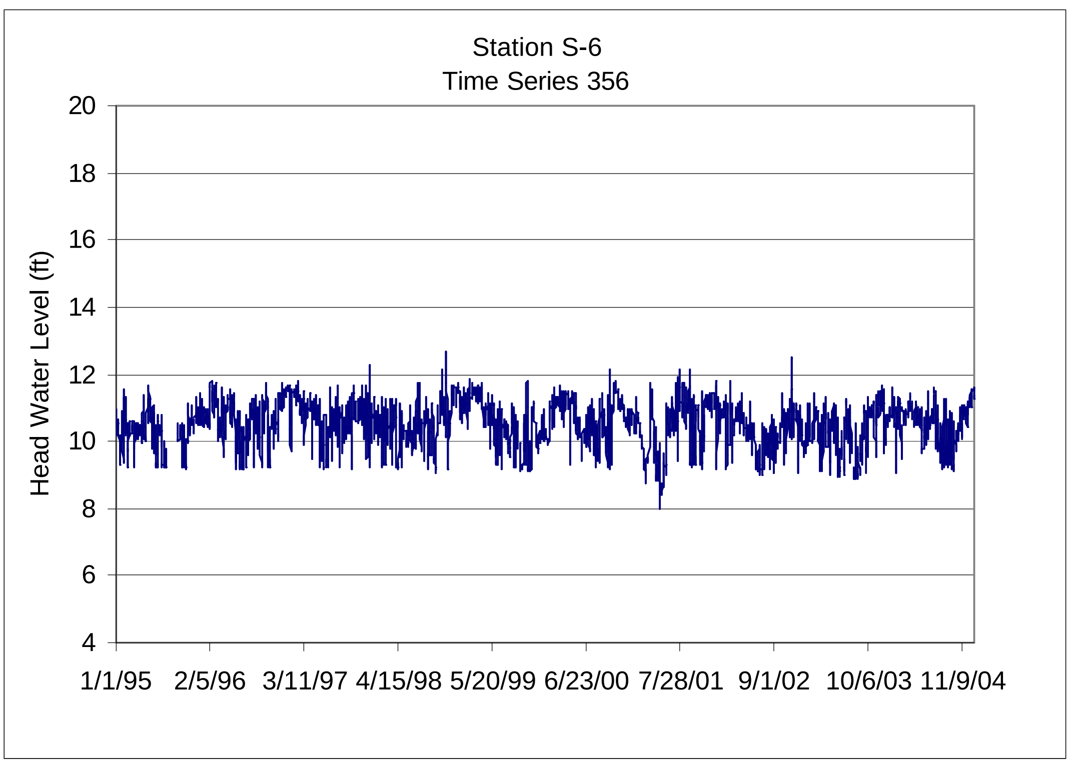

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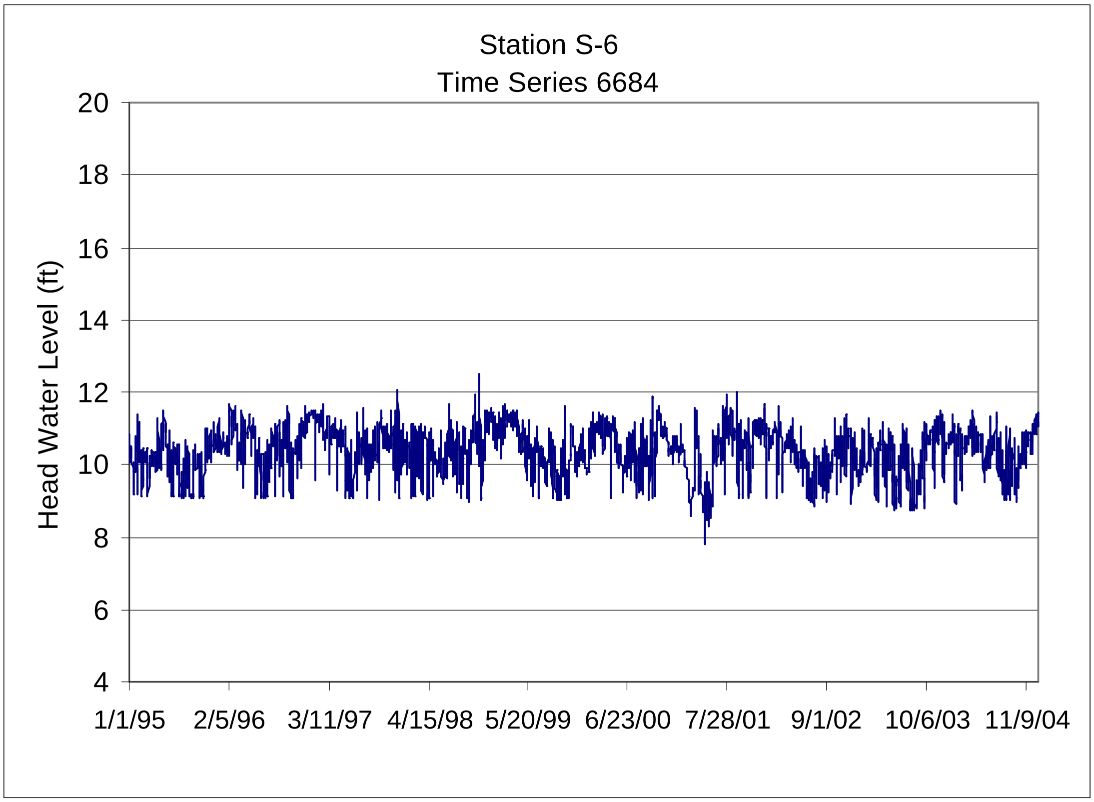

Figure A2.29 Station S-6 Head Water Level

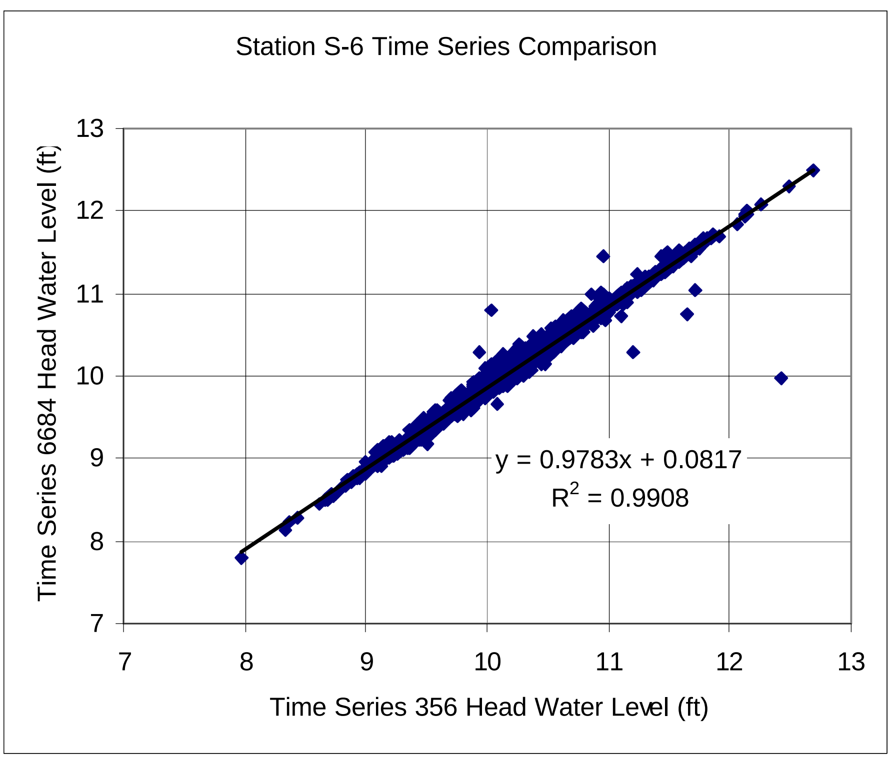

Figure A2.30 Station S-6 head water level time series comparison.

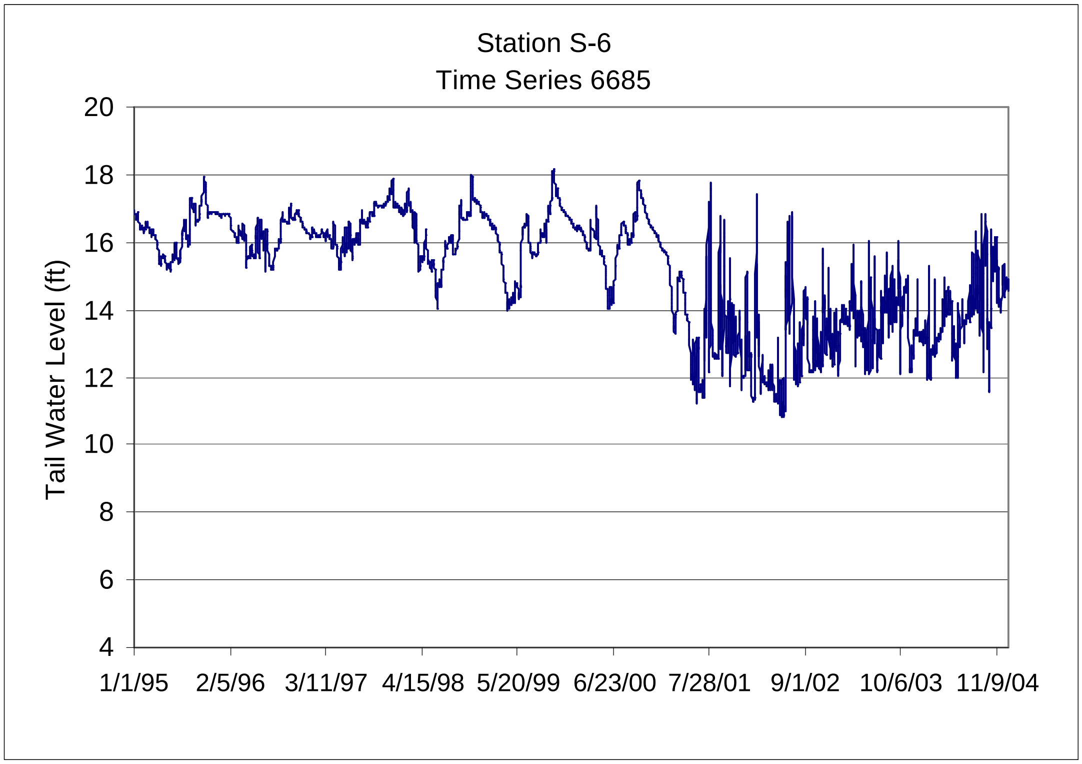

Figure A2.31 Station S-6 Tail Water Level

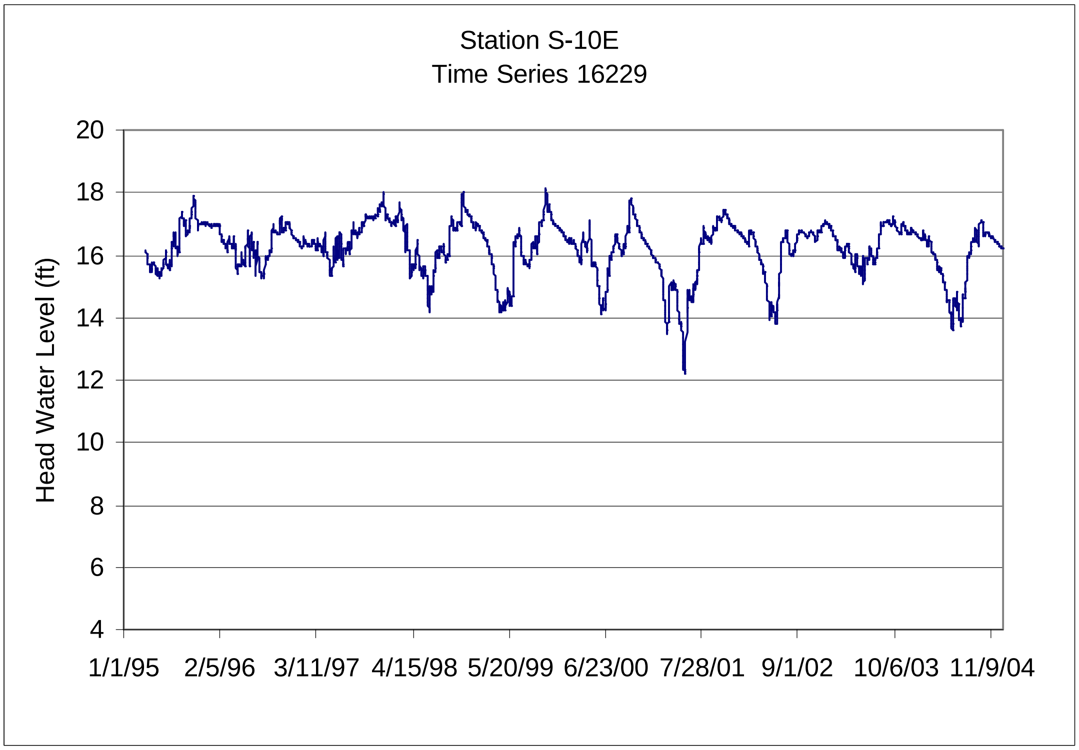

Figure A2.32 Station S-10E Head Water Level

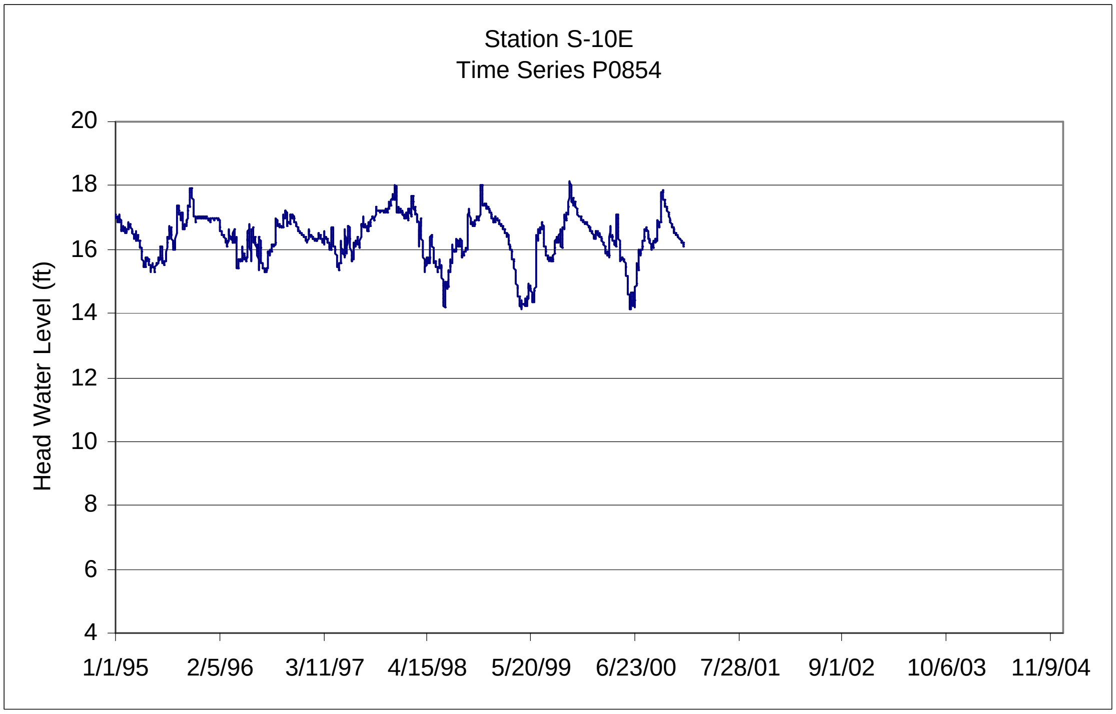

Figure A2.33 Station S-10E Head Water Level

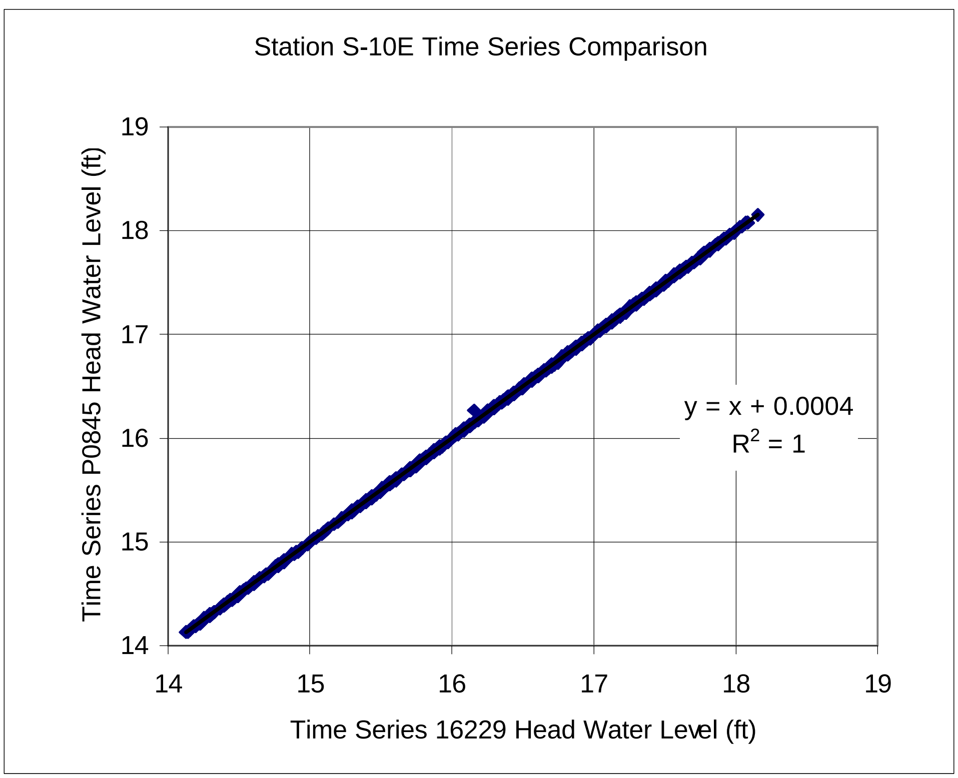

Figure A2.34 Station S-10E head water level time series comparison.

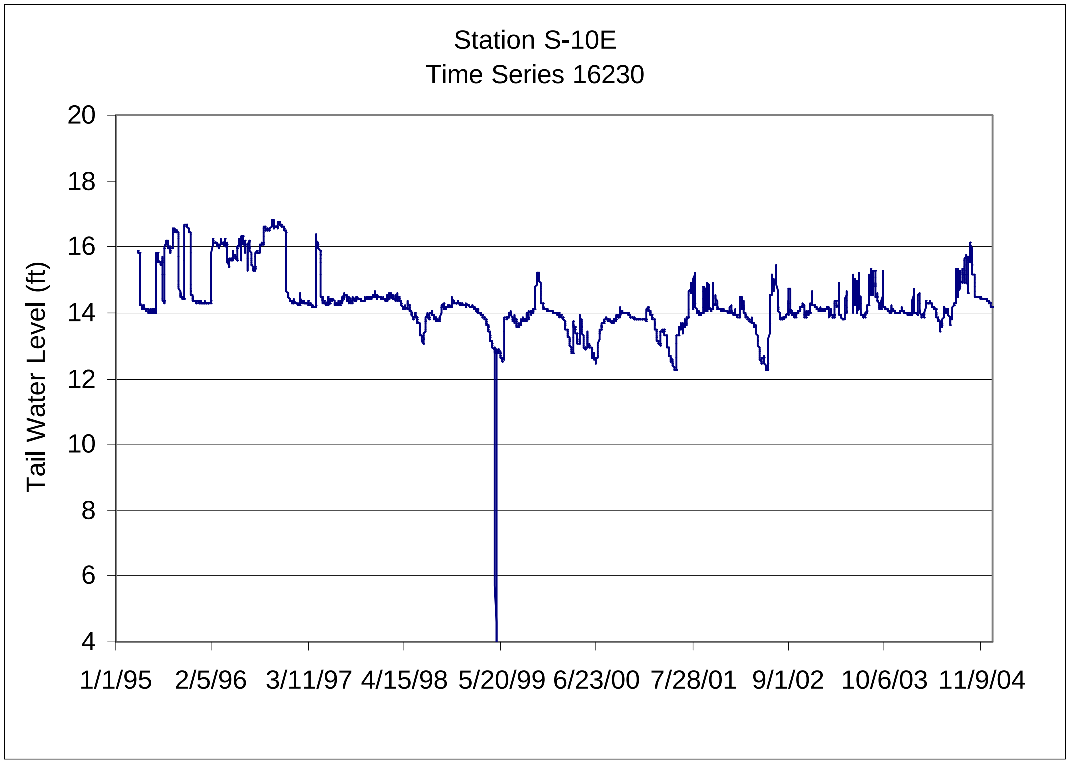

Figure A2.35 Station S-10E Tail Water Level

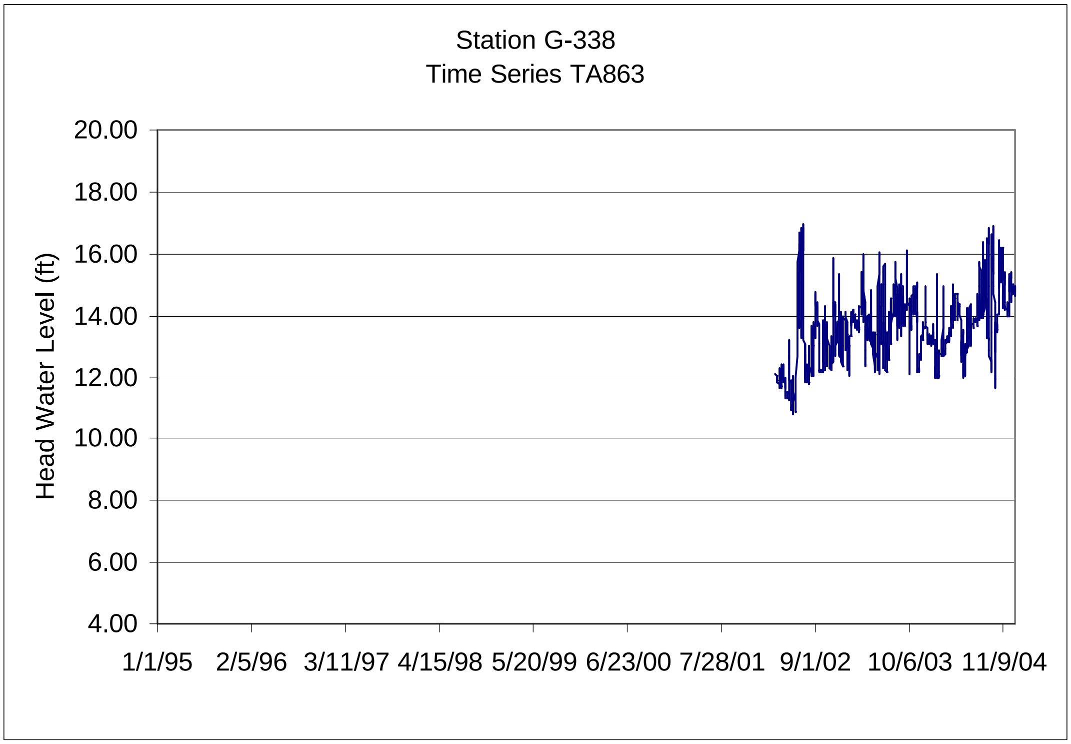

Figure A2.36 Station G-338 Head Water Level

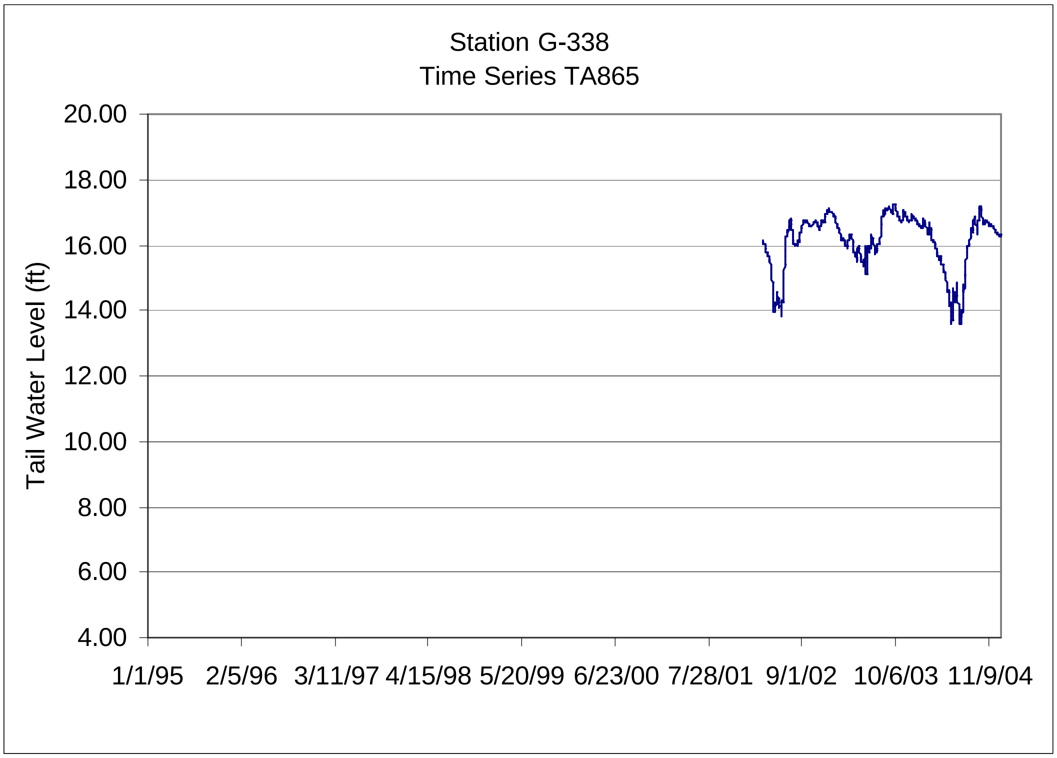

Figure A2.37 Station G-338 Tail Water Level

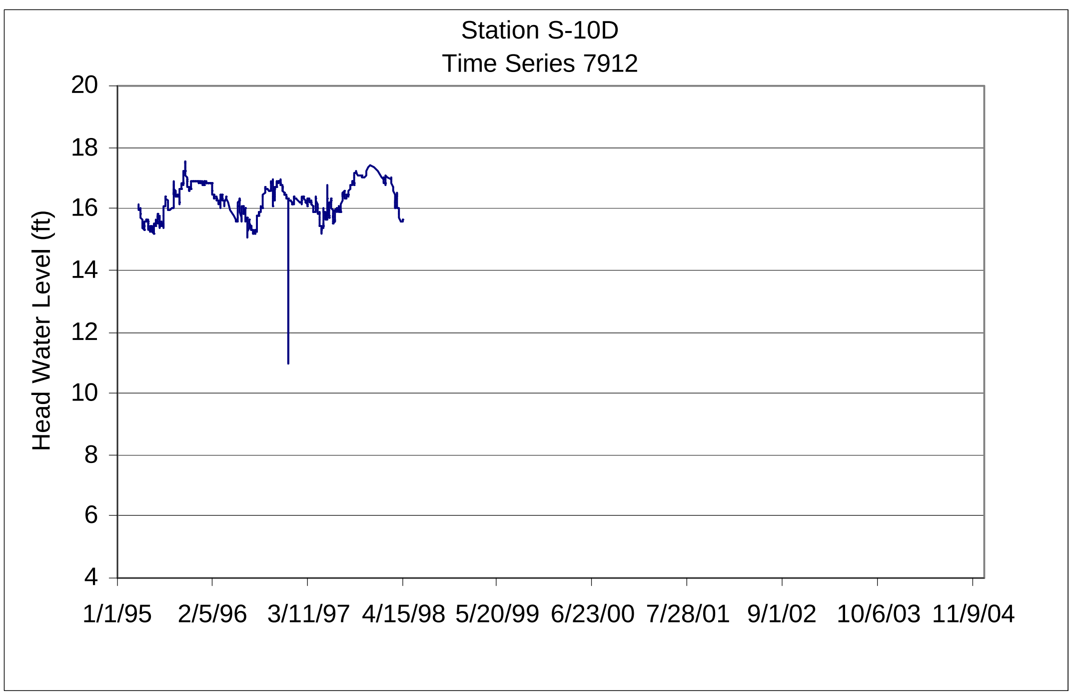

Figure A2.38 Station S-10D Head Water Level (DWR)

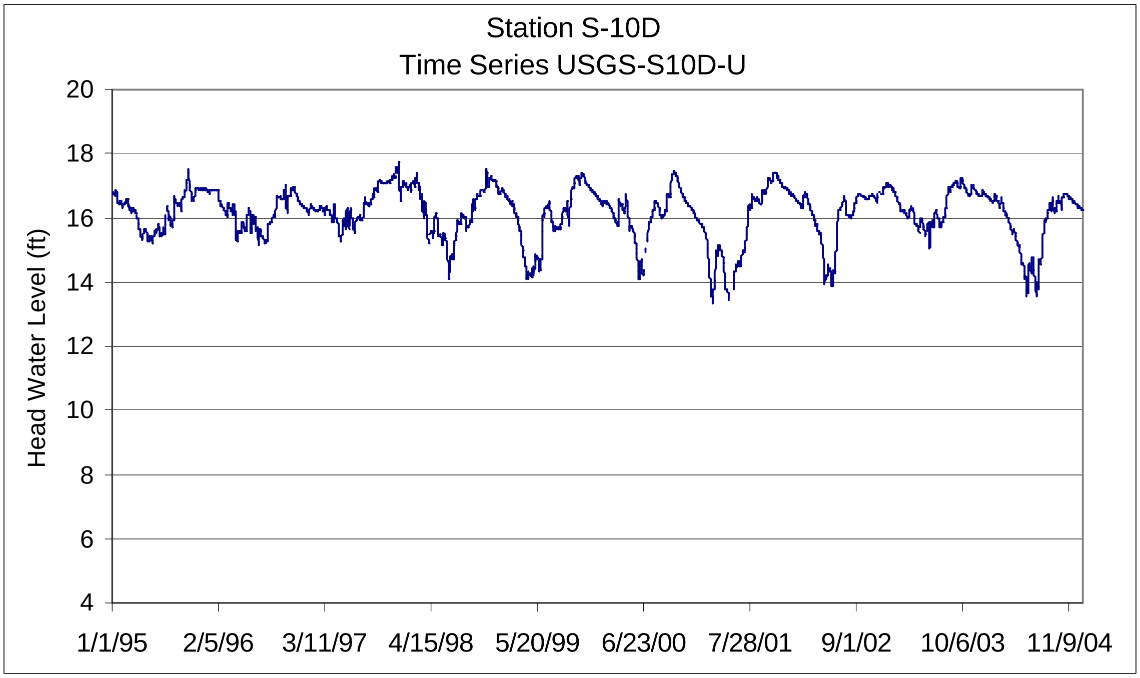

Figure A2.39 Station S-10D Head Water Level

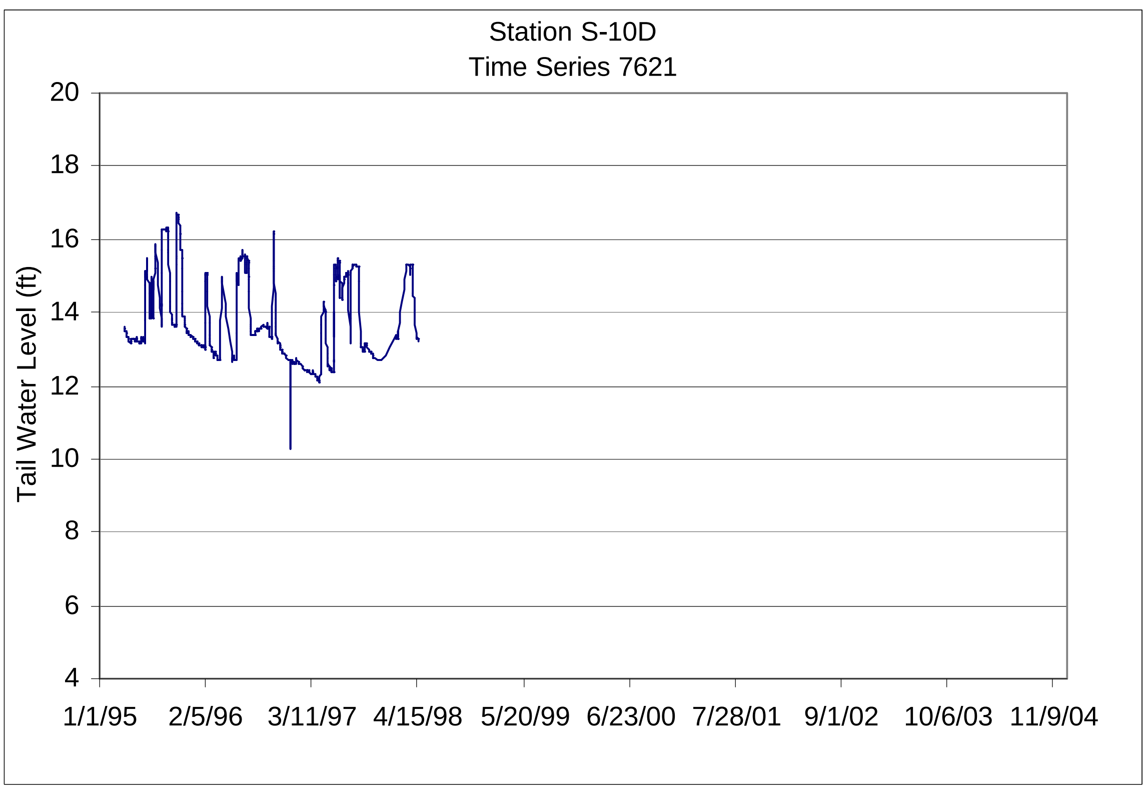

Figure A2.40 Station S-10D Tail Water Level (DWR)

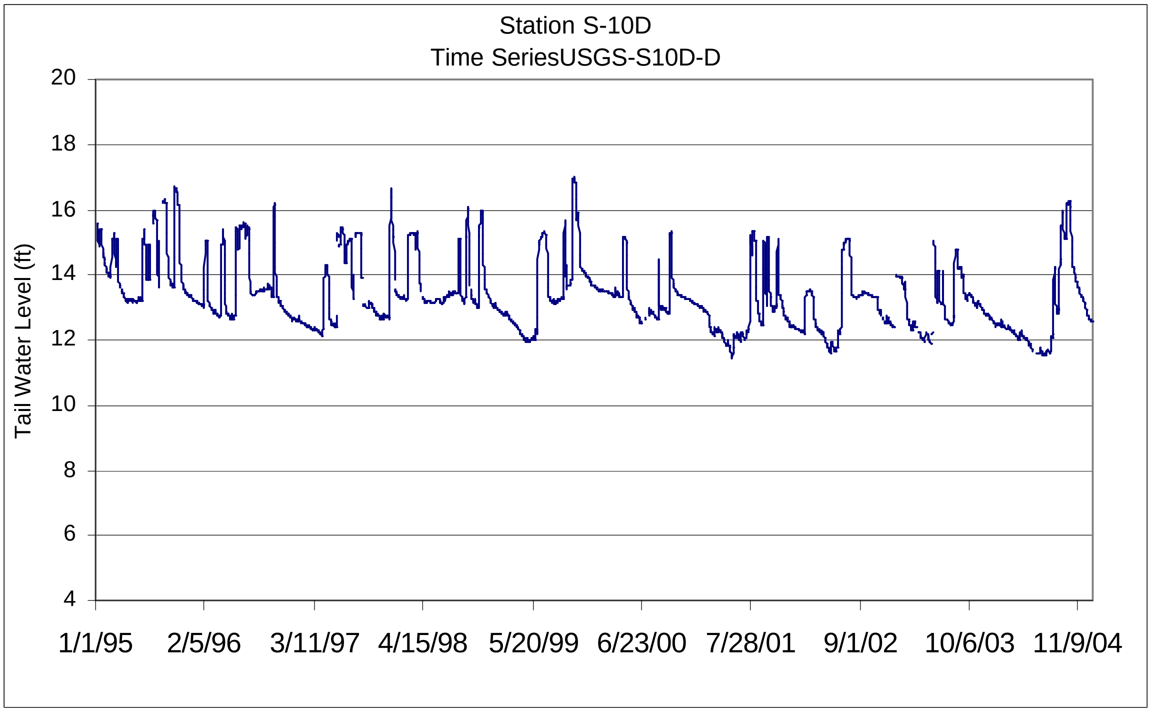

Figure A2.41 Station S-10D Tail Water Level

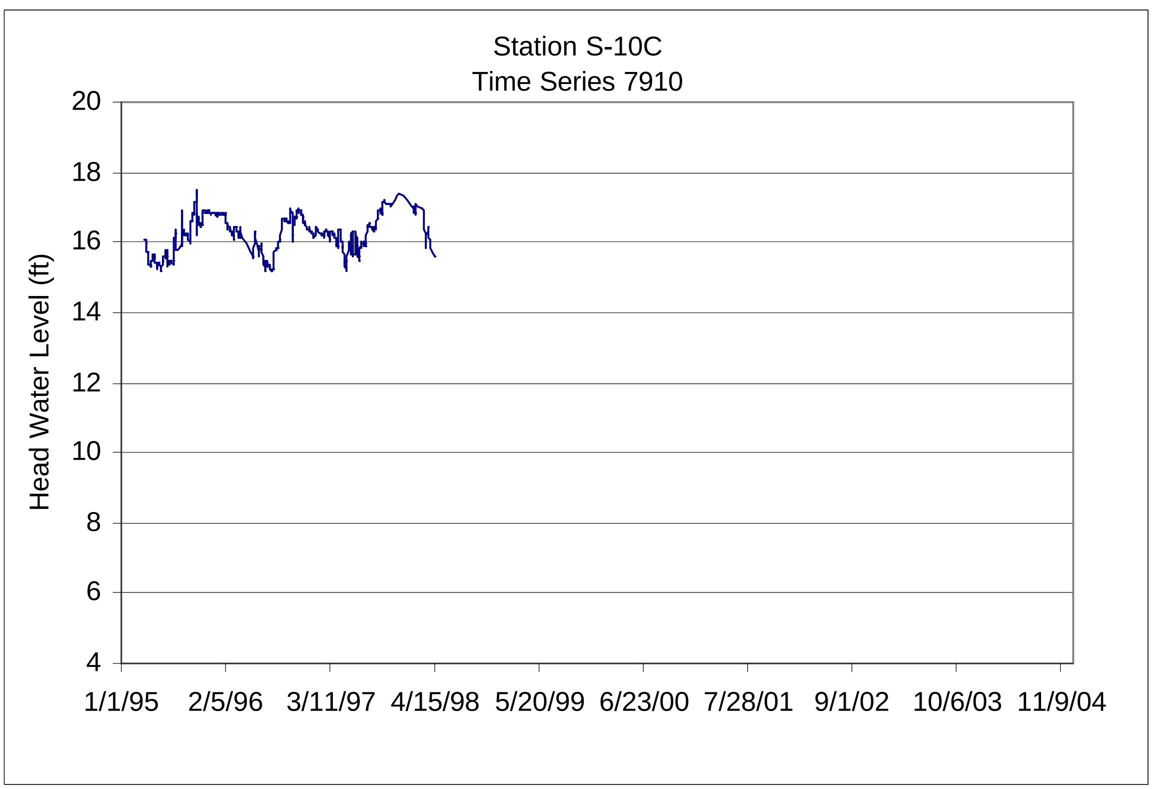

Figure A2.42 Station S-10C Head Water Level (DWR)

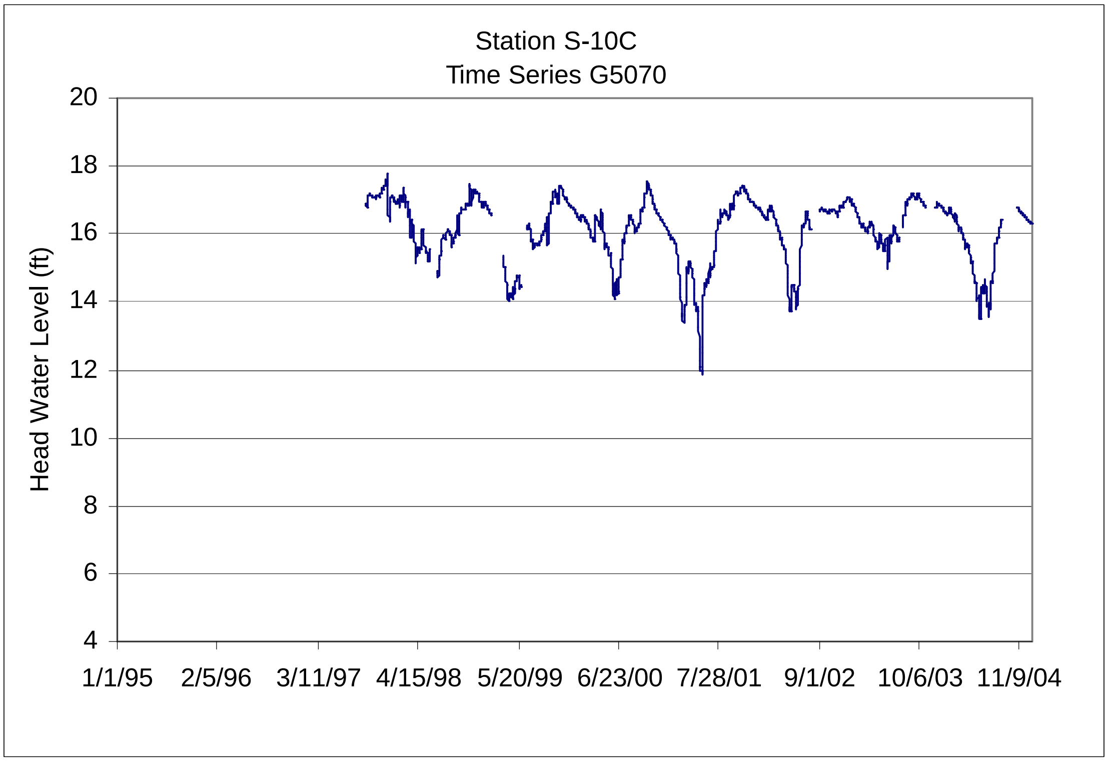

Figure A2.43 Station S-10C Head Water Level

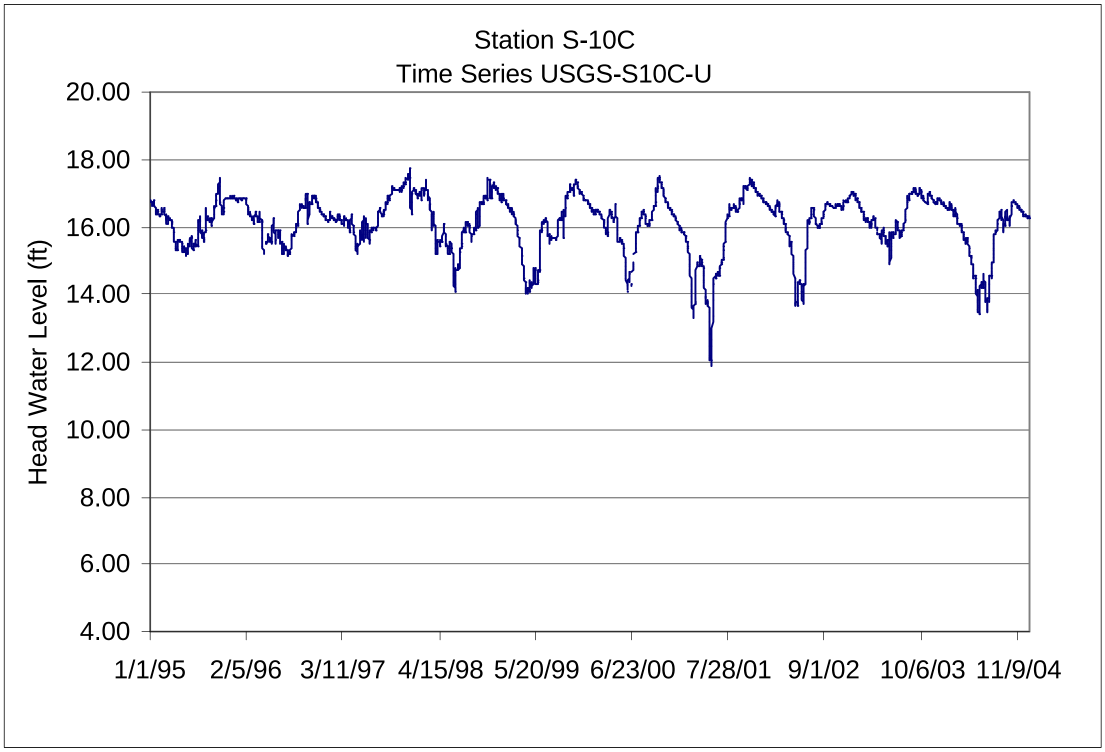

Figure A2.44 Station S-10C Head Water Level

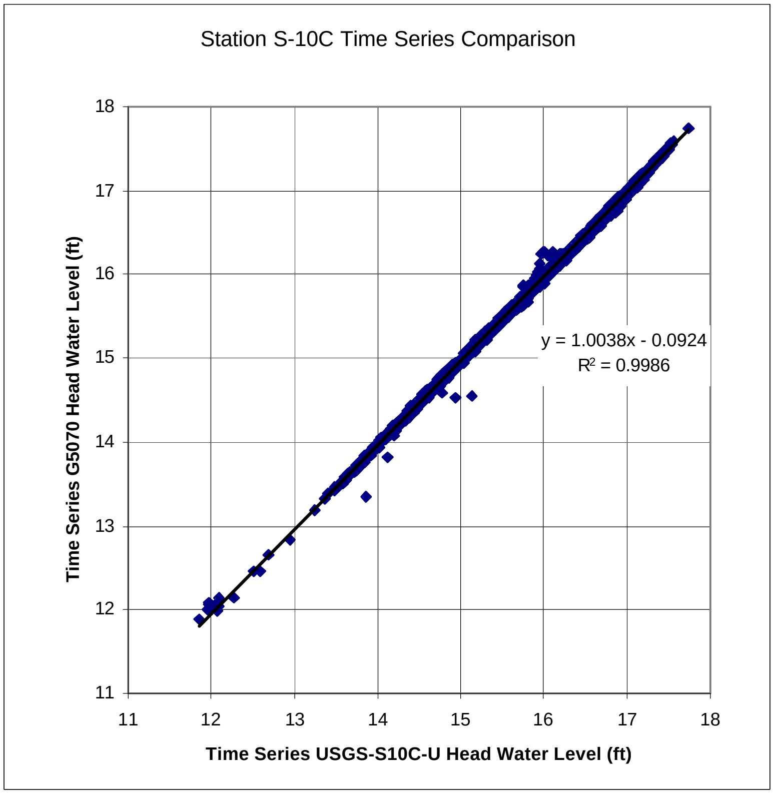

Figure A2.45 Station S-10C head water level time series comparison.

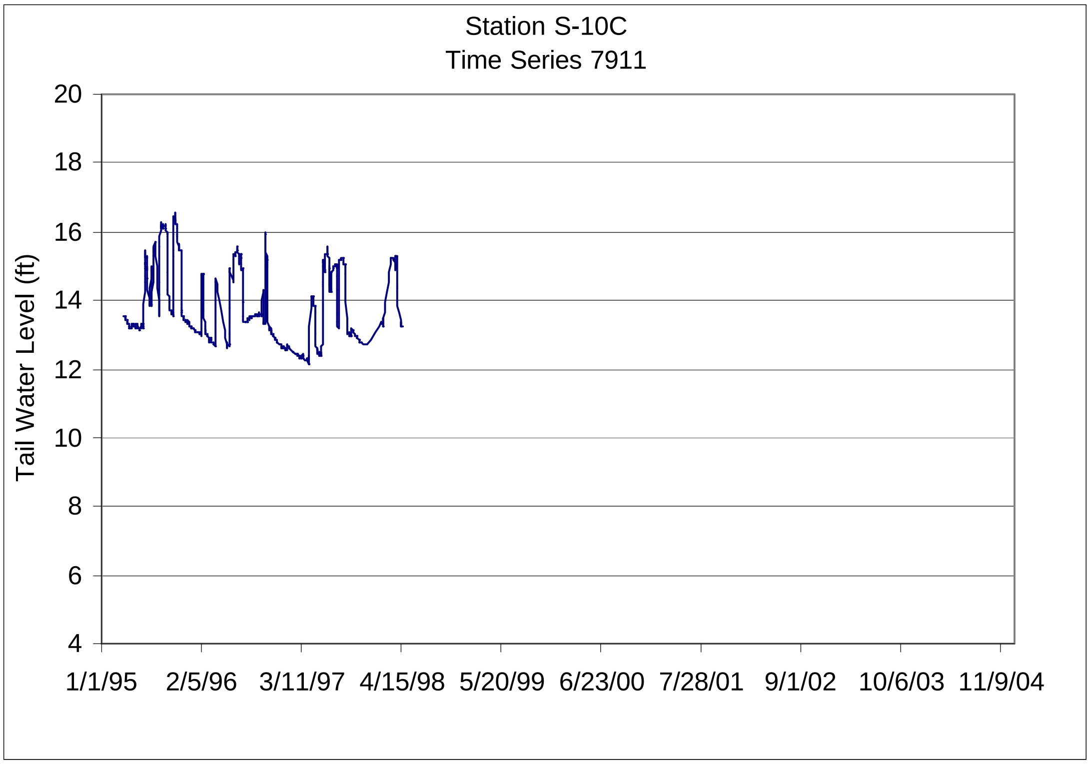

Figure A2.46 Station S-10C Tail Water Level (DWR)

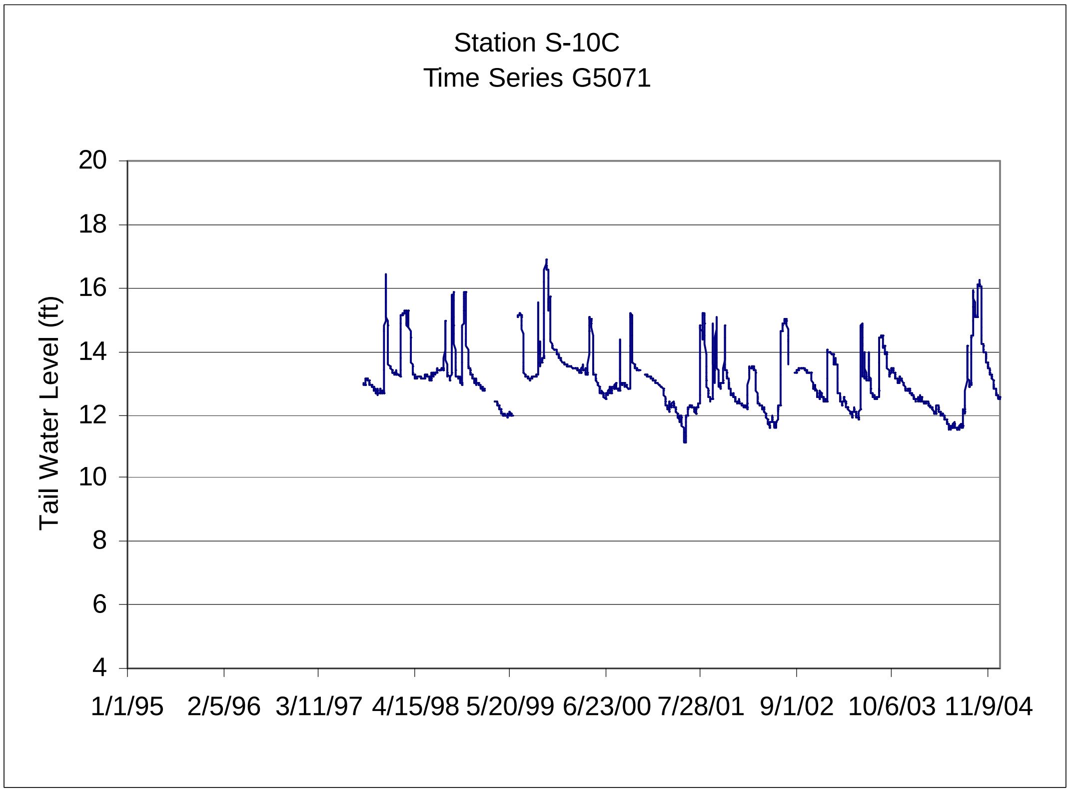

Figure A2.47 Station S-10C Tail Water Level

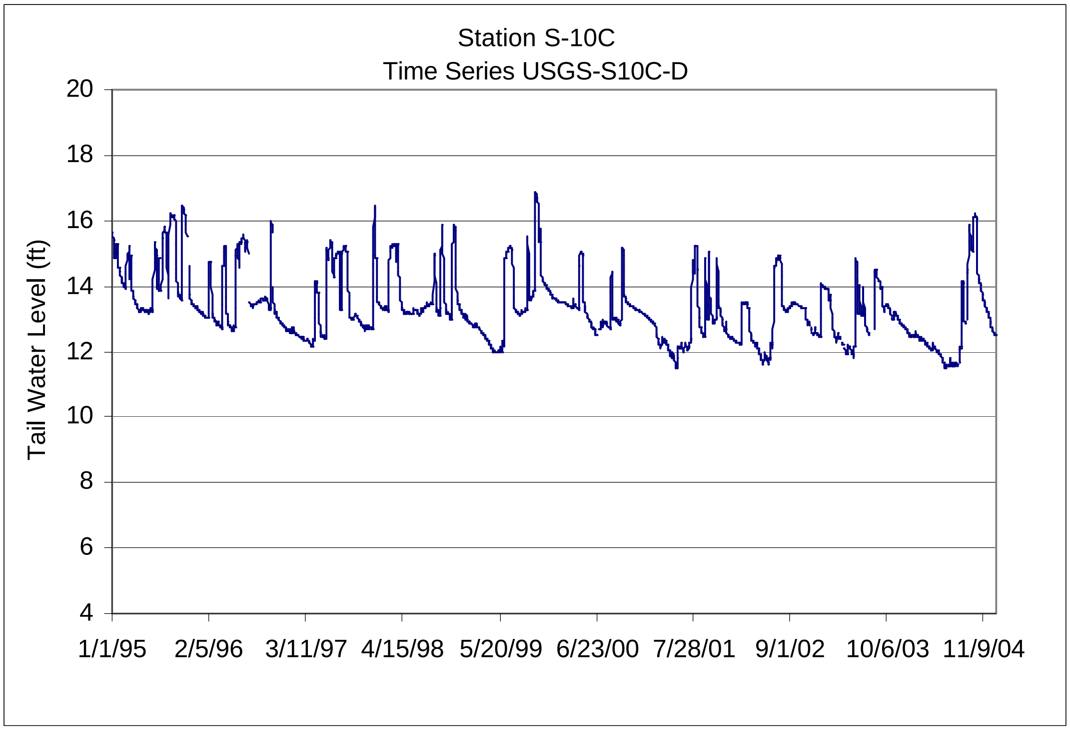

Figure A2.48 Station S-10C Tail Water Level

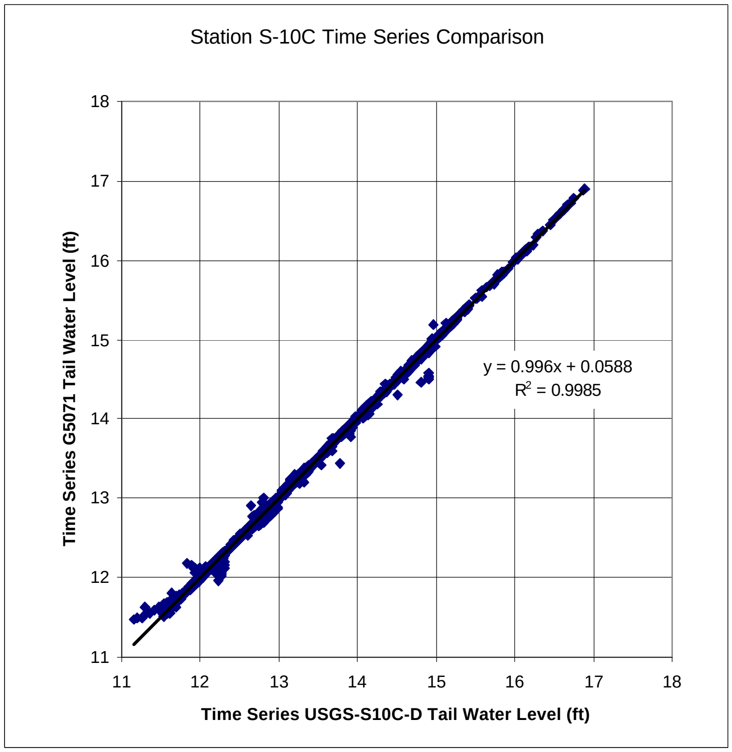

Figure A2.49 Station S-10C tail water level time series comparison.

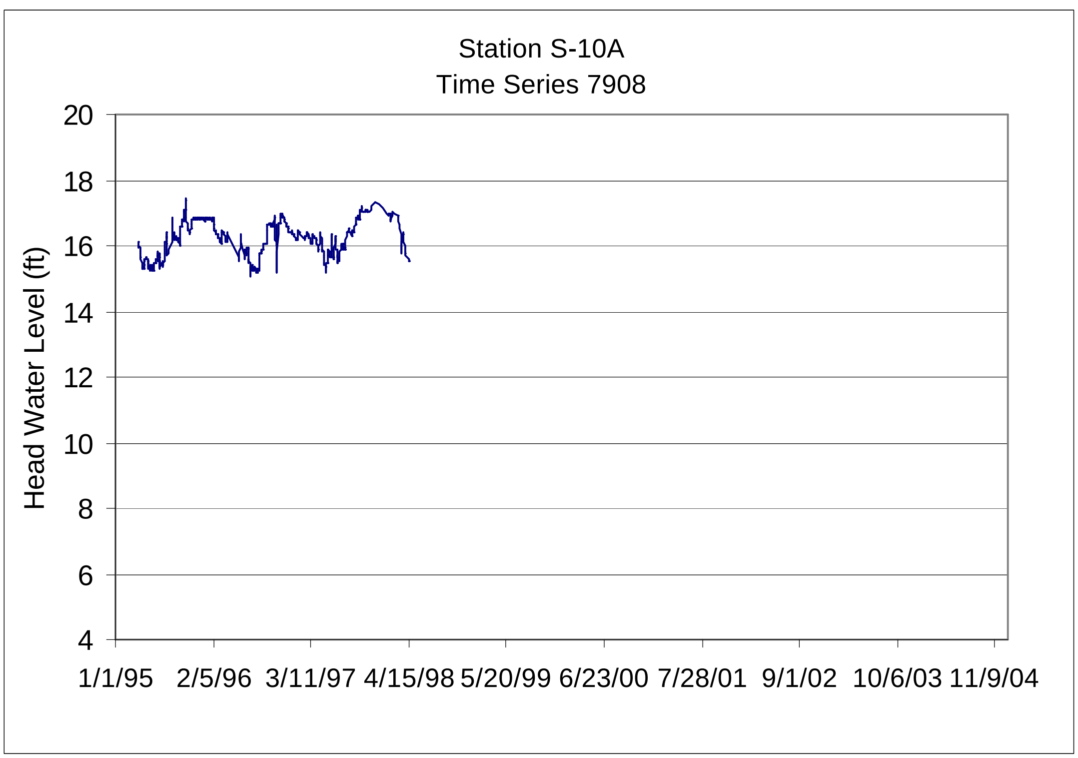

Figure A2.50 Station S-10A Head Water Level (DWR)

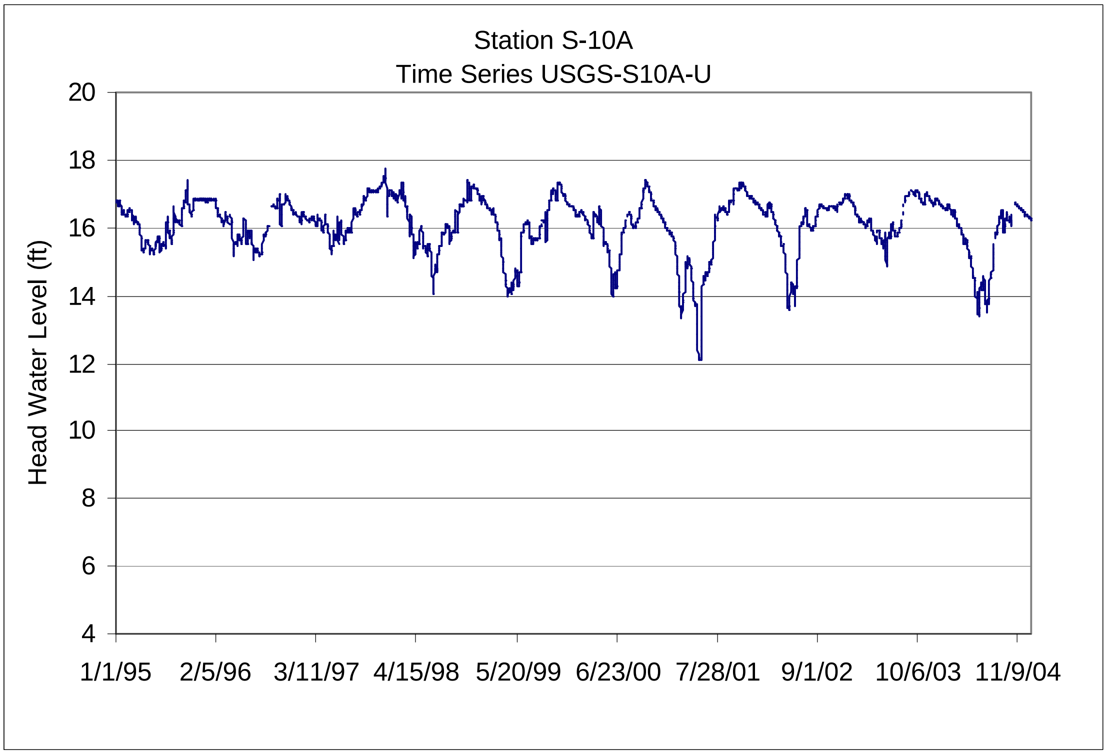

Figure A2.51 Station S-10A Head Water Level

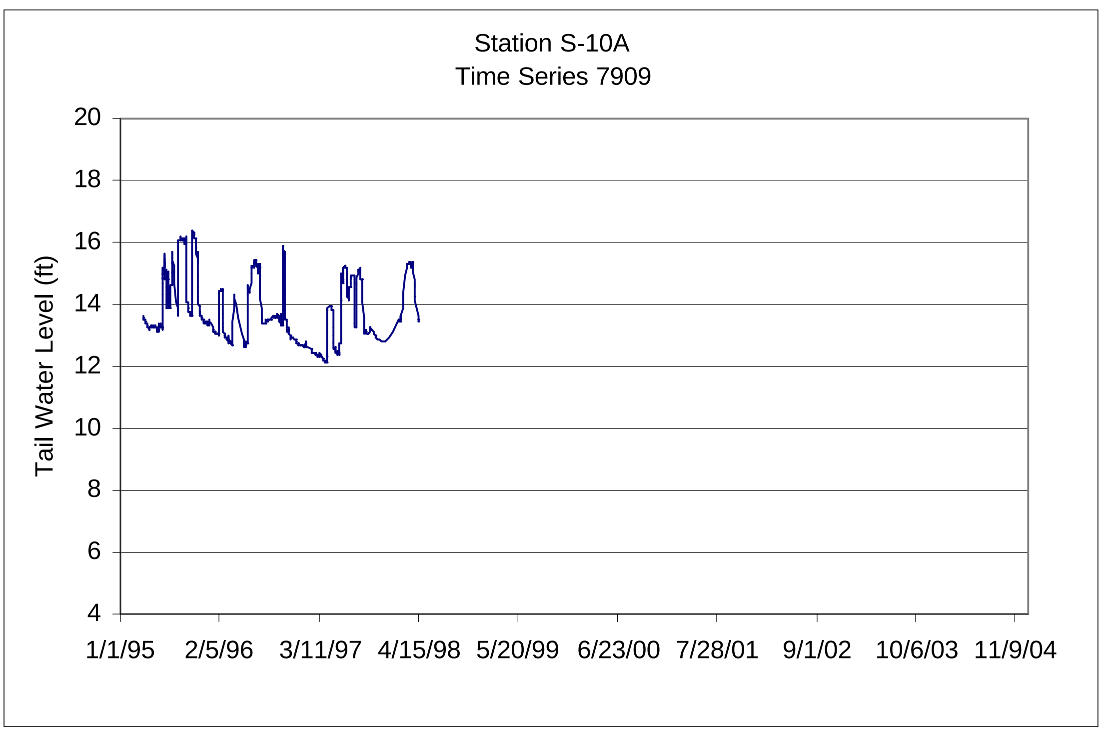

Figure A2.52 Station S-10A Tail Water Level (DWR)

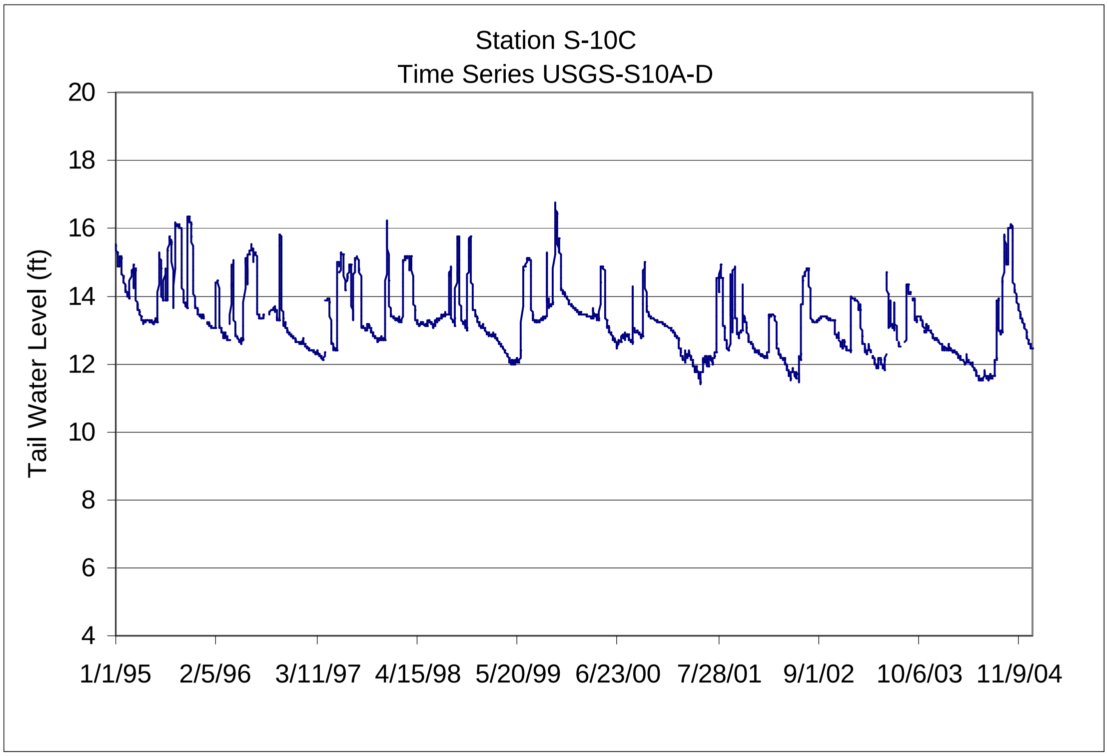

Figure A2.53 Station S-10A Tail Water Level

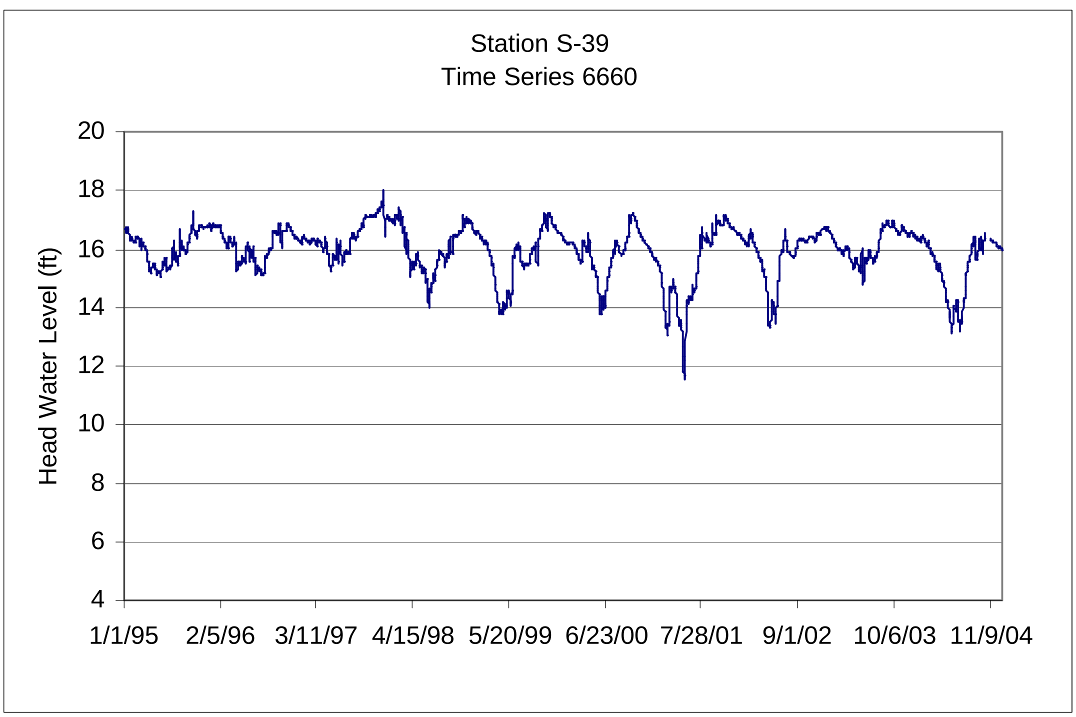

Figure A2.54 Station S-39 Head Water Level

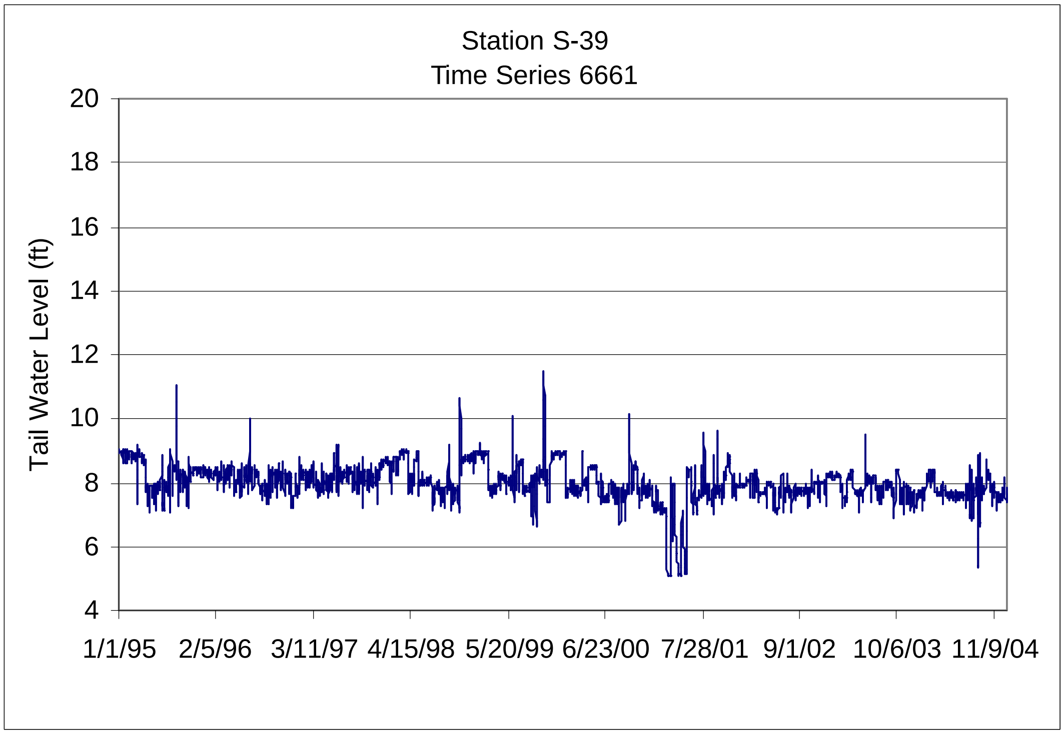

Figure A2.55 Station S-39 Tail Water Level

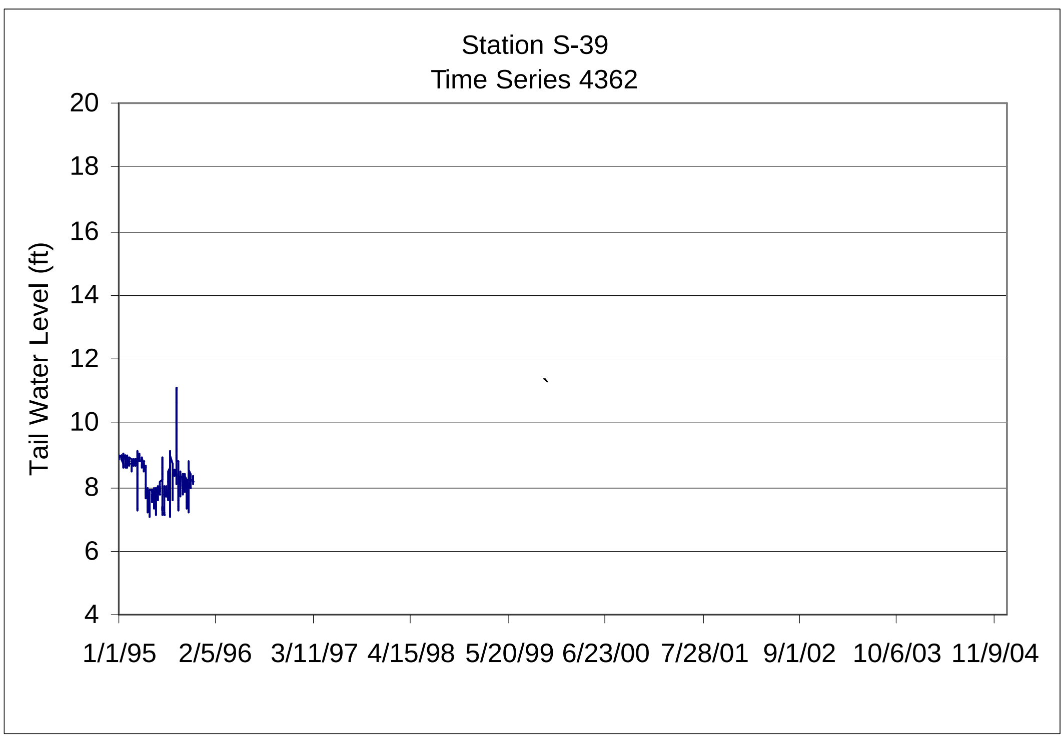

Figure A2.56 Station S-39 Tail Water Level

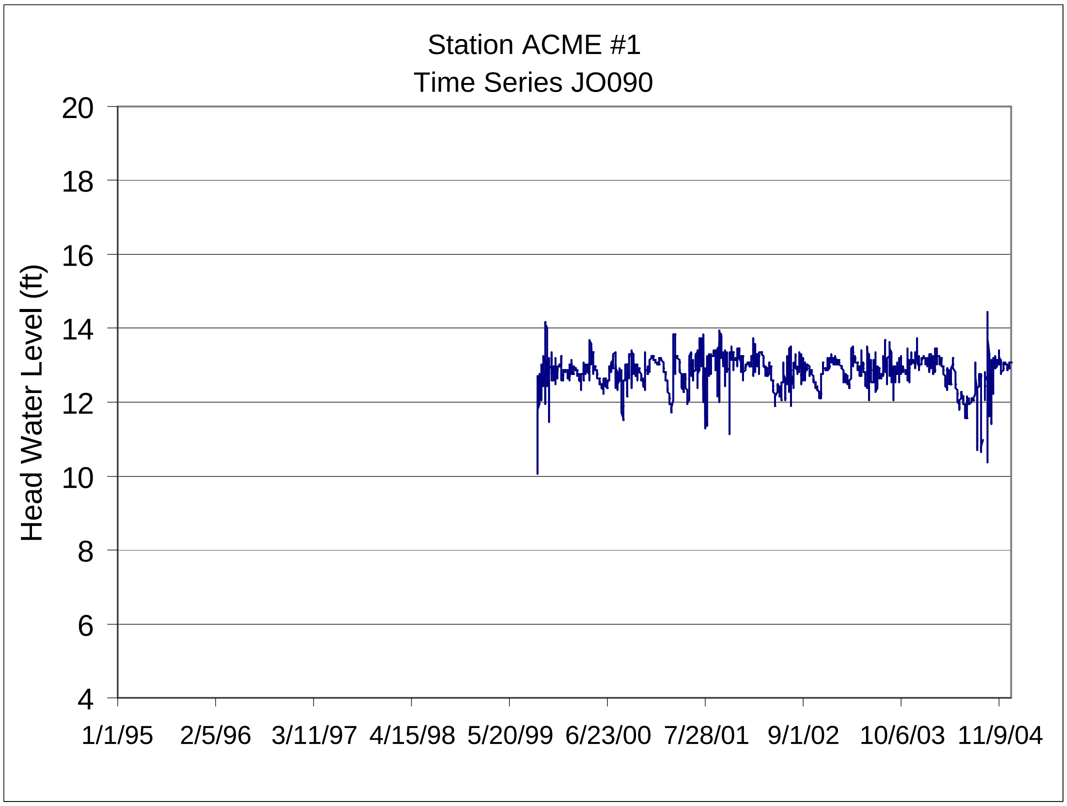

Figure A2.57 Station ACME #1 Head Water Level

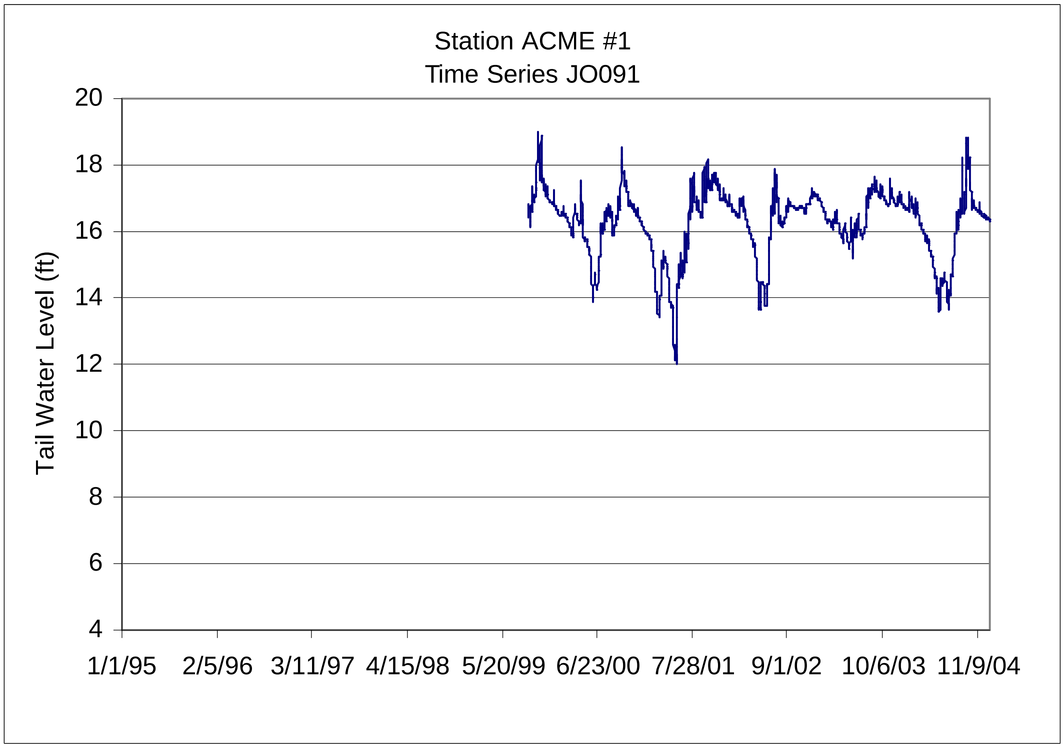

Figure A2.58 Station ACME #1 Tail Water Level

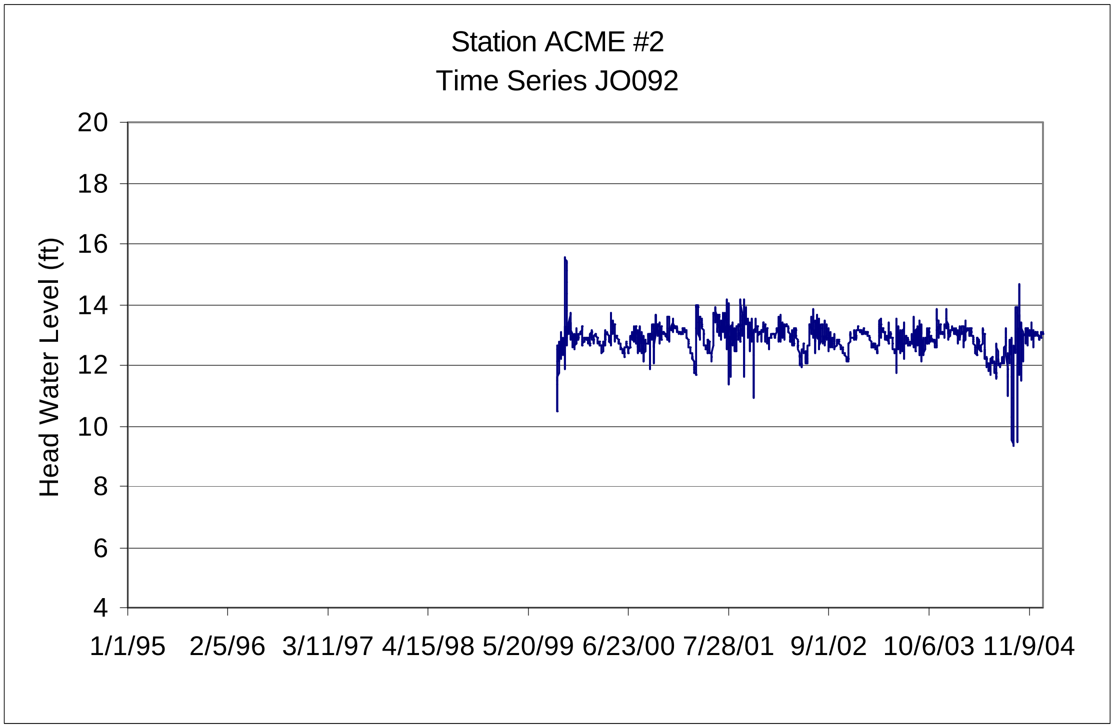

Figure A2.59 Station ACME #2 (G-94B) Head Water Level

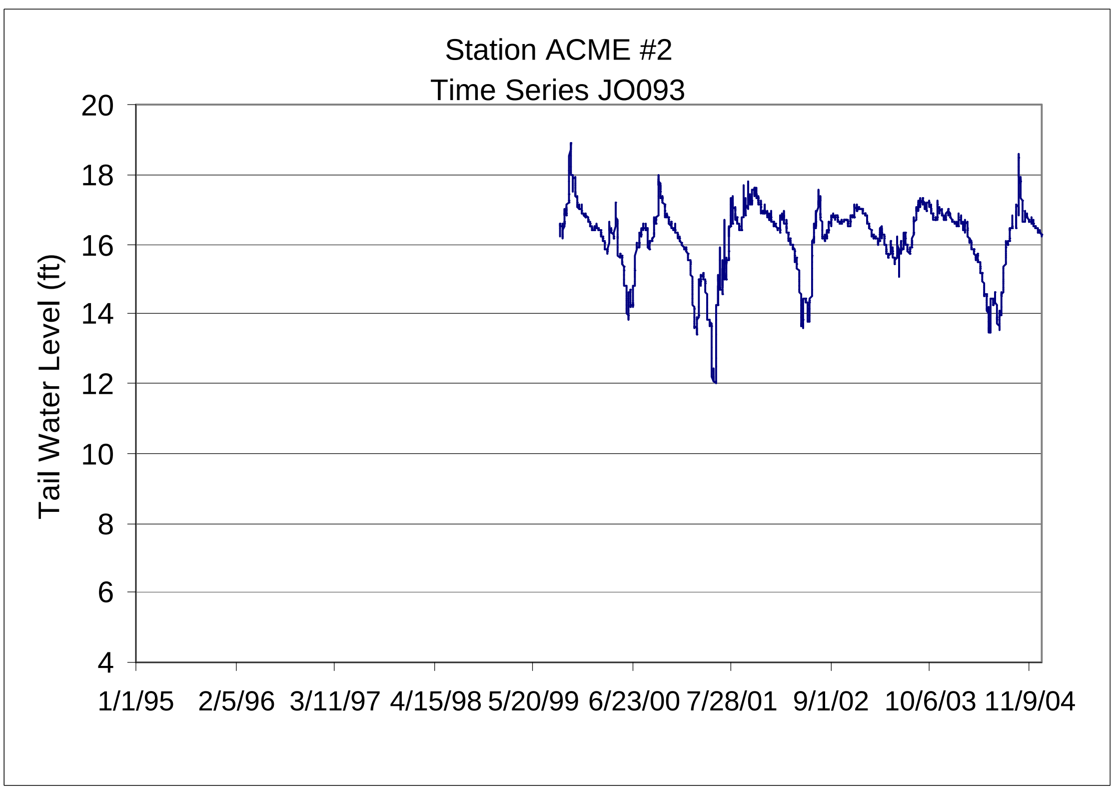

Figure A2.60 Station ACME #2 (G-94B) Tail Water Level

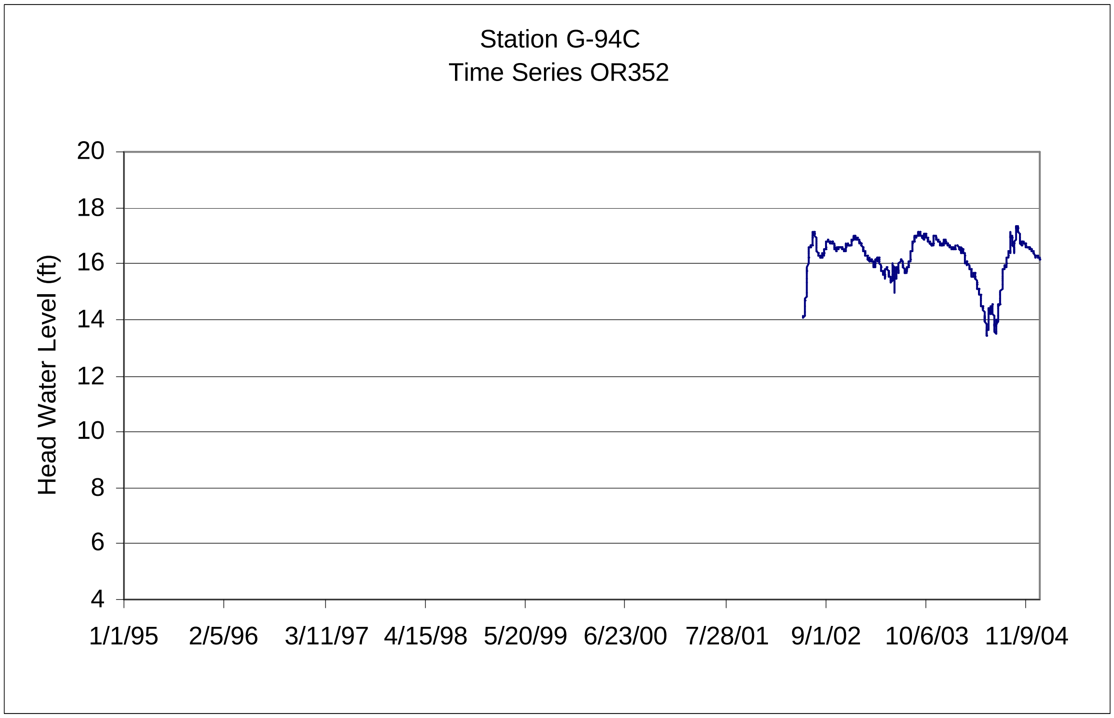

Figure A2.61 Station G-94C Head Water Level

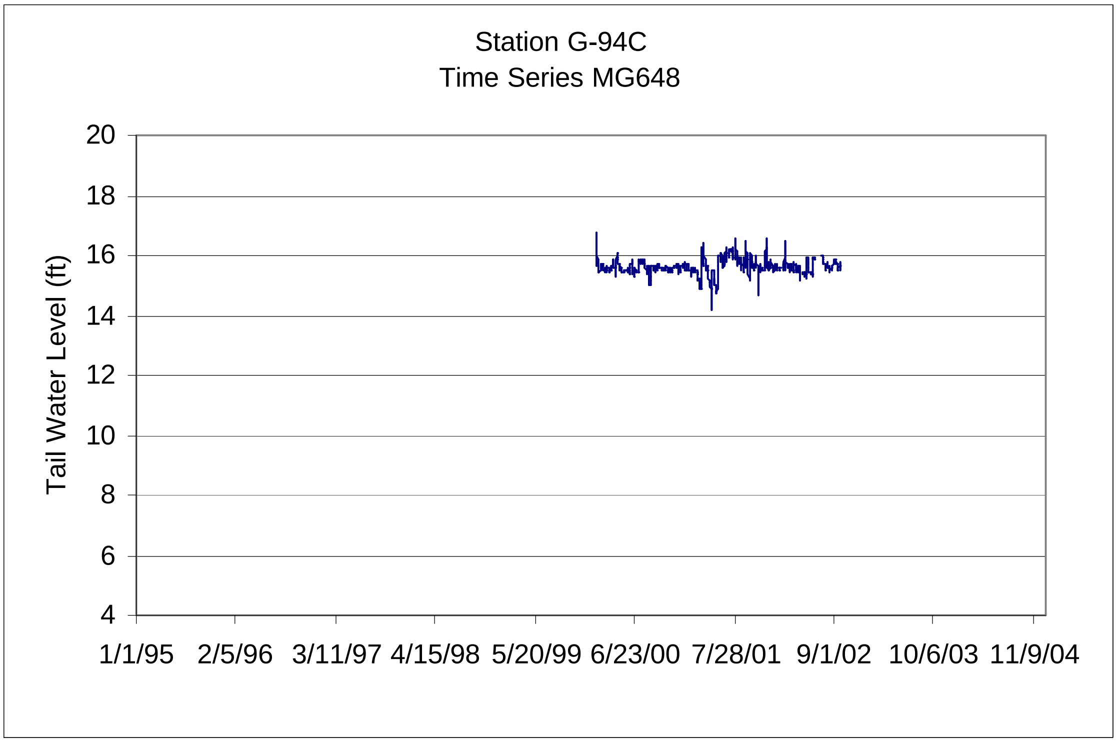

Figure A2.62 Station G-94C Tail Water Level

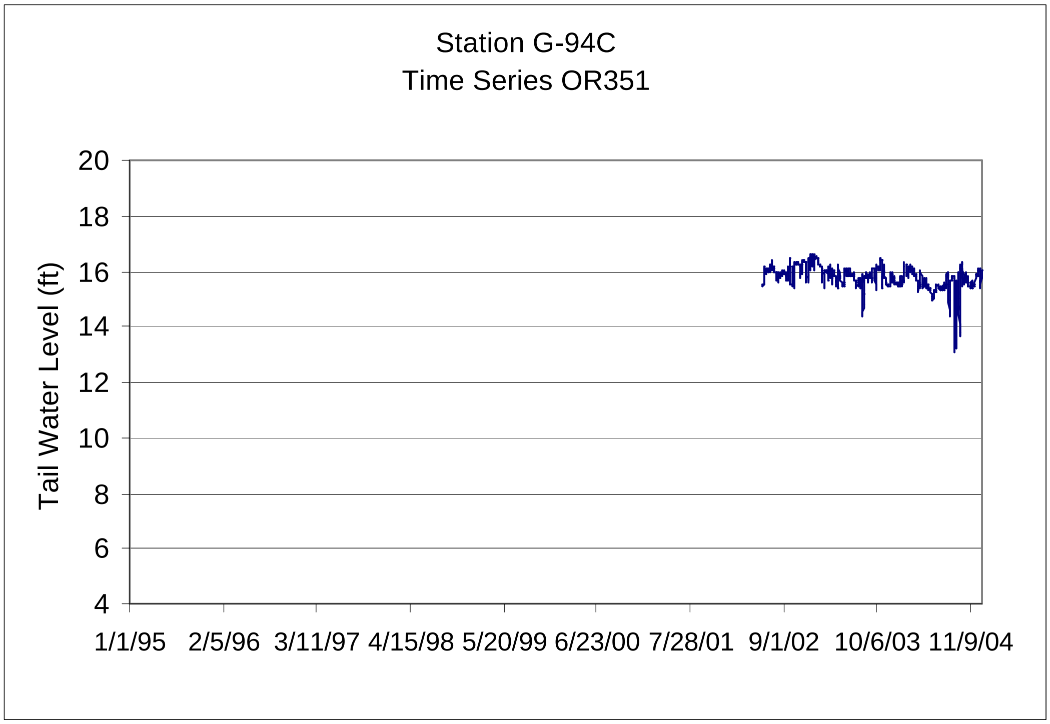

Figure A2.63 Station G-94C Tail Water Level

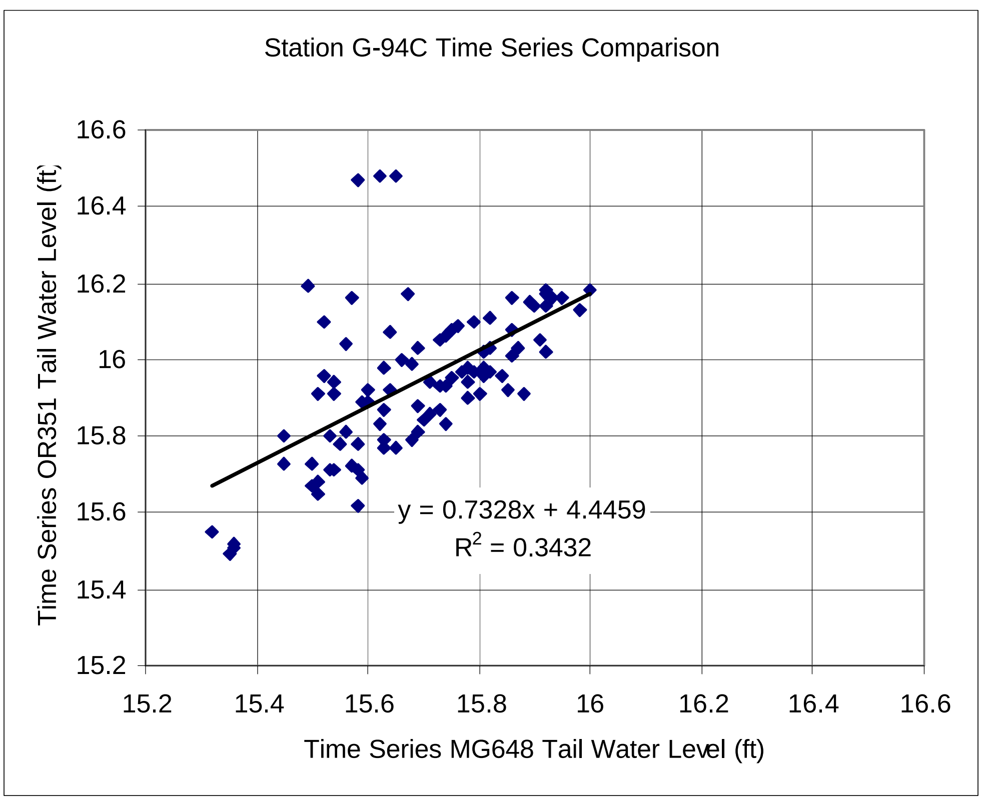

Figure A2.64 Station G-94C tail water level time series comparison.

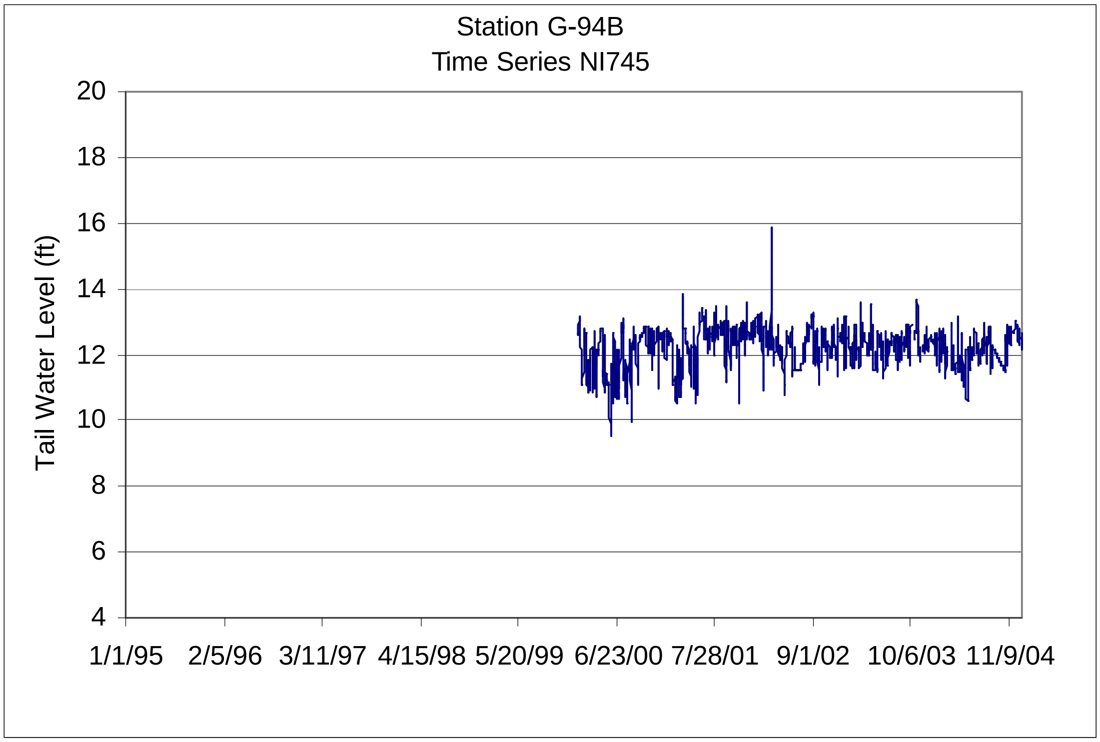

Figure A2.65 Station G-94B Tail Water Level

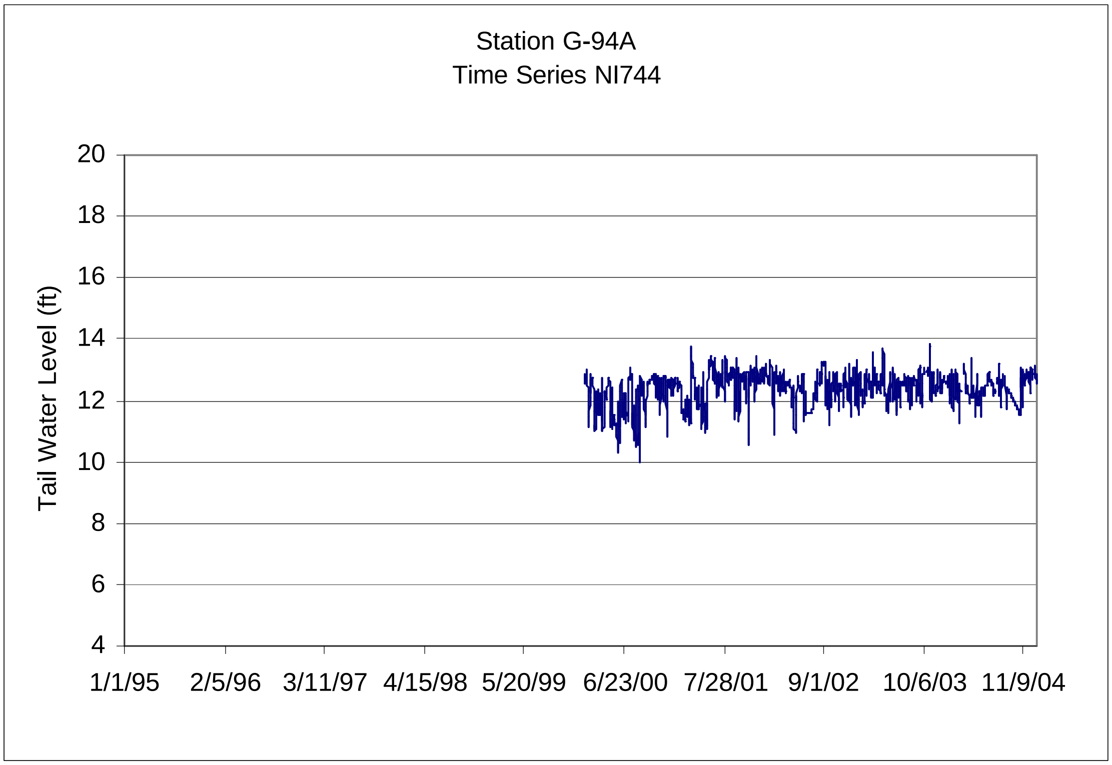

Figure A2.66 Station G-94A Tail Water Level

Appendix B
(Flow through Structures and Pump Stations)

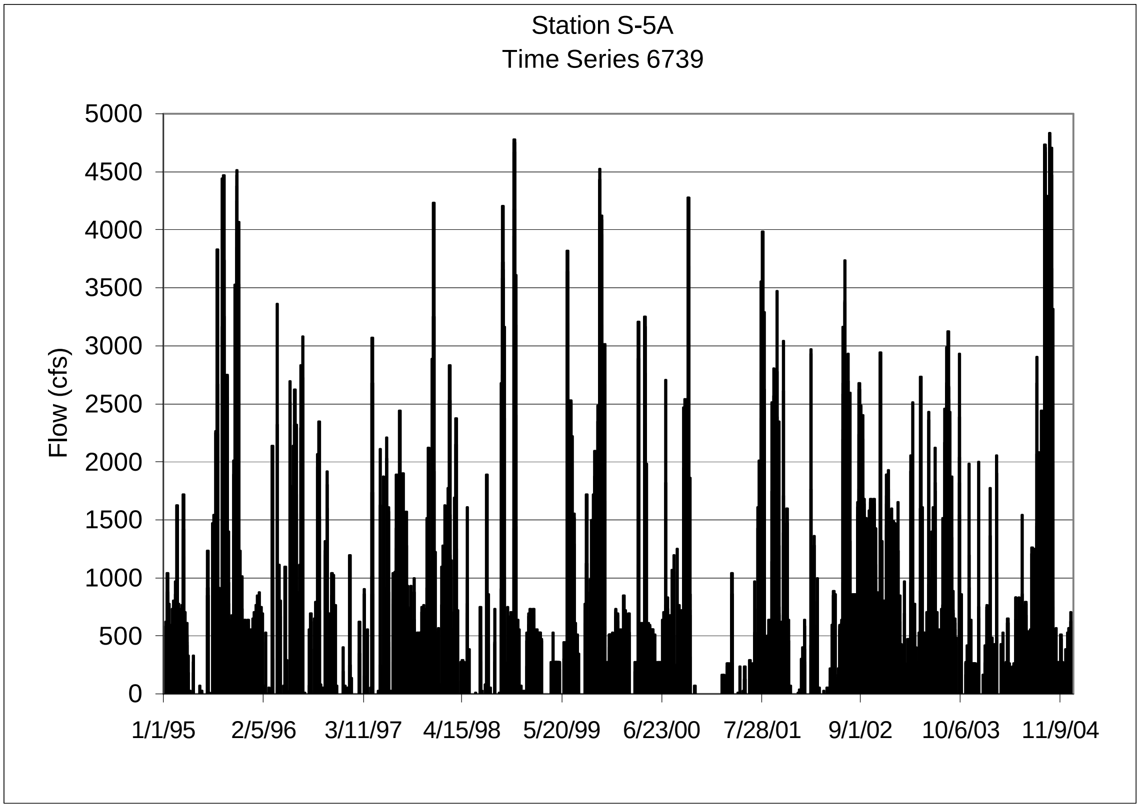

Figure B.1 S-5A Flow

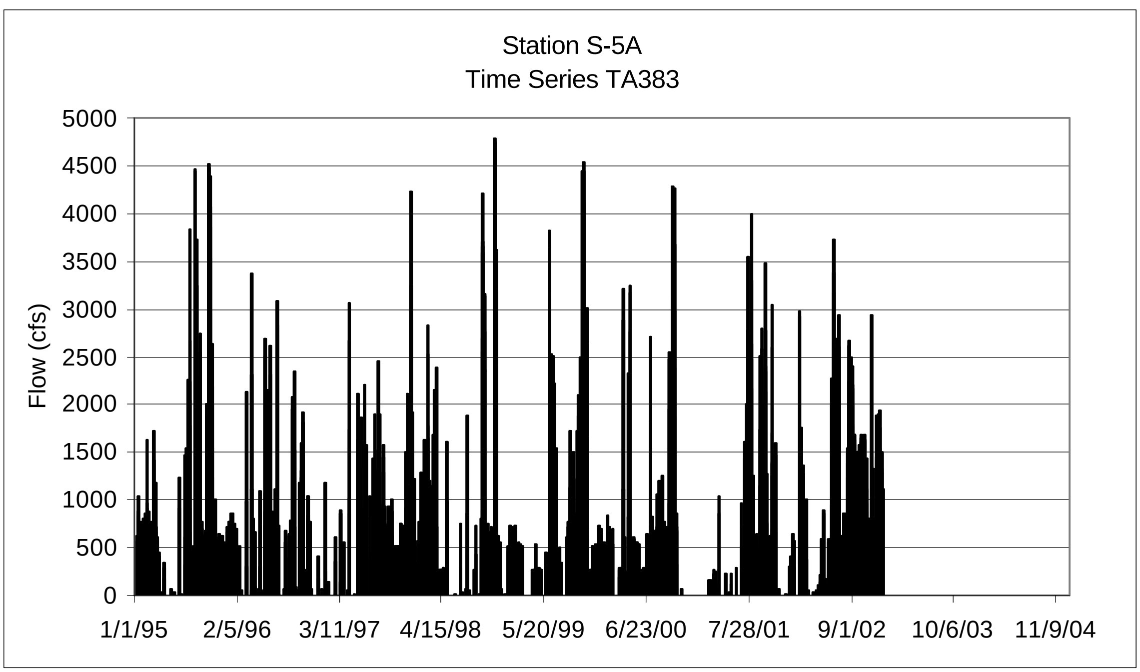

Figure B.2 S-5A Flow

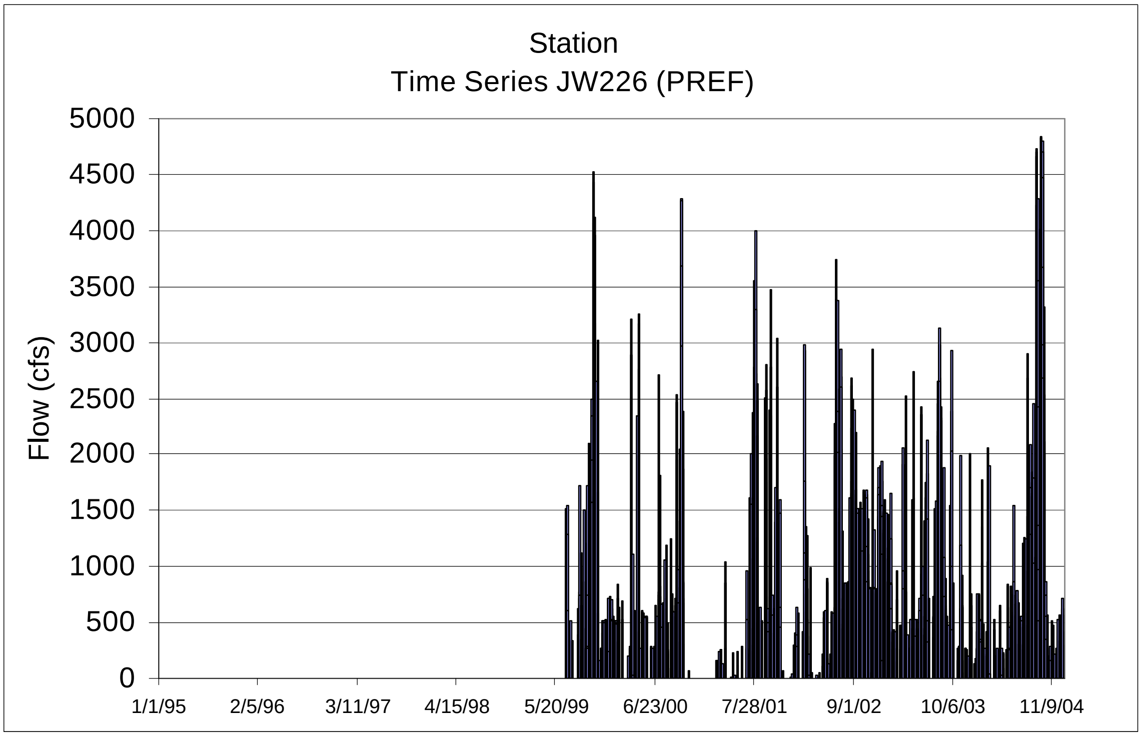

Figure B.3 S-5A Flow

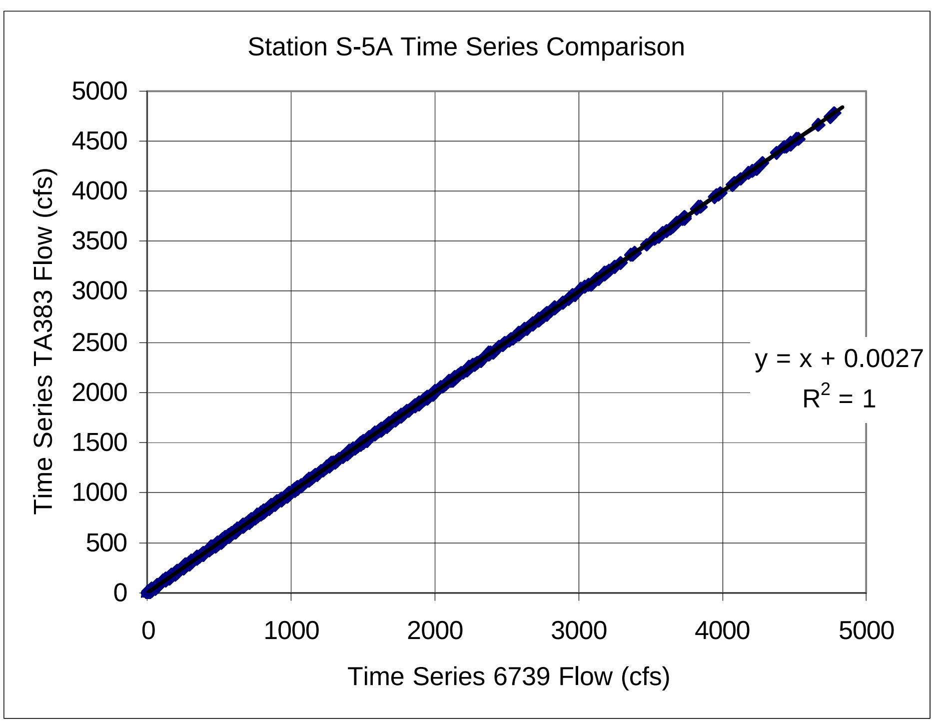

Figure B.4 S-5A flow time series comparison.

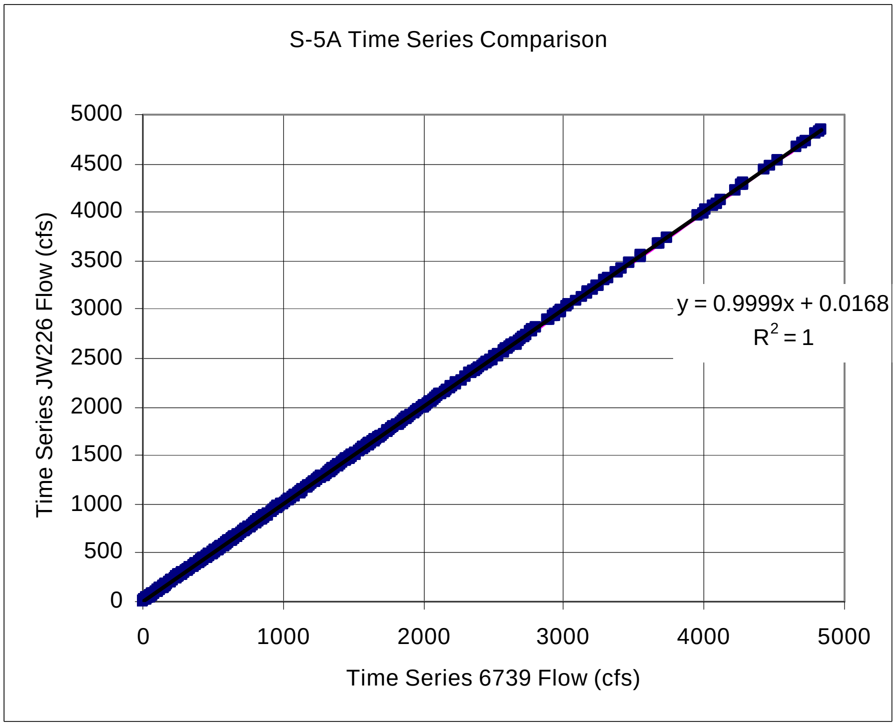

Figure B.5 S-5A flow time series comparison.

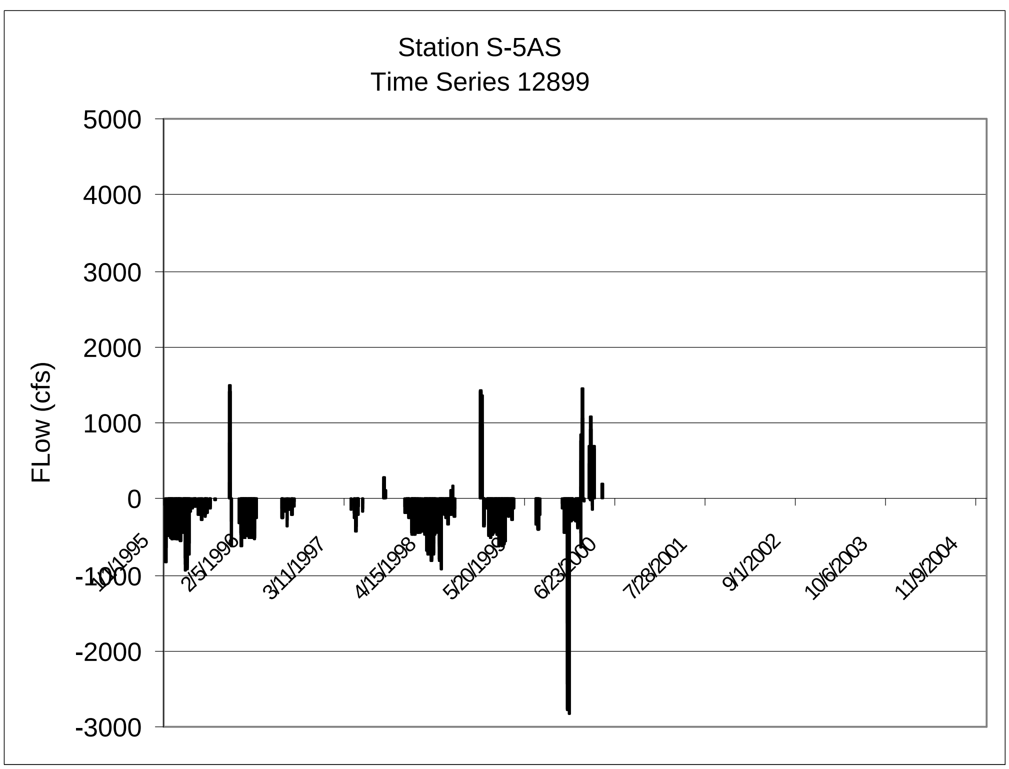

Figure B.6 S-5AS Flow

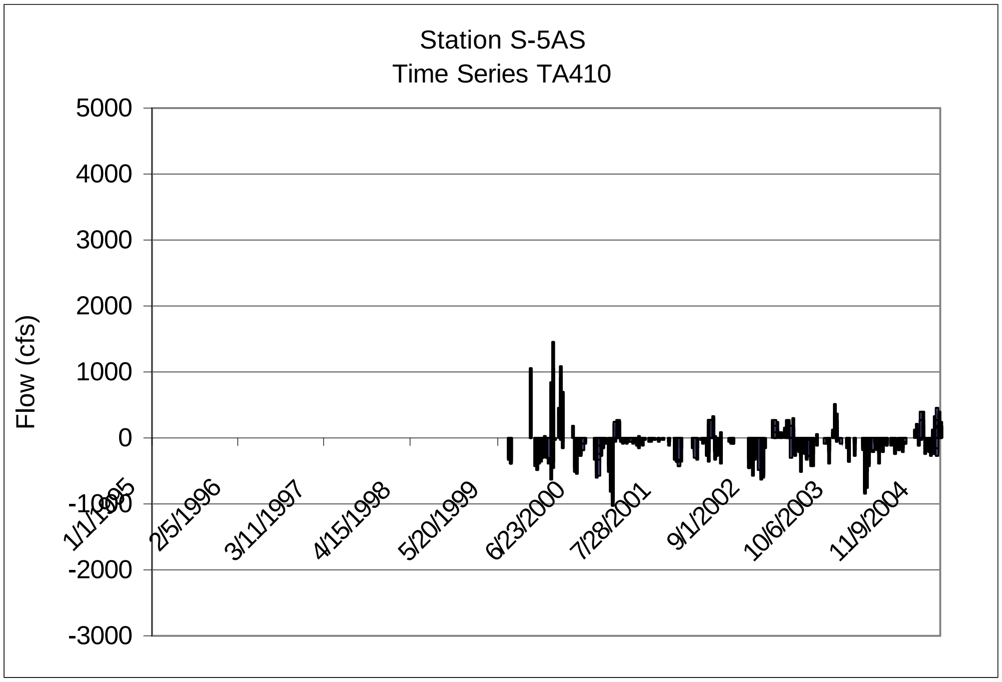

Figure B.7 S-5AS Flow

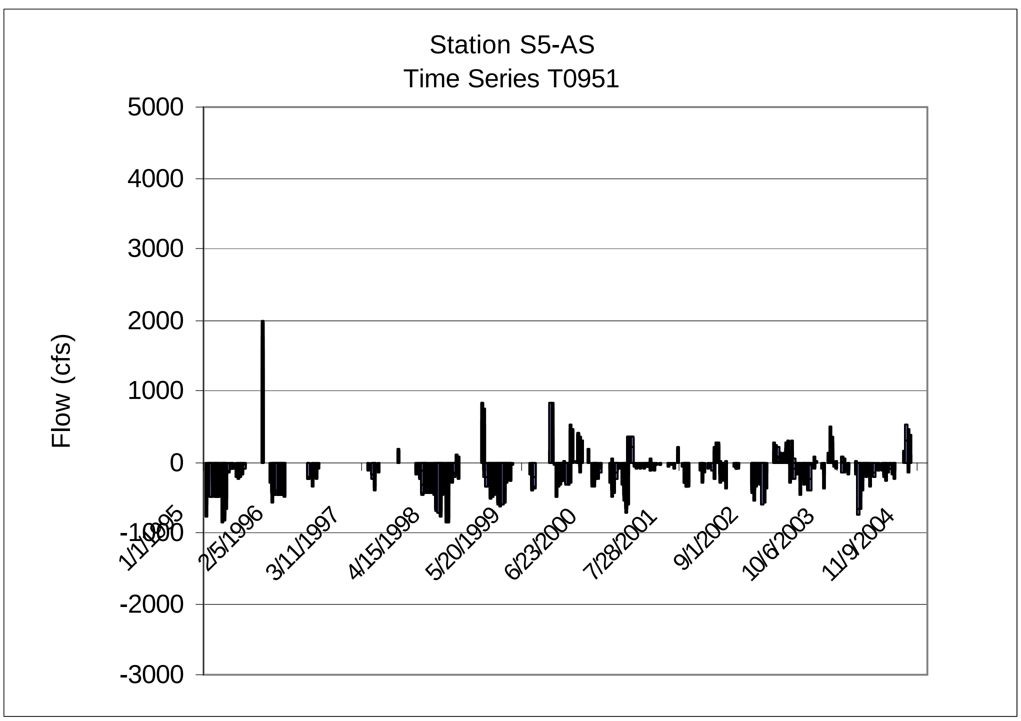

Figure B.8 S-5AS Flow

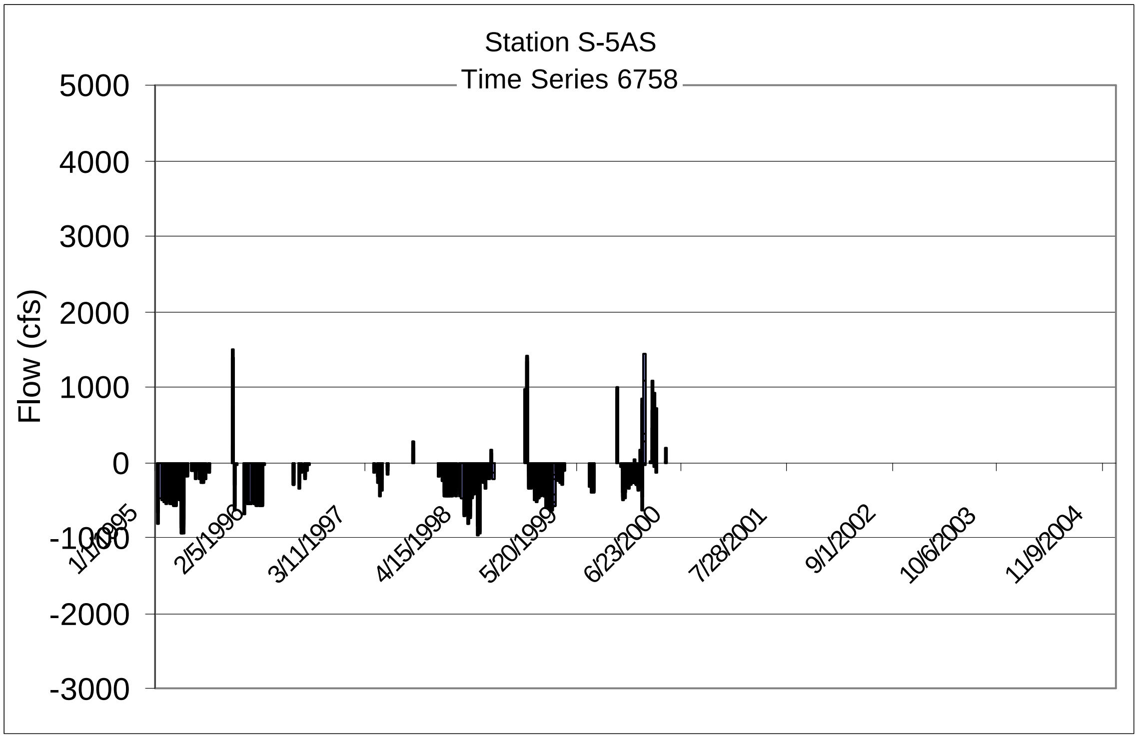

Figure B.9 S-5AS Flow

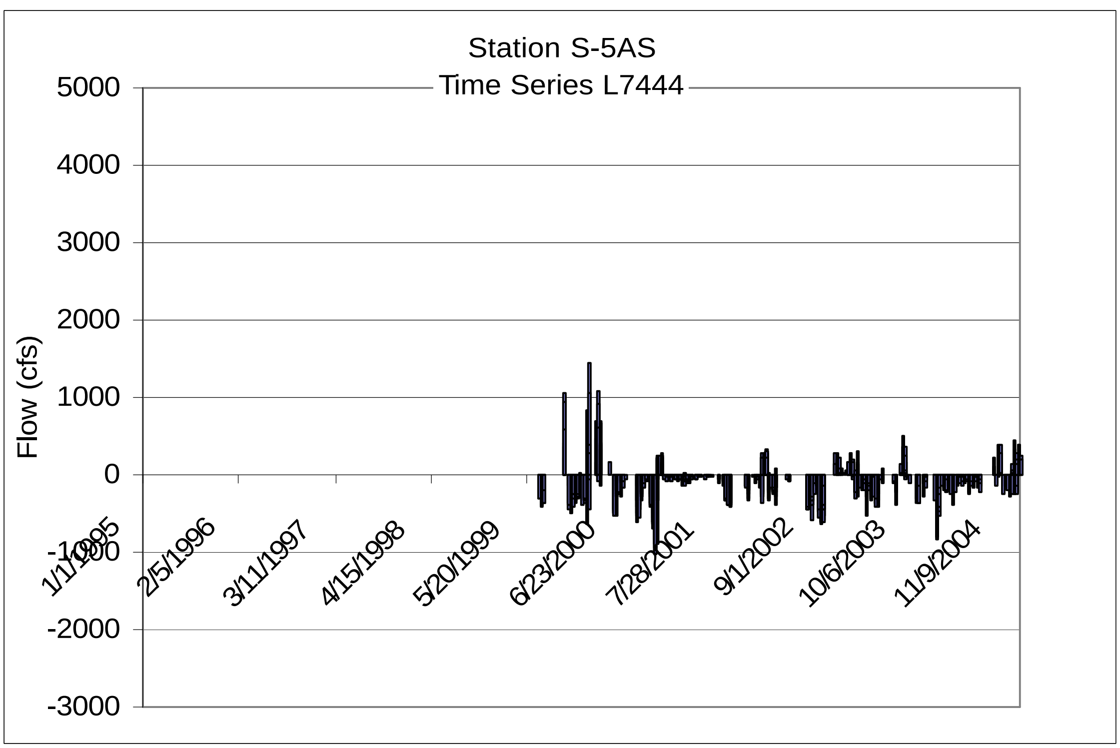

Figure B.10 S-5AS Flow

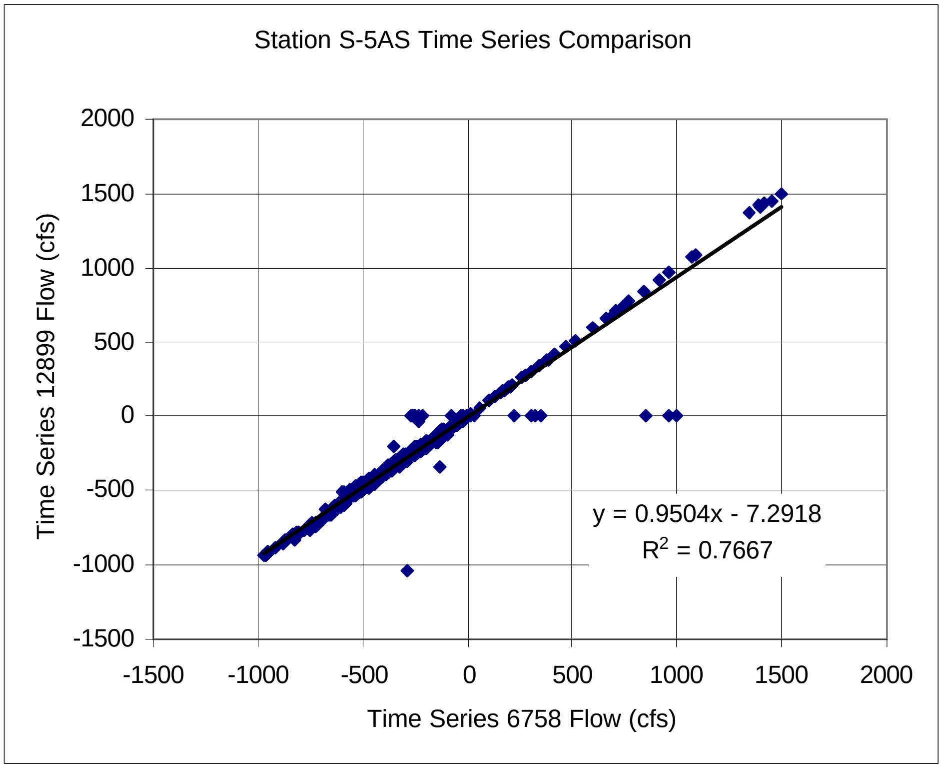

Figure B.11 S-5AS flow time series comparison.

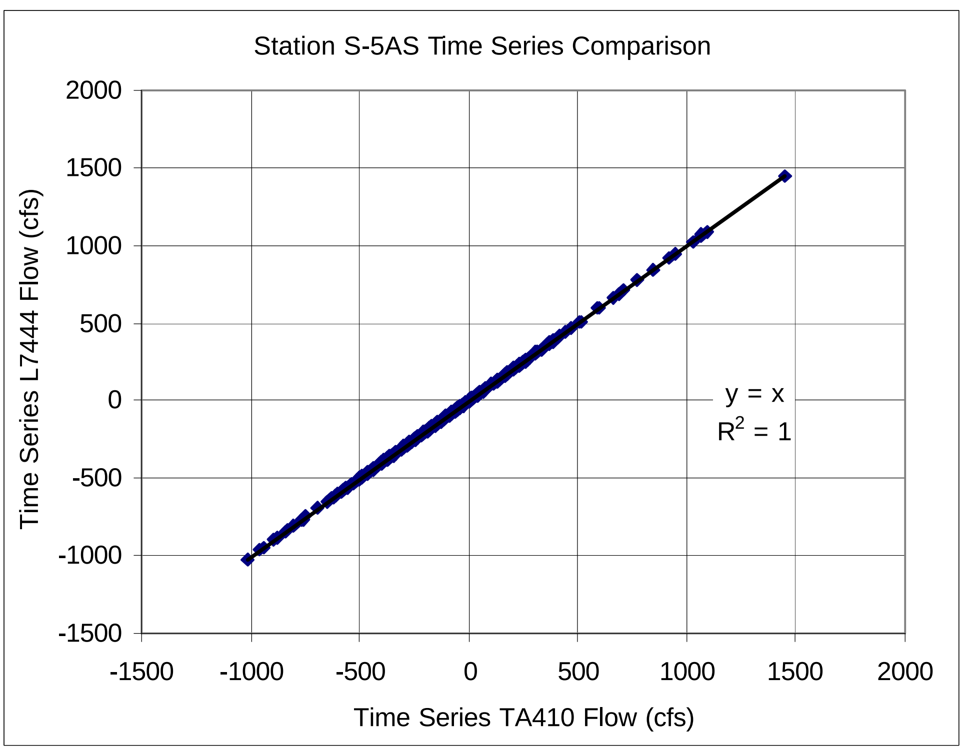

Figure B.12 S-5AS flow time series comparison.

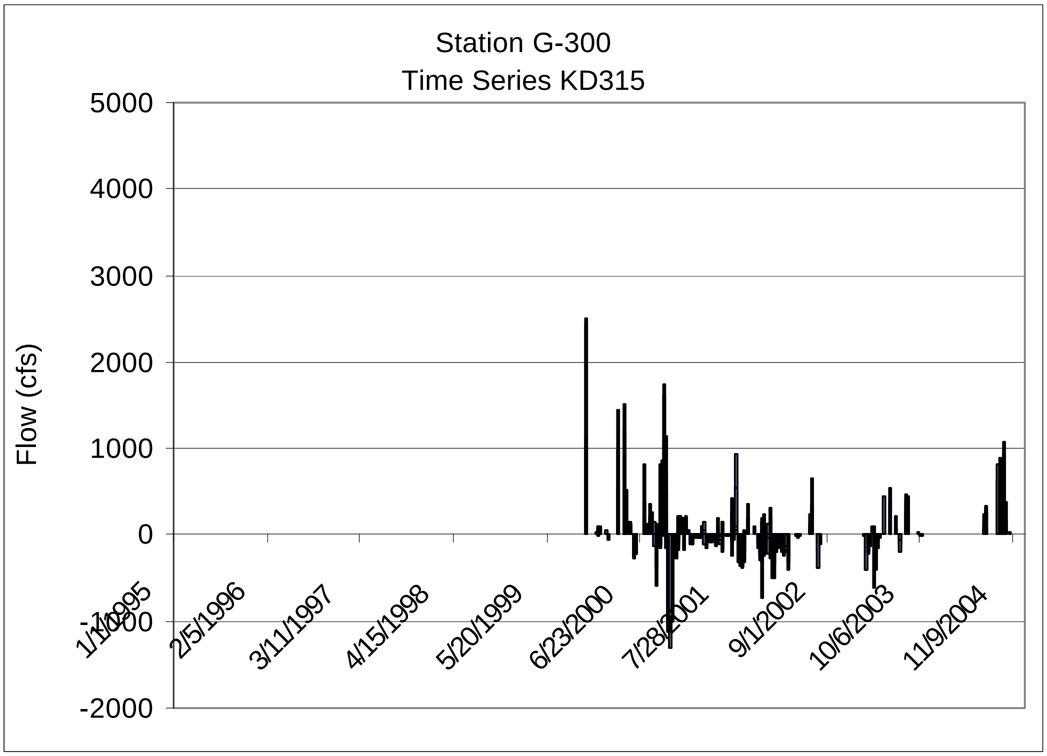

Figure B.13 G-300 Flow

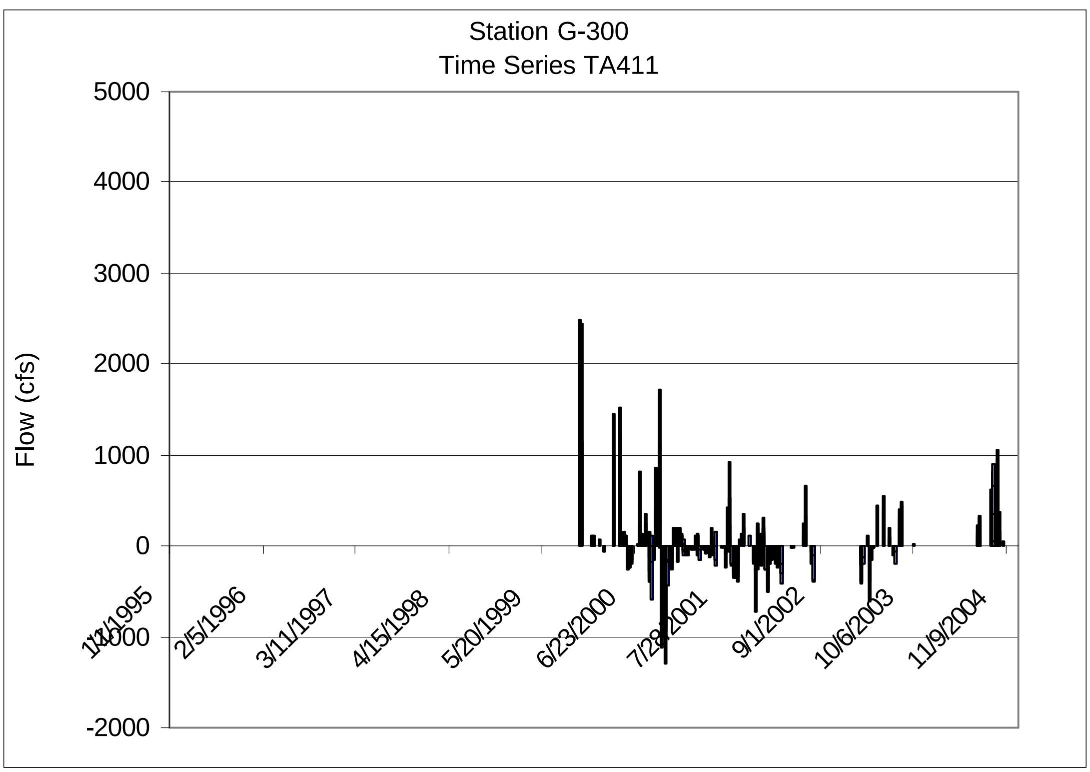

Figure B.14 G-300 Flow

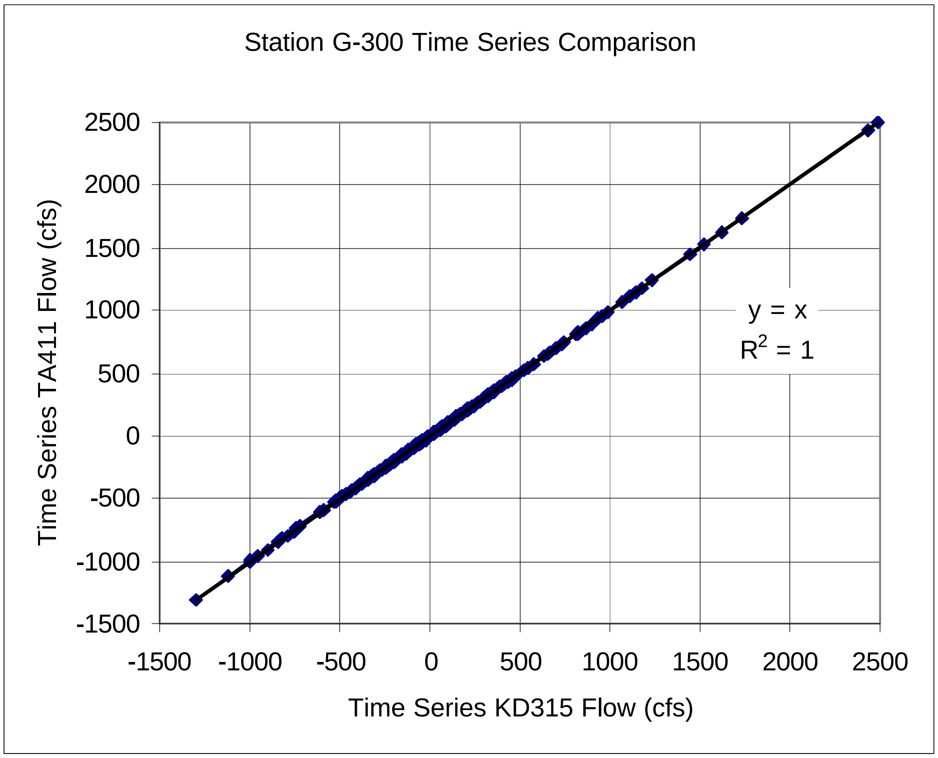

Figure B.15 G-300 flow time series comparison.

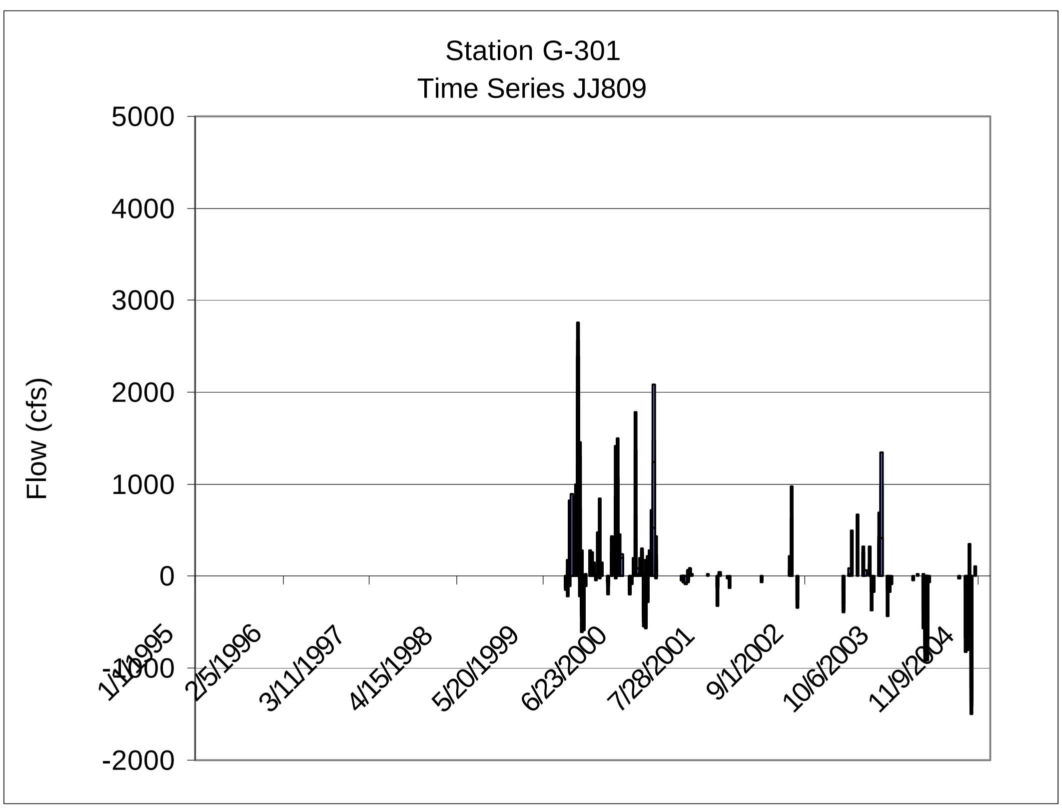

Figure B.16 G-301 Flow

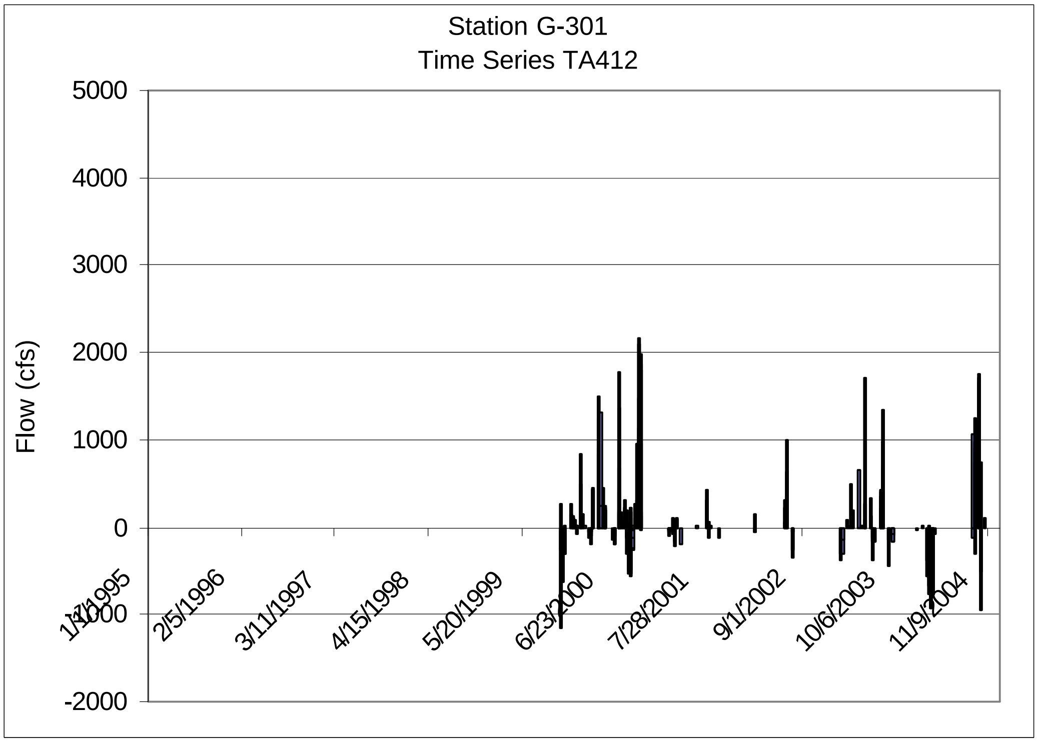

Figure B.17 G-301 Flow

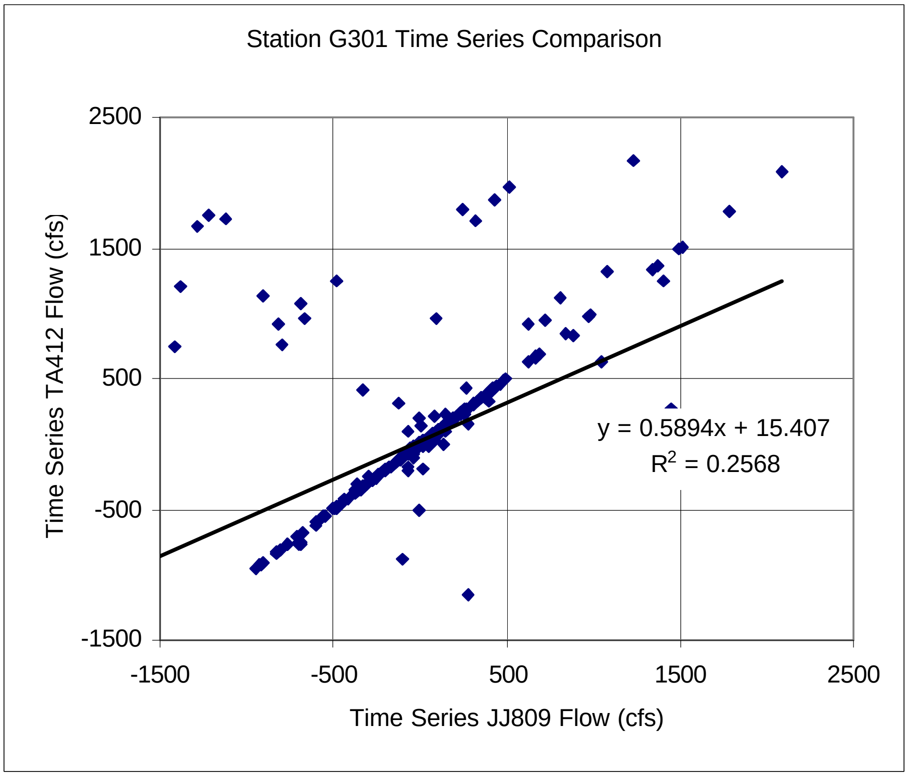

Figure B.18 G-301 flow time series comparison.

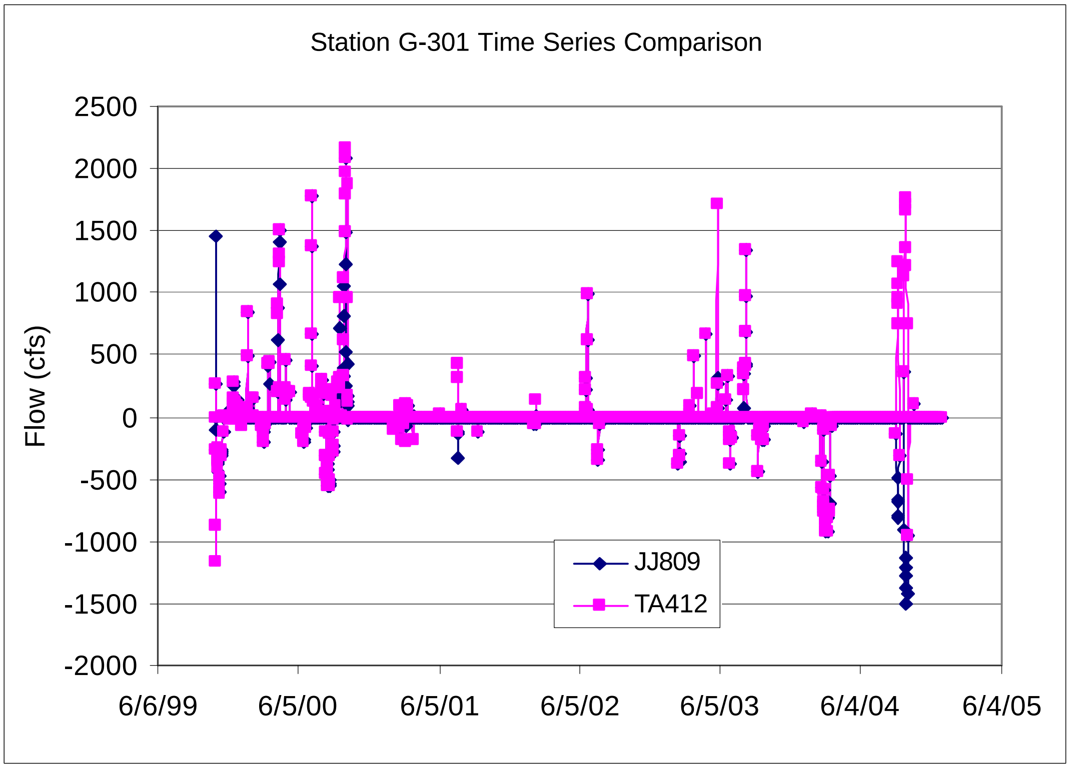

Figure B.19 G-301 flow time series comparison.

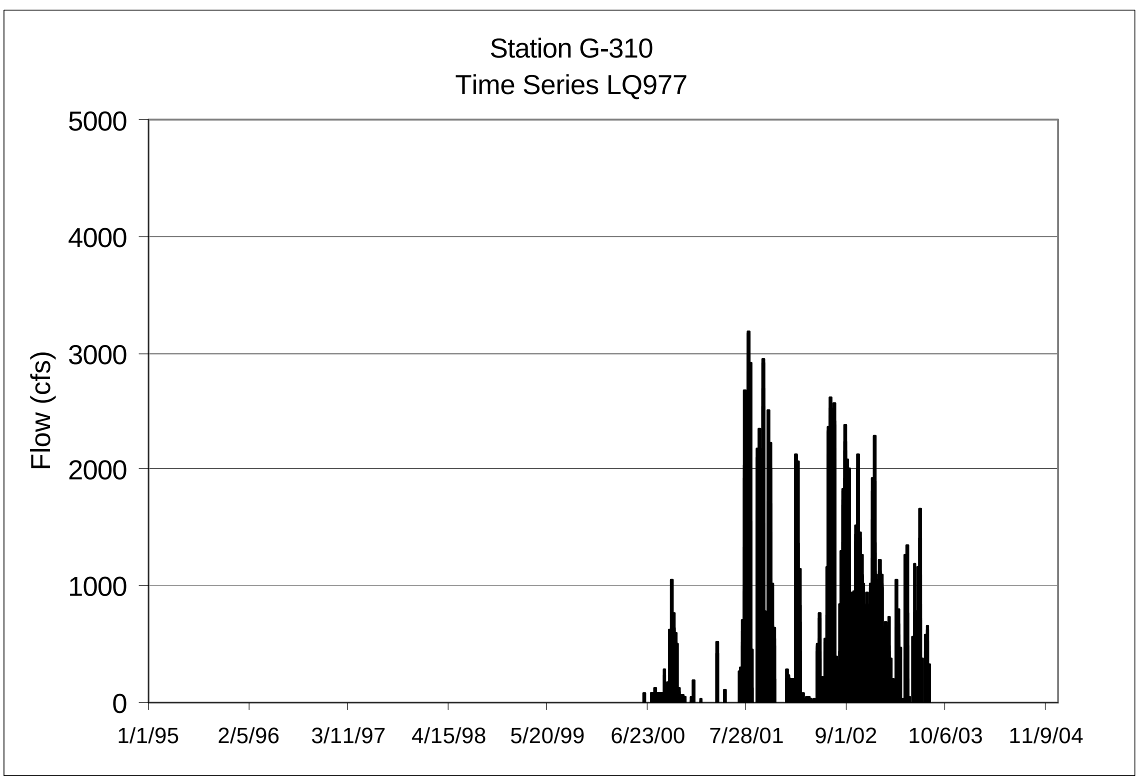

Figure B.20 G-310 Flow

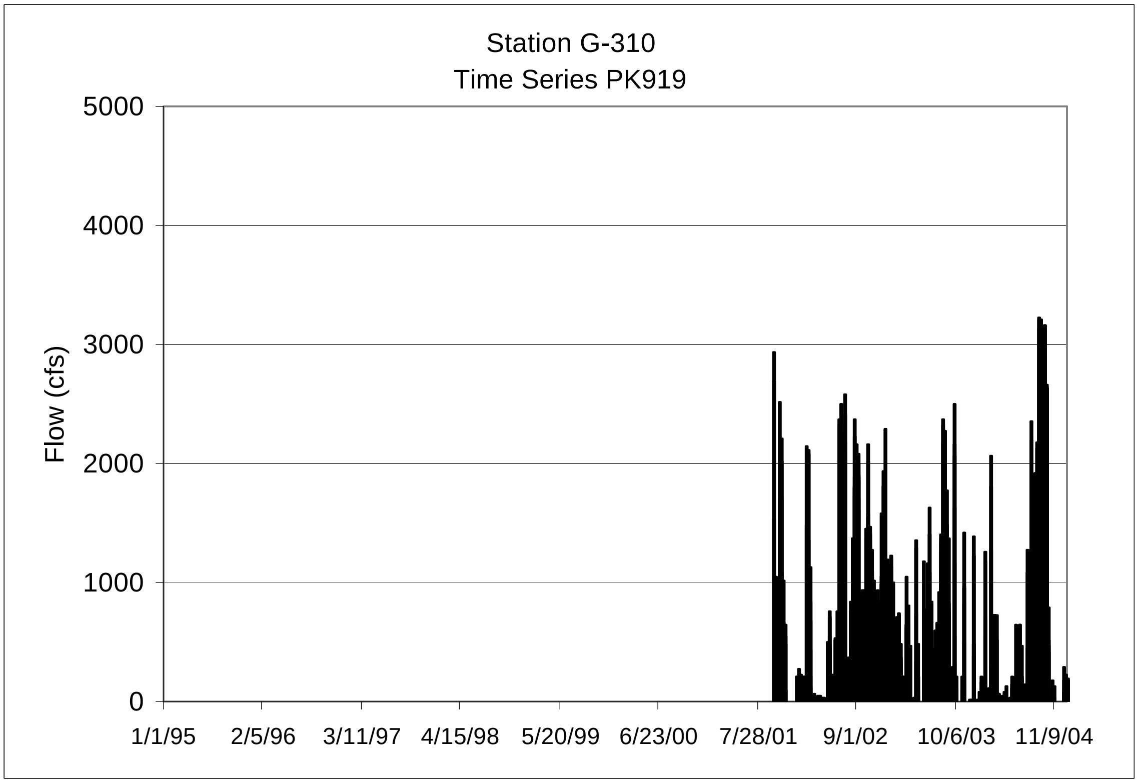

Figure B.21 G-310 Flow

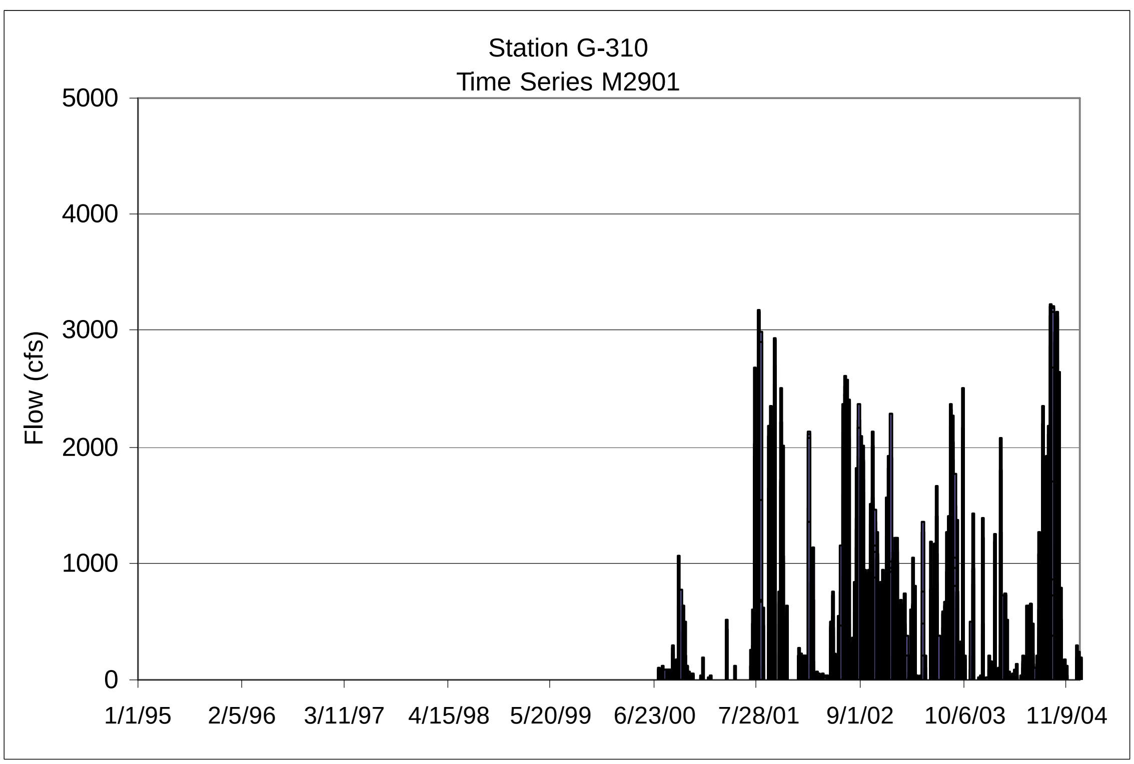

Figure B.22 G-310 Flow

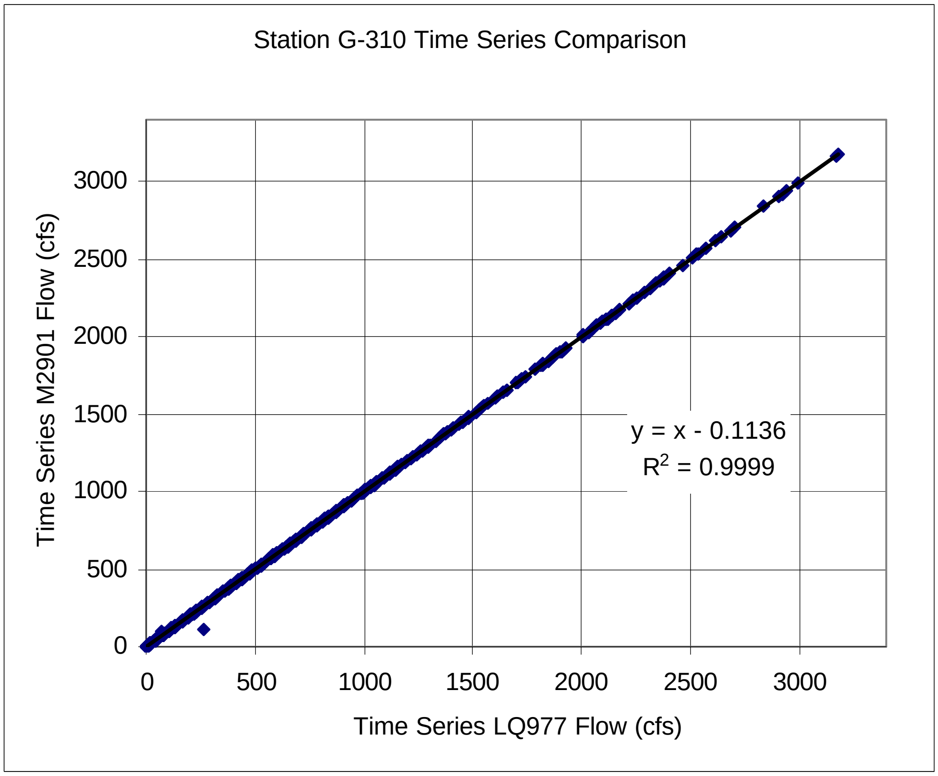

Figure B.23 G-310 flow time series comparison.

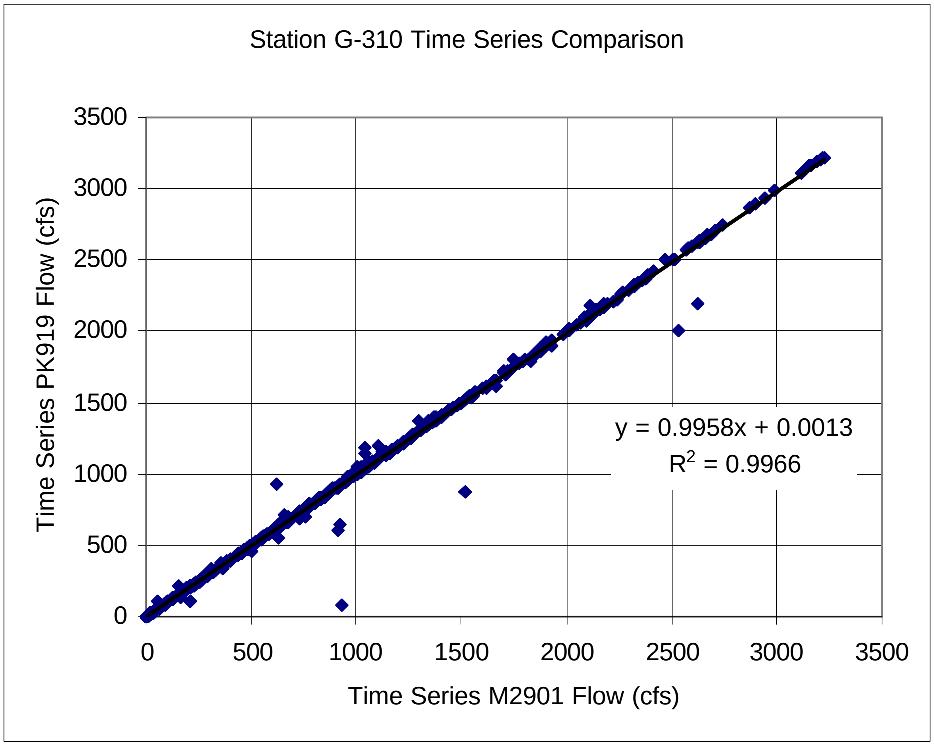

Figure B.24 G-310 flow time series comparison.

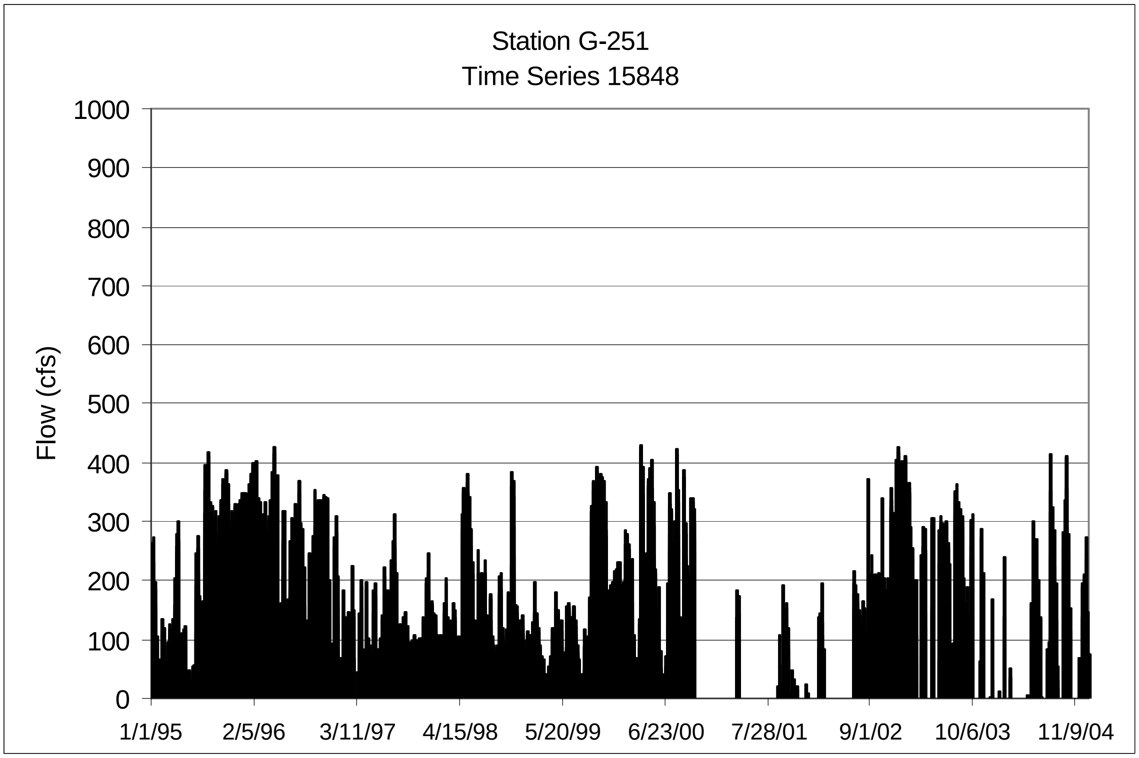

Figure B.25 G-251 Flow

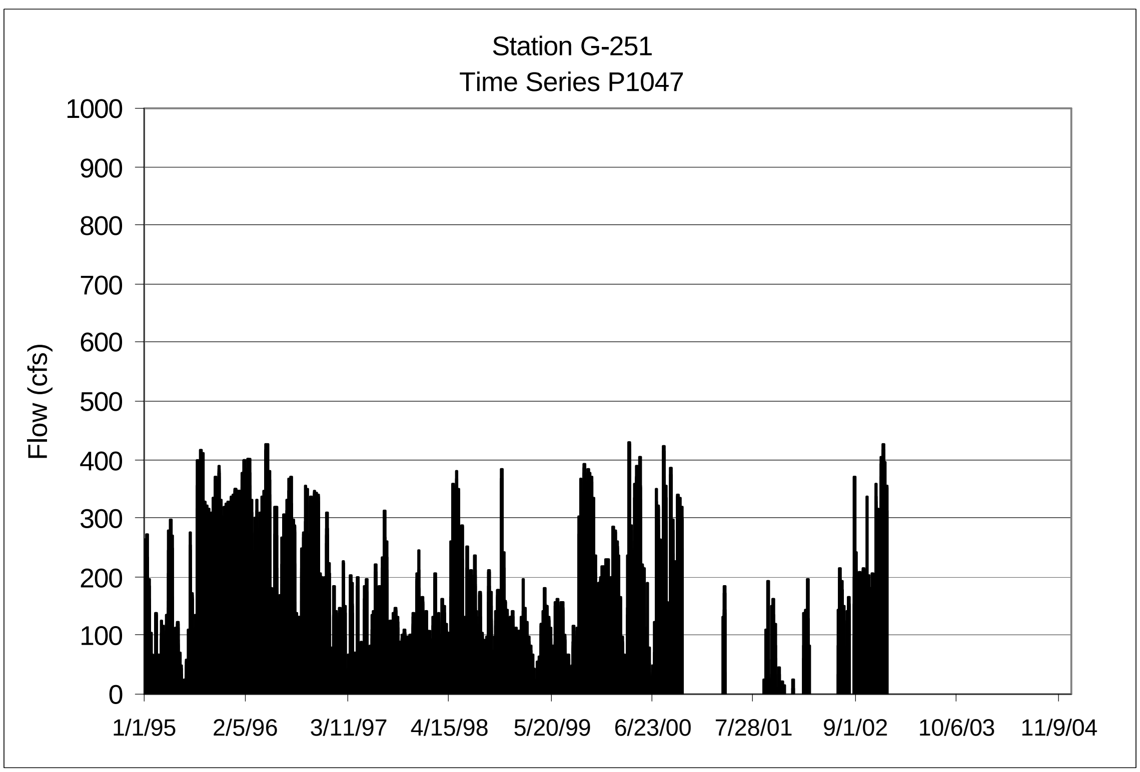

Figure B.26 G-251 Flow

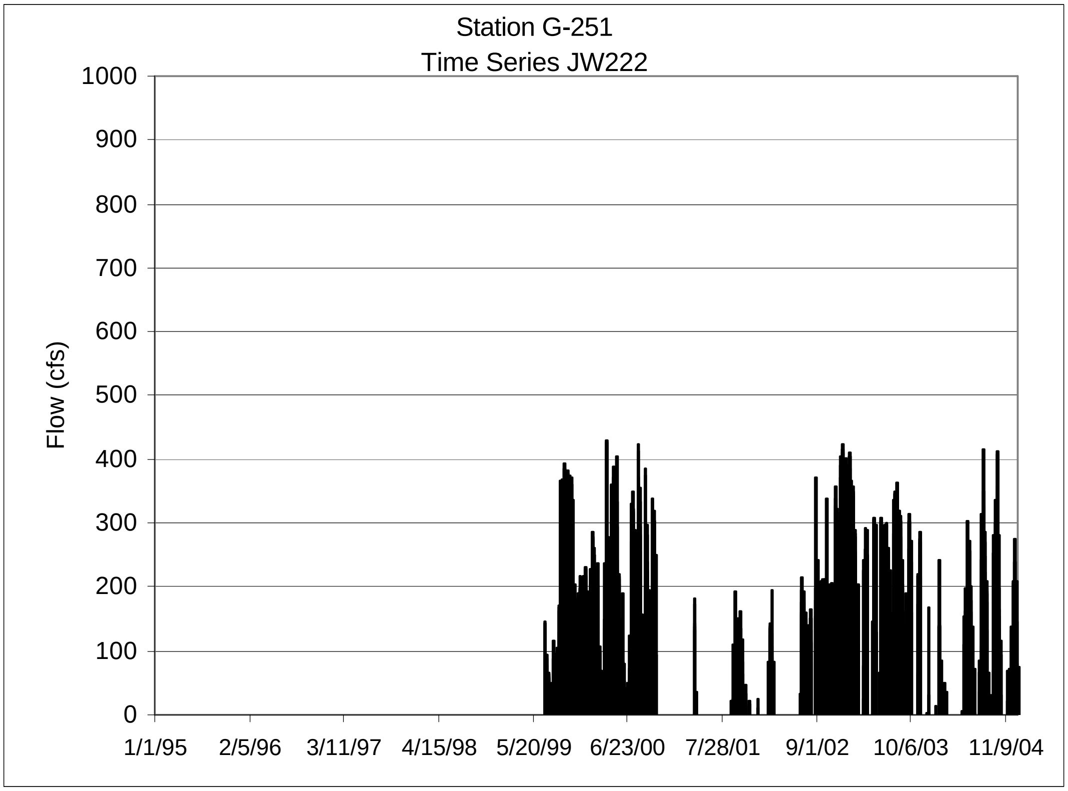

Figure B.27 G-251 Flow

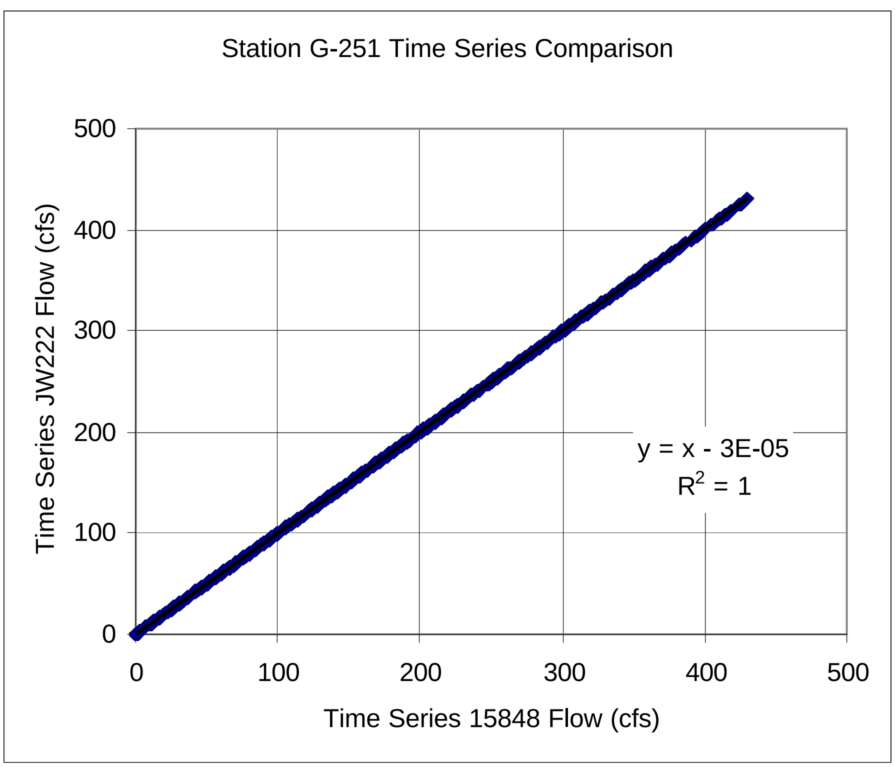

Figure B.28 G-251 flow time series comparison.

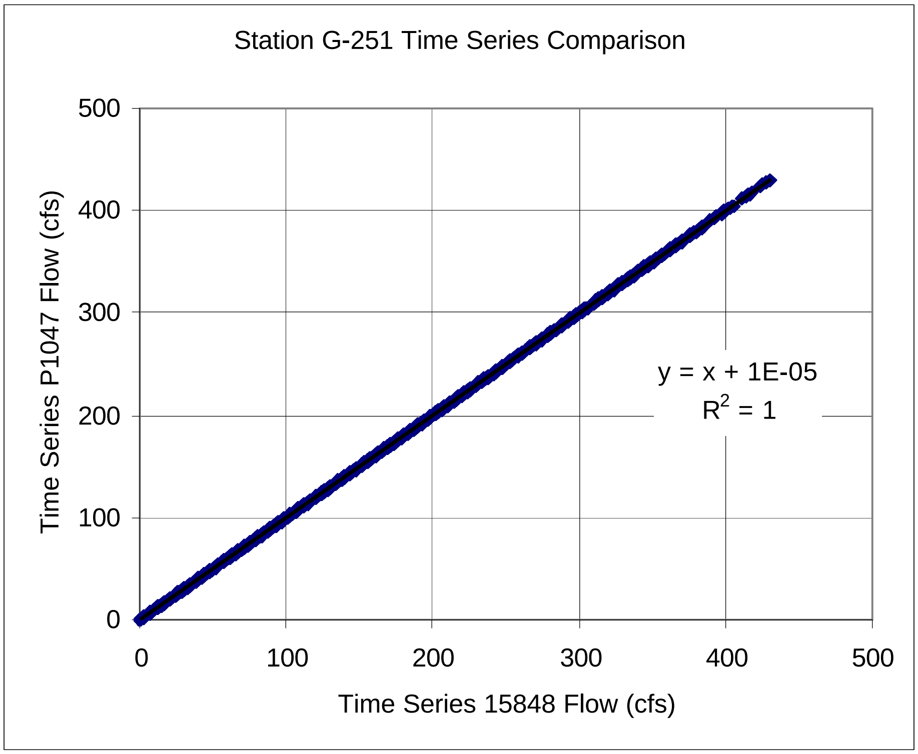

Figure B.29 G-251 flow time series comparison.

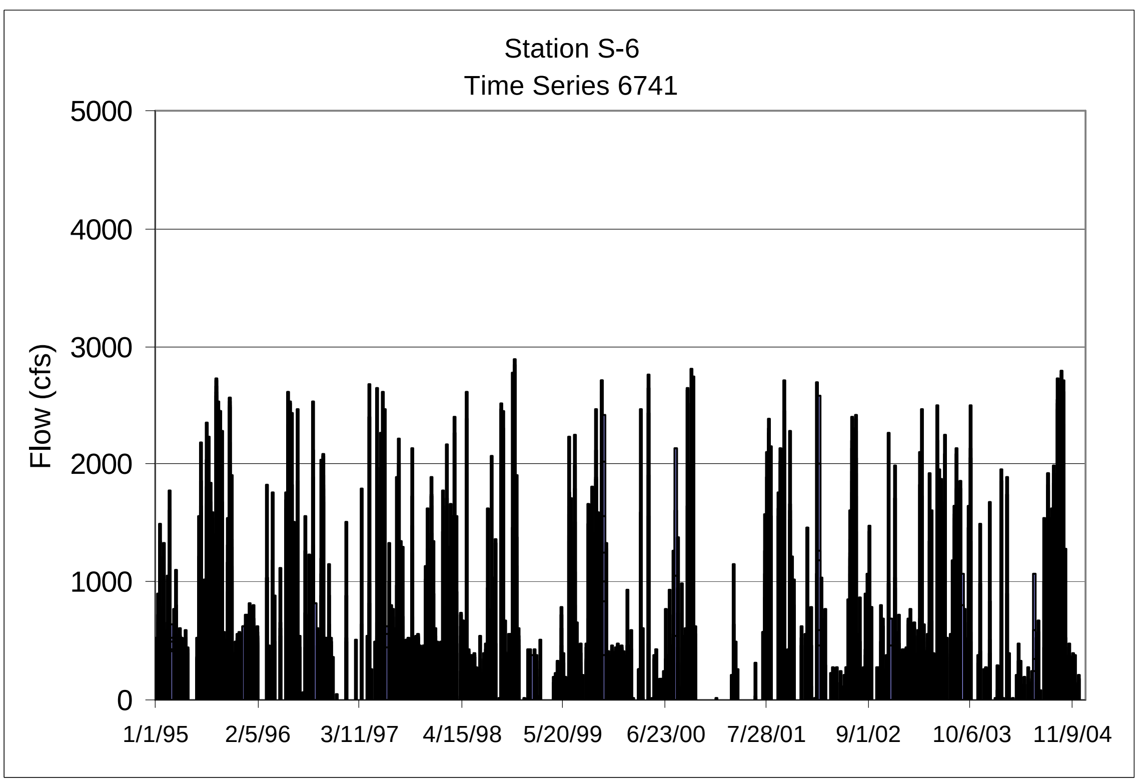

Figure B.30 S-6 Flow

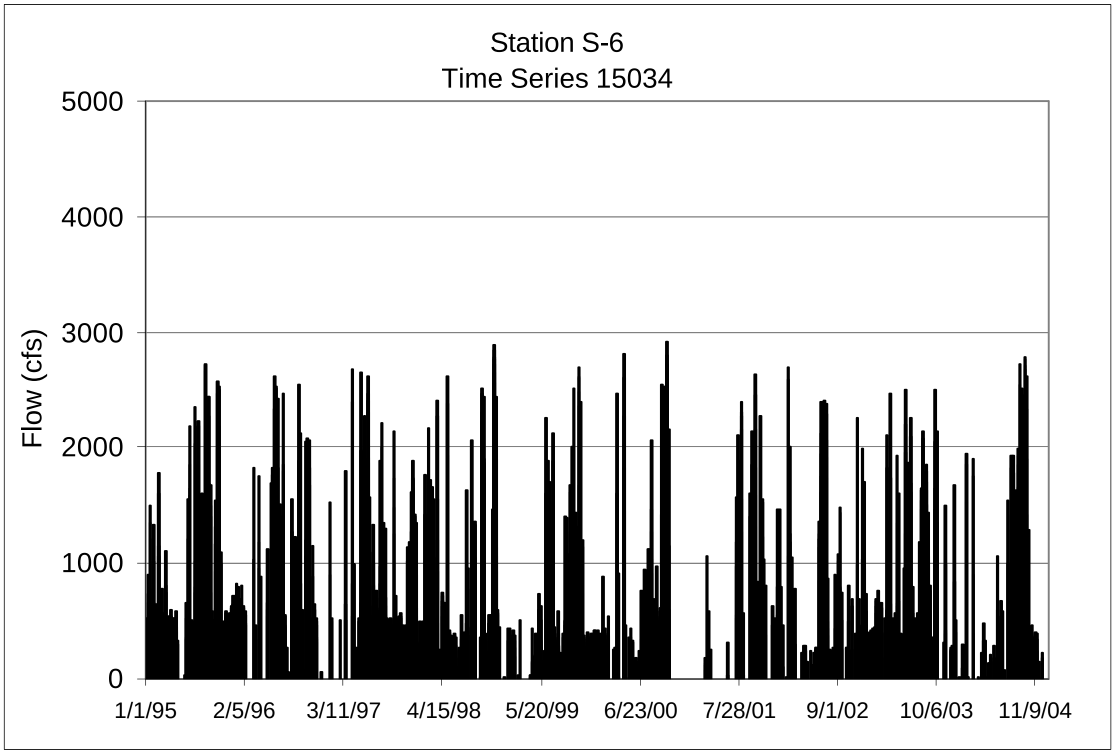

Figure B.31 S-6 Flow

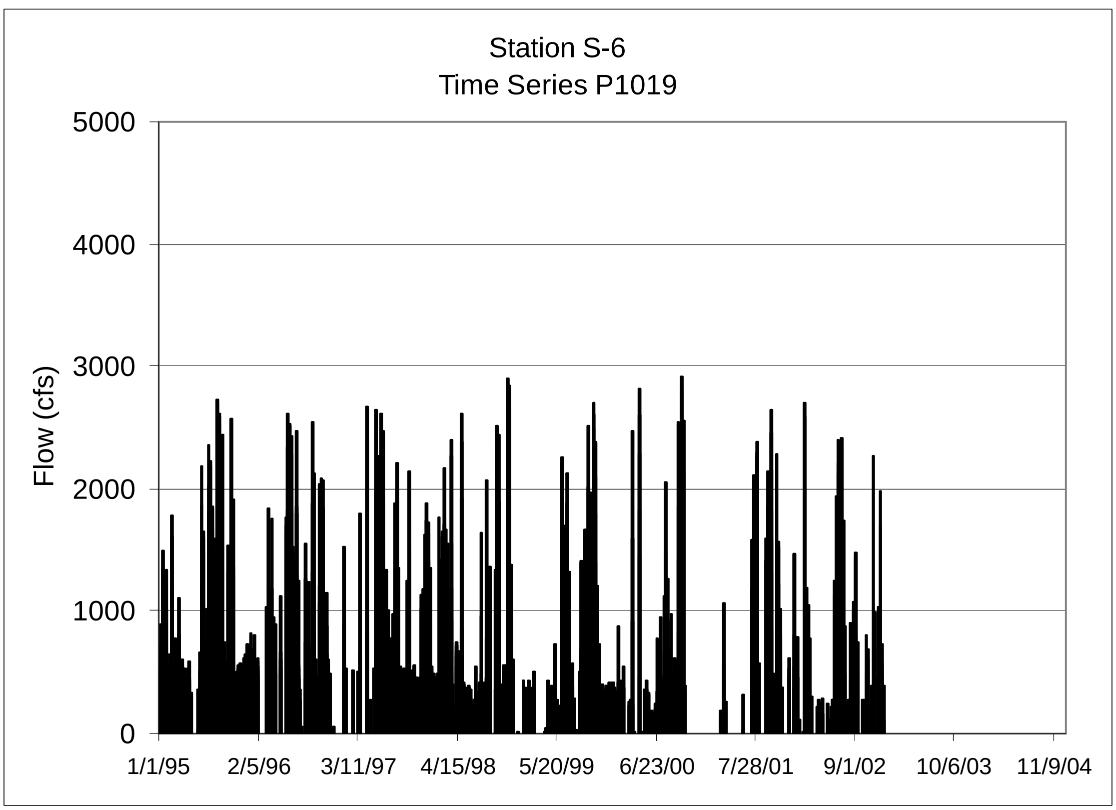

Figure B.32 S-6 Flow

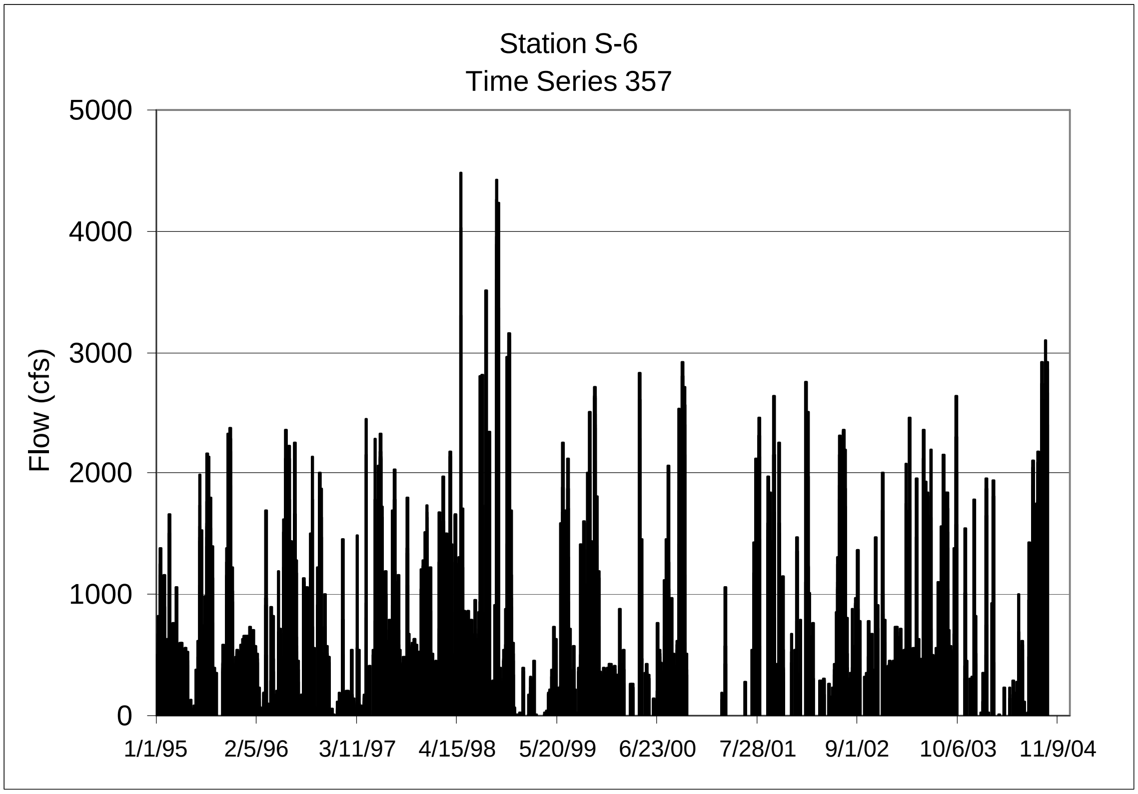

Figure B.33 S-6 Flow

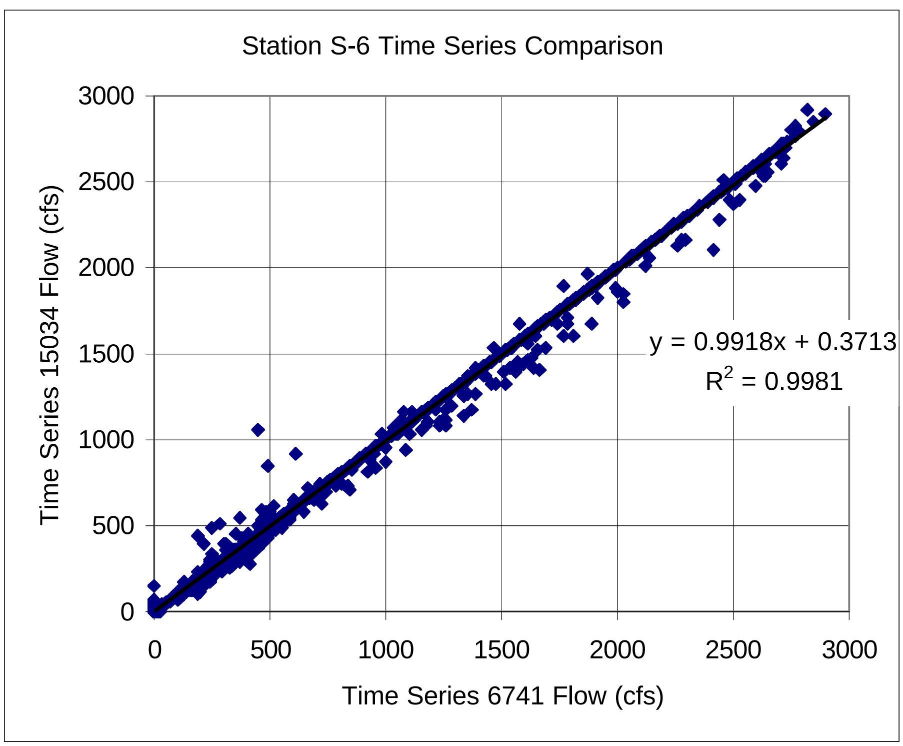

Figure B.34 S-6 flow time series comparison.

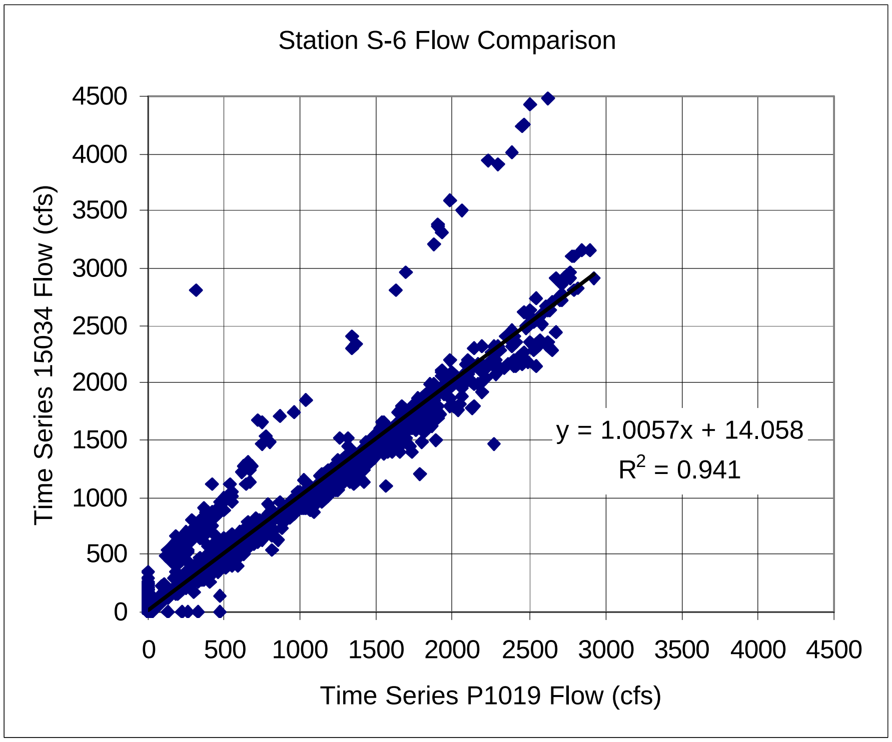

Figure B.35 S-6 flow time series comparison.

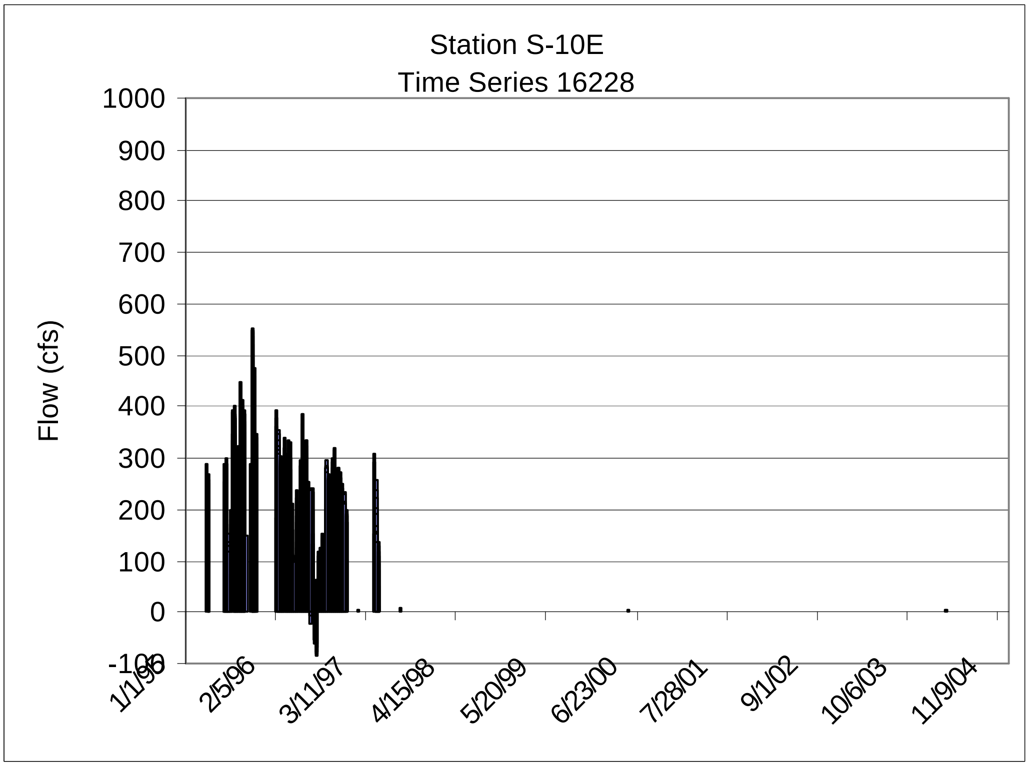

Figure B.36 S-10E Flow

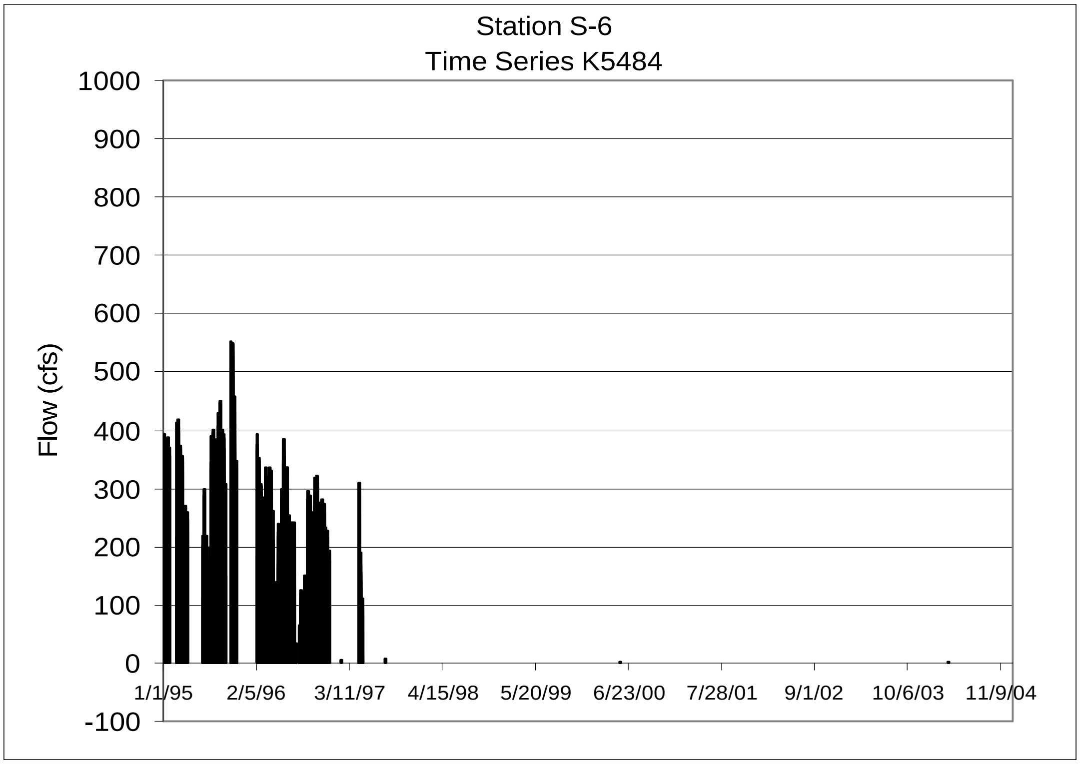

Figure B.37 S-10E Flow

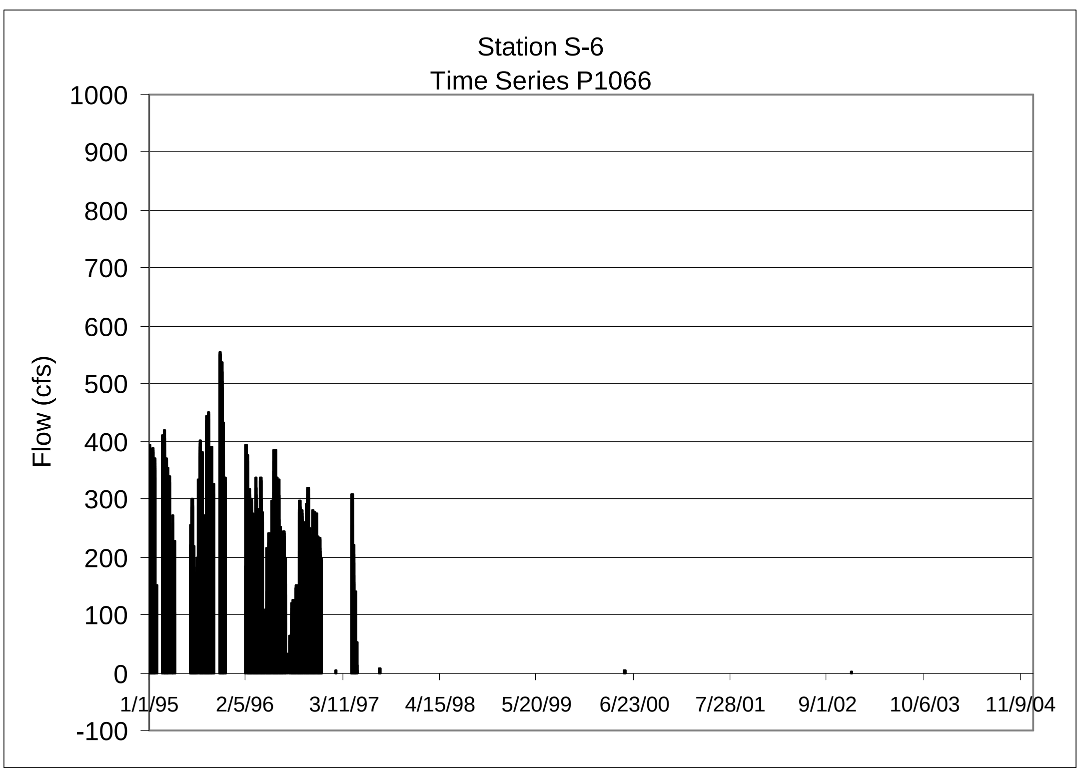

Figure B.38 S-10E Flow

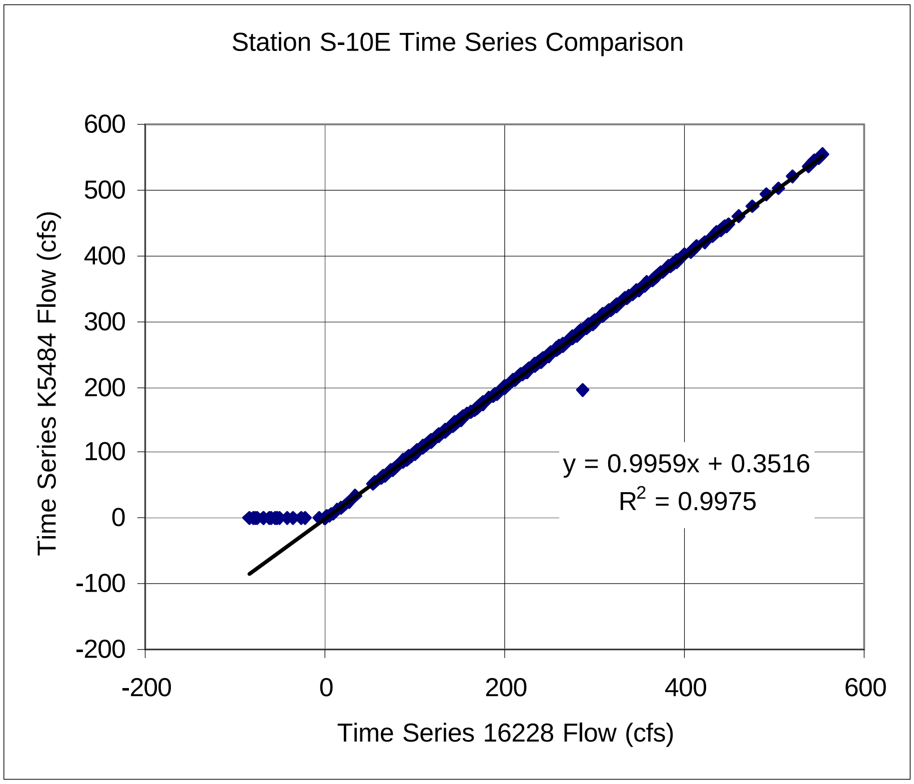

Figure B.39 S-10E flow time series comparison.

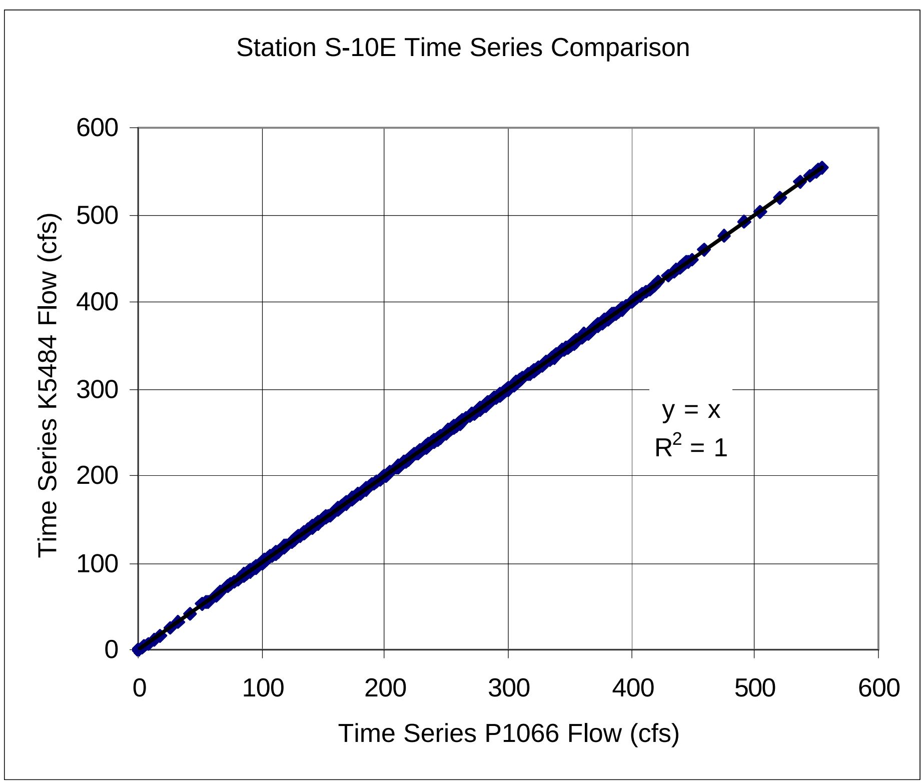

Figure B.40 S-10E flow time series comparison.

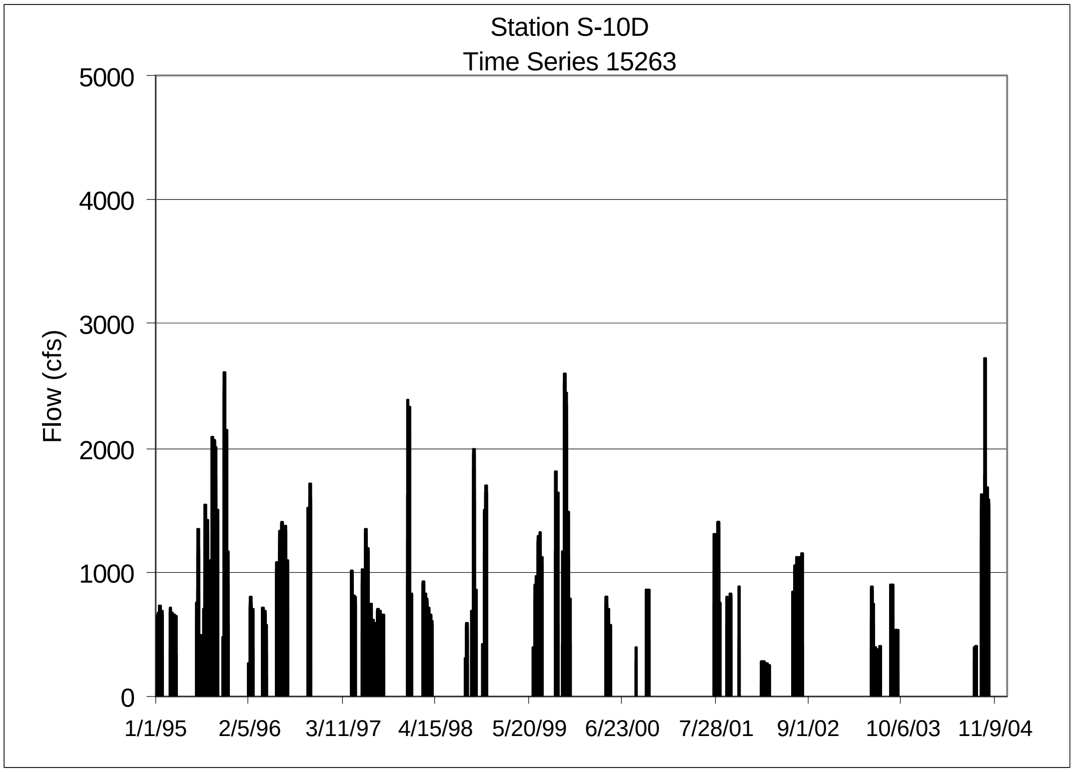

Figure B.41 S-10D Flow

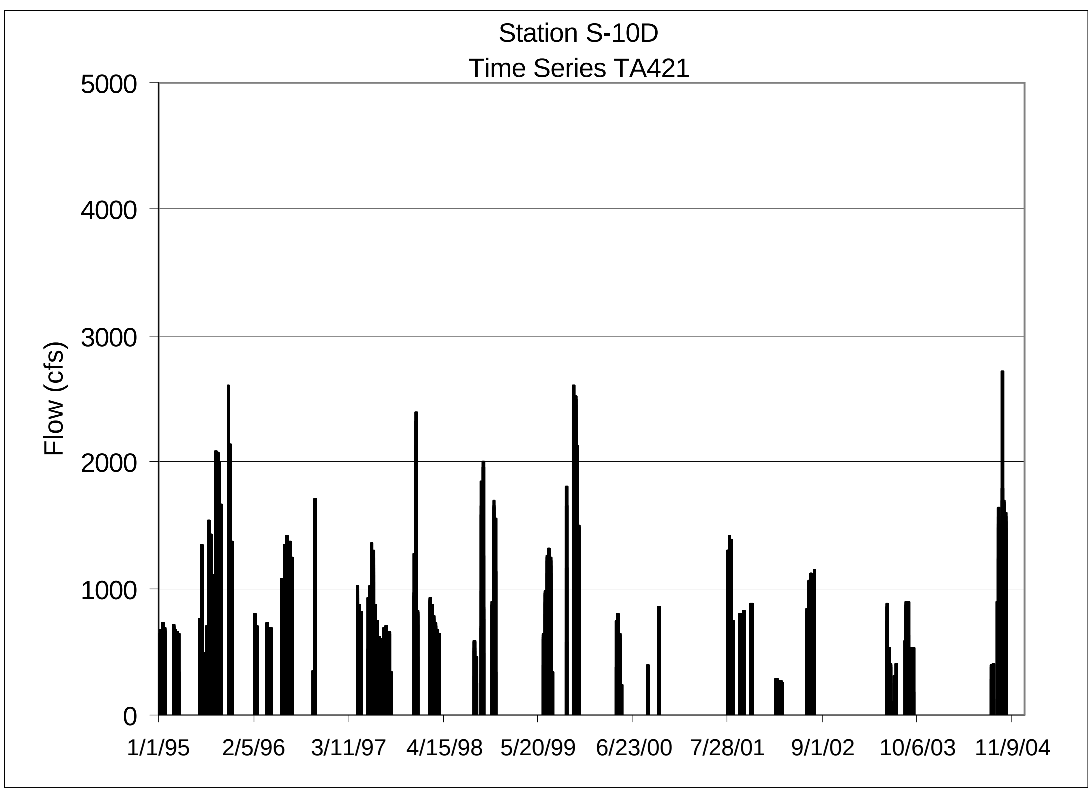

Figure B.42 S-10D Flow

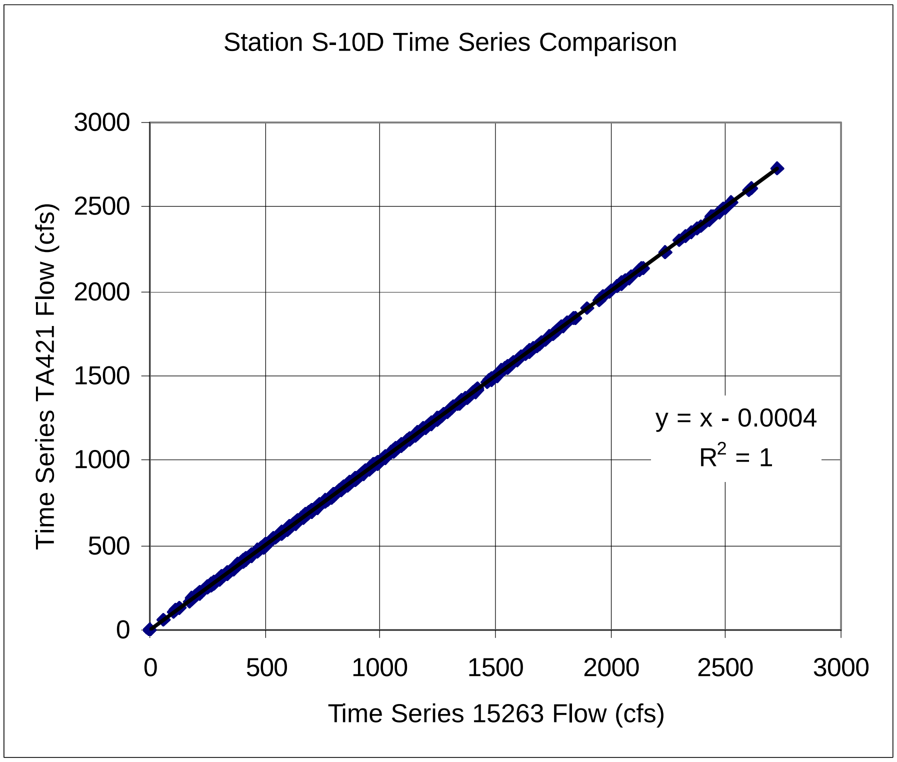

Figure B.43 S-10D flow time series comparison.

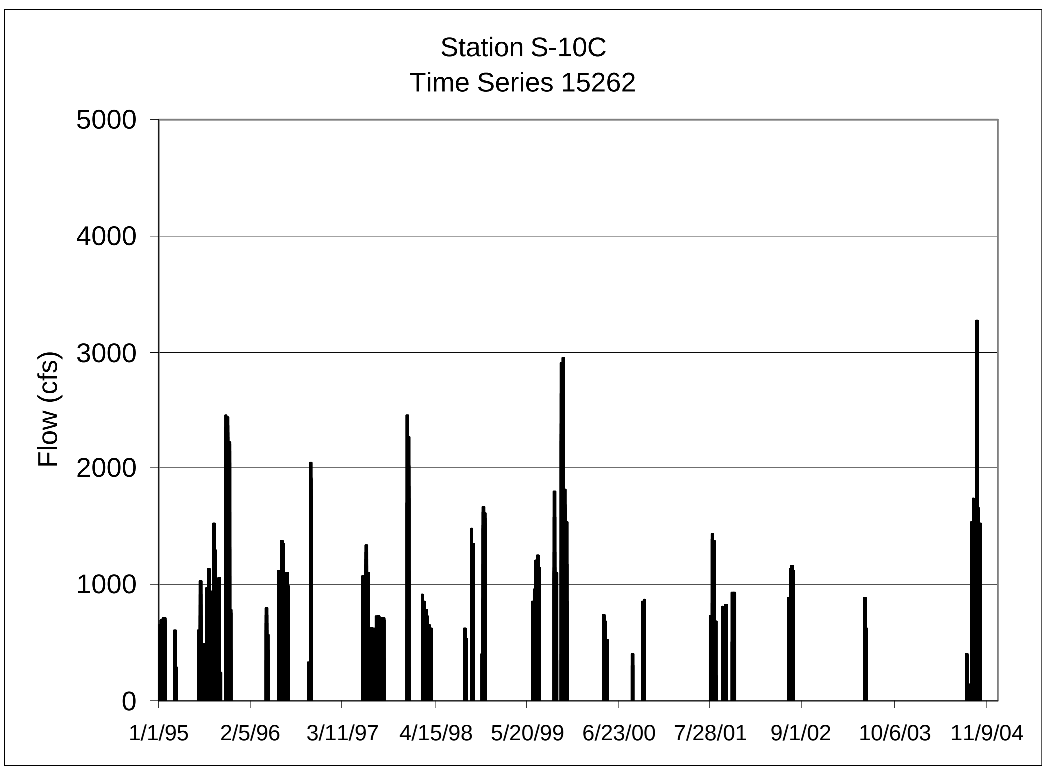

Figure B.44 S-10C Flow

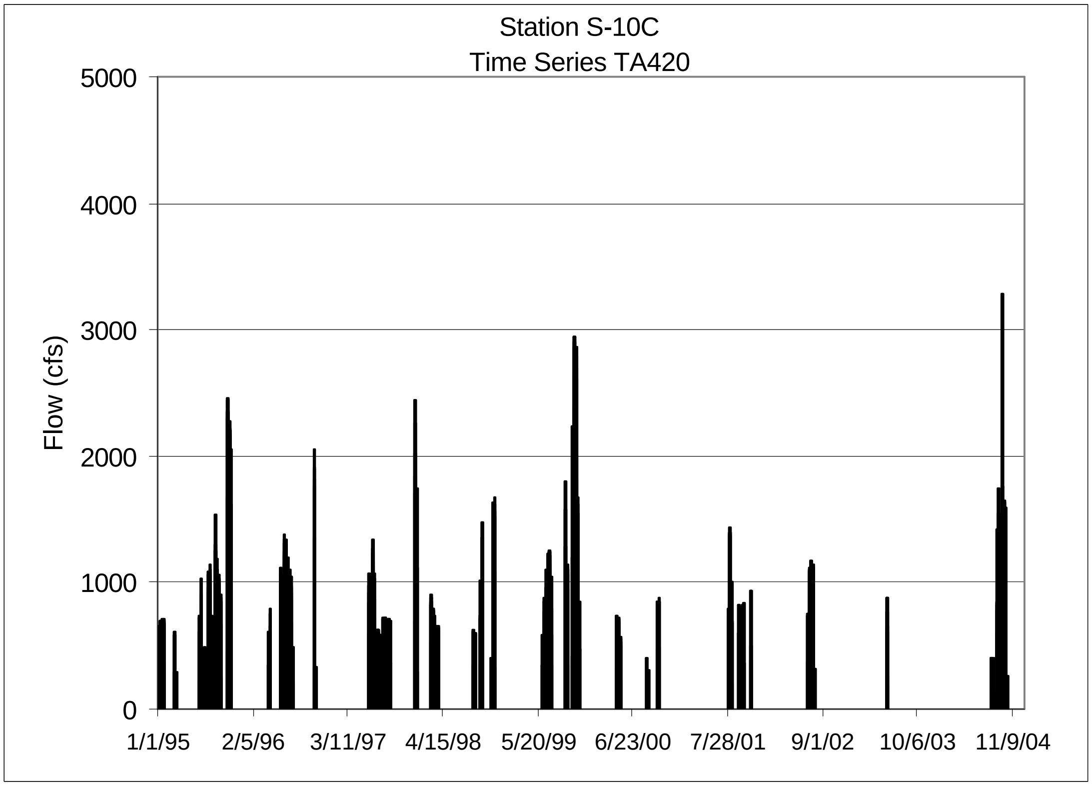

Figure B.45 S-10C Flow

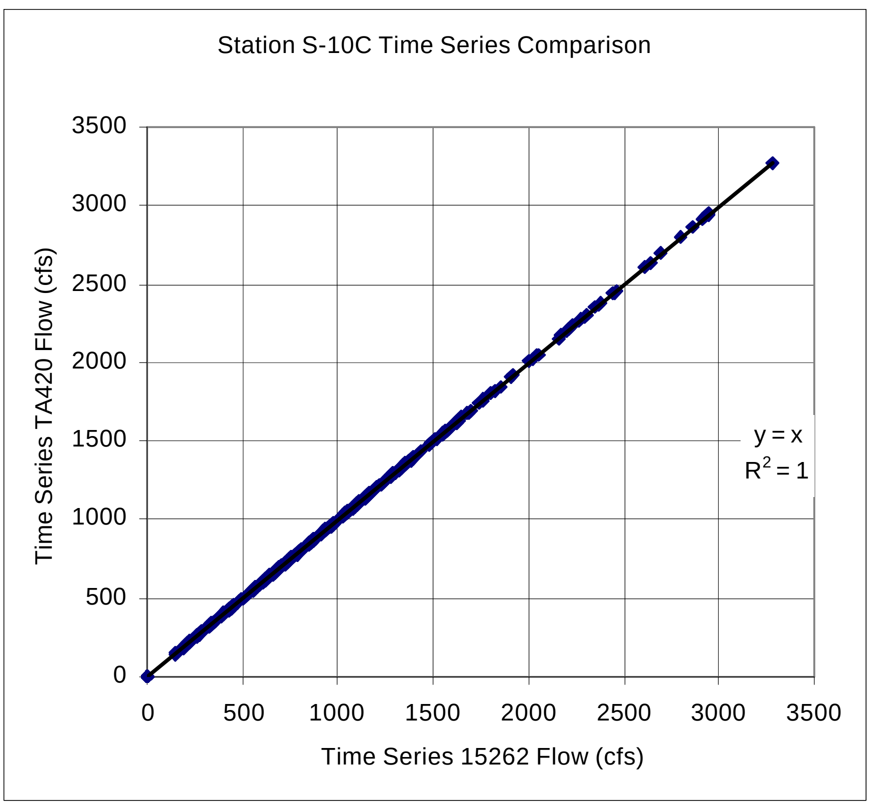

Figure B.46 S-10C flow time series comparison.

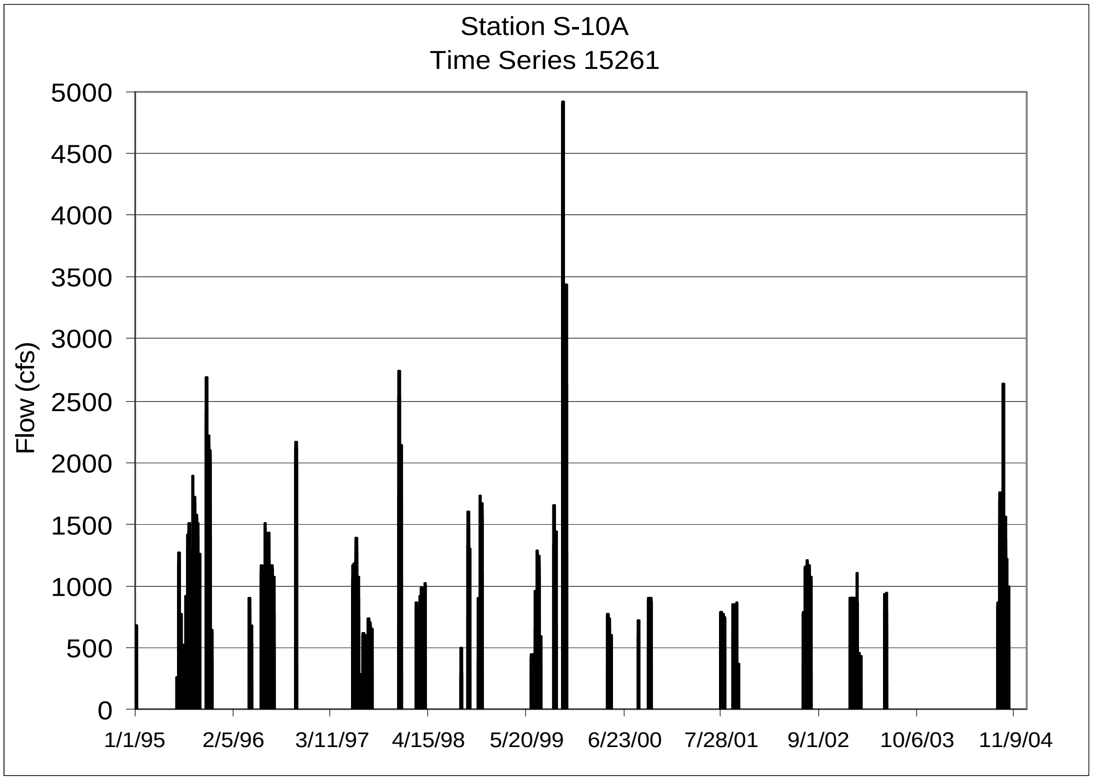

Figure B.47 S-10A Flow

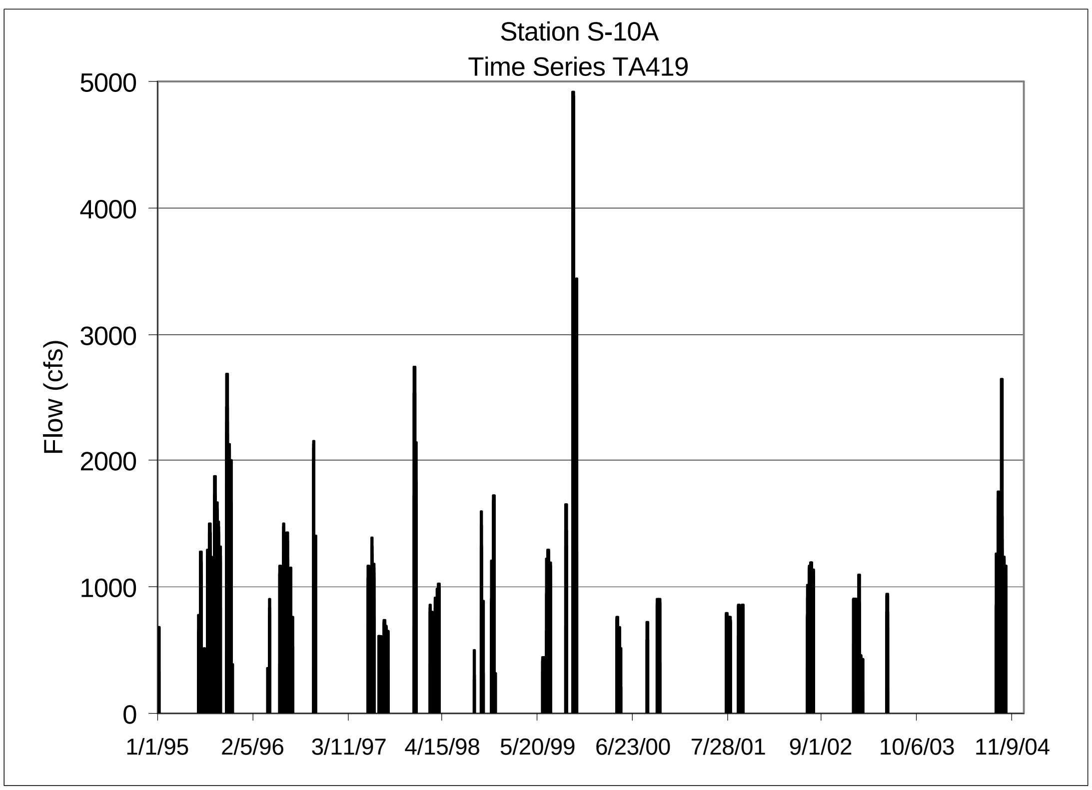

Figure B.48 S-10A Flow

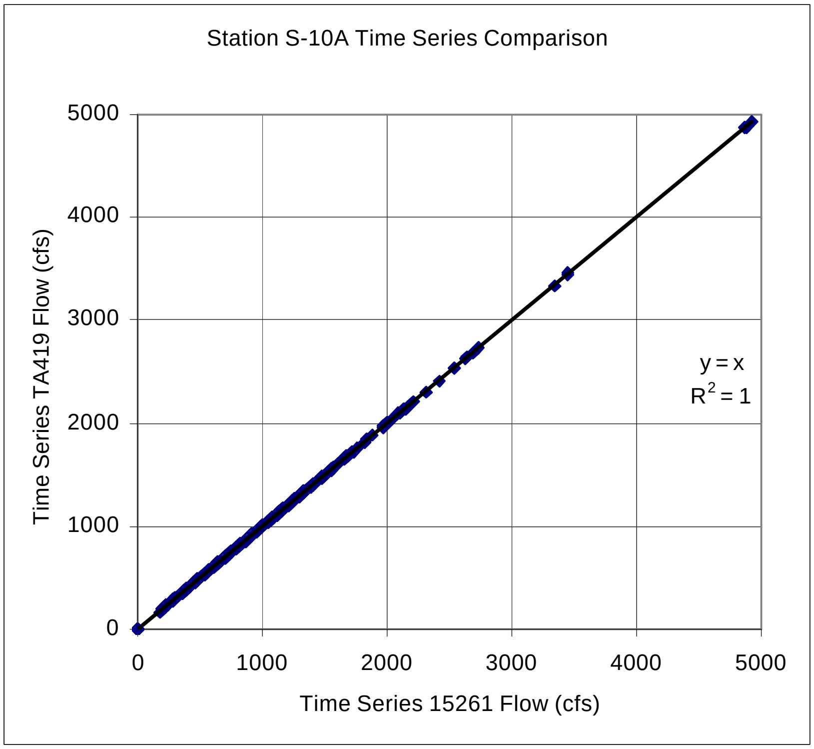

Figure B.49 S-10A flow time series comparison.

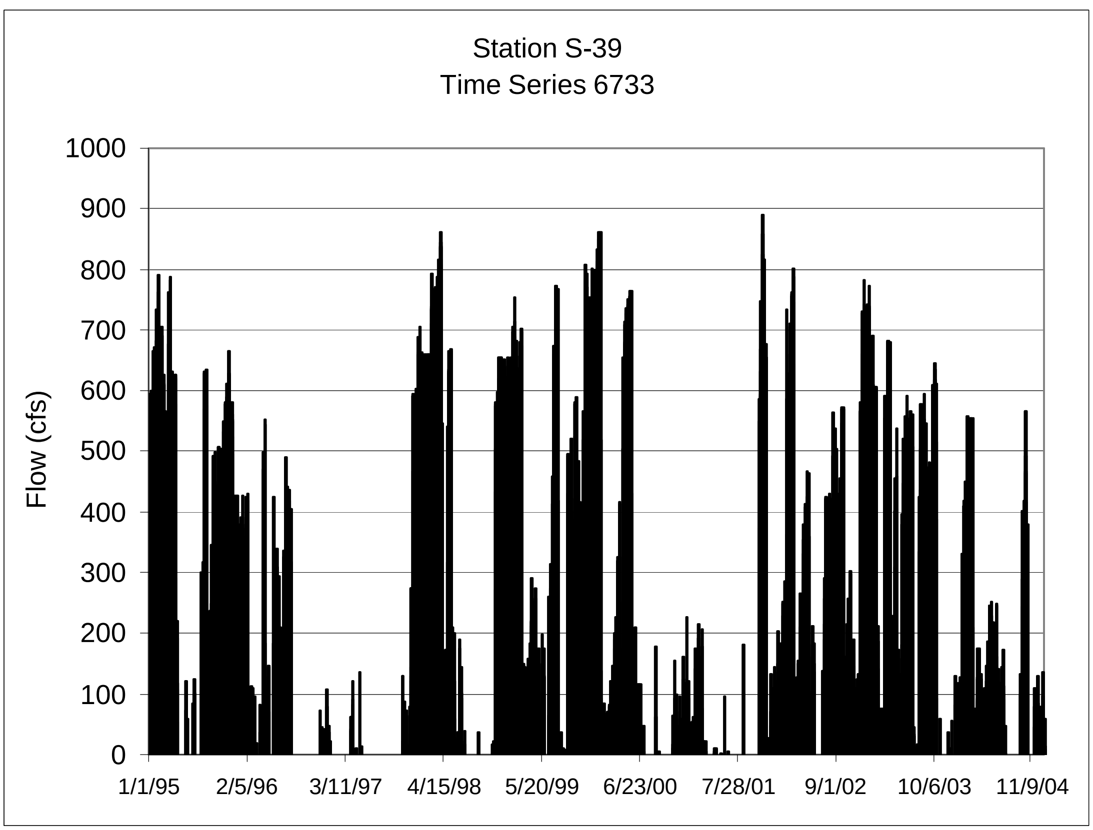

Figure B.50 S-39 Flow

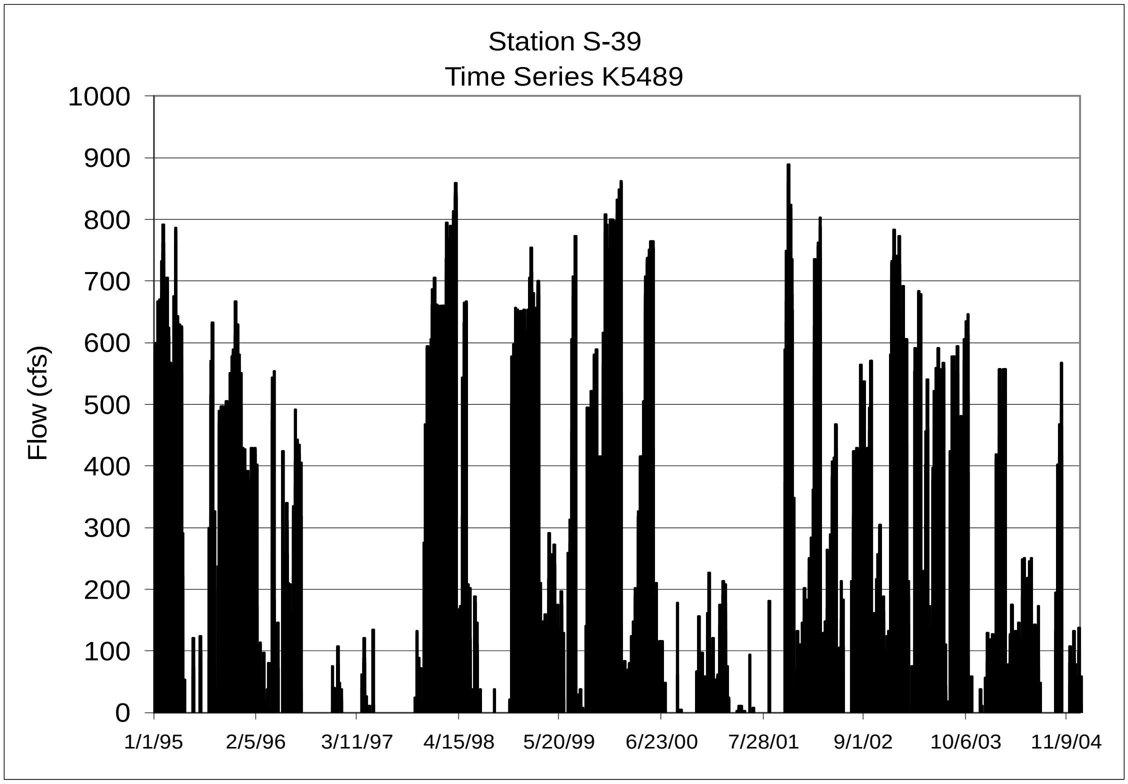

Figure B.51 S-39 Flow

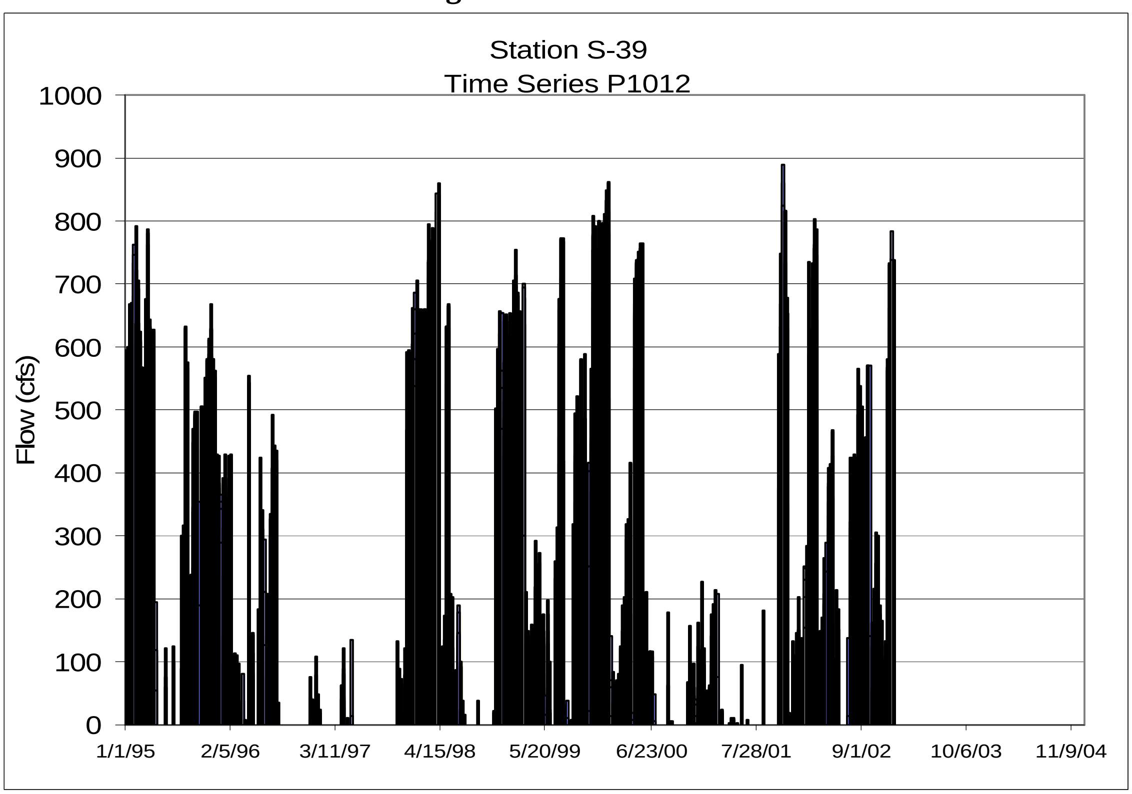

Figure B.52 S-39 Flow

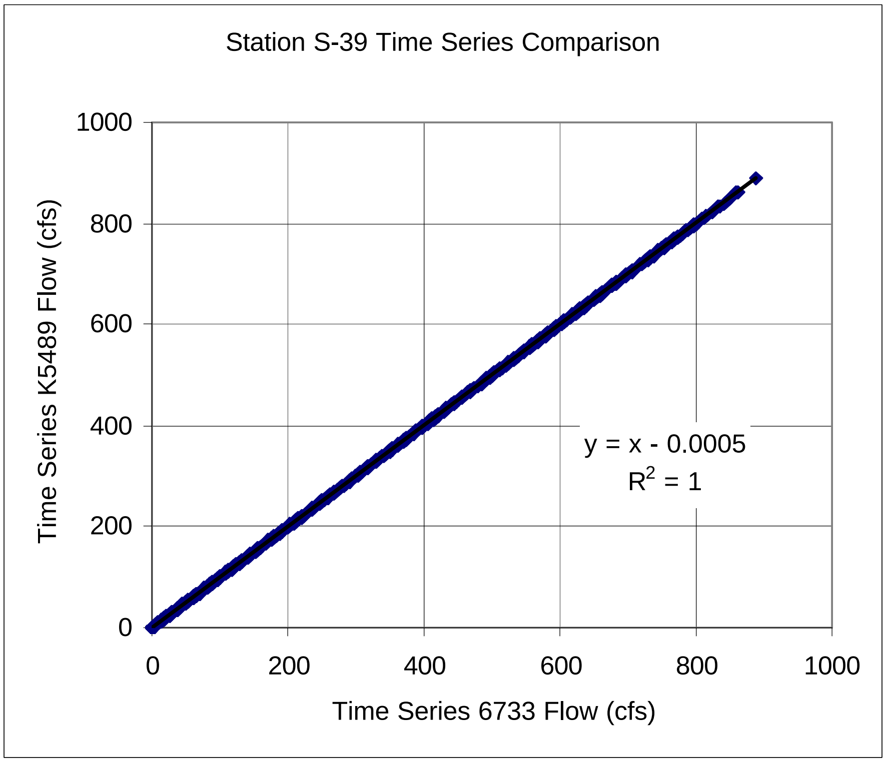

Figure B.53 S-39 flow time series comparison.

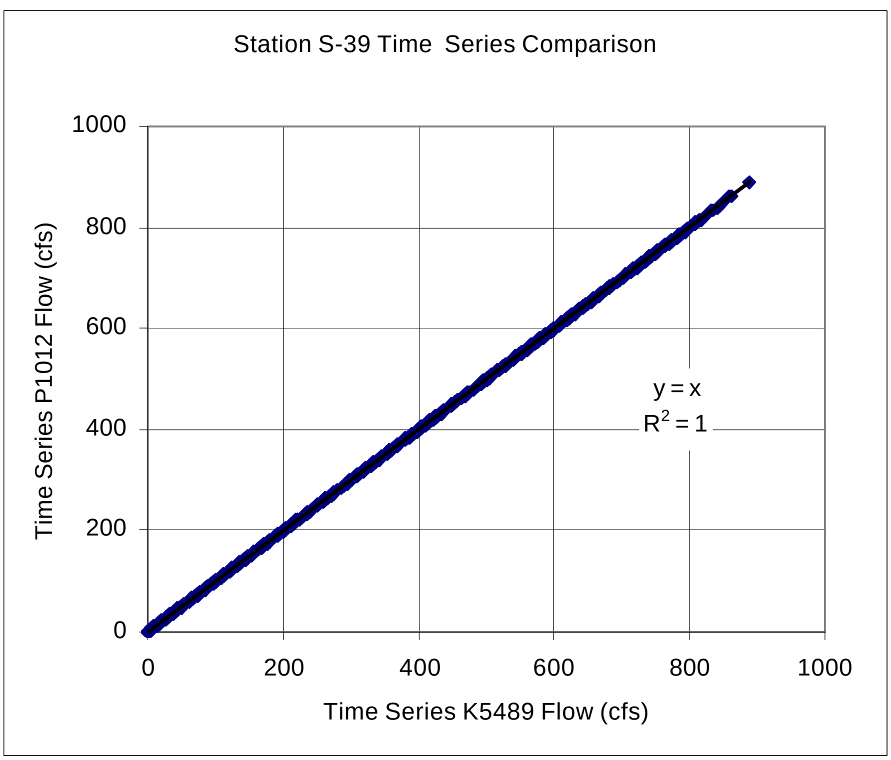

Figure B.54 S-39 flow time series comparison.

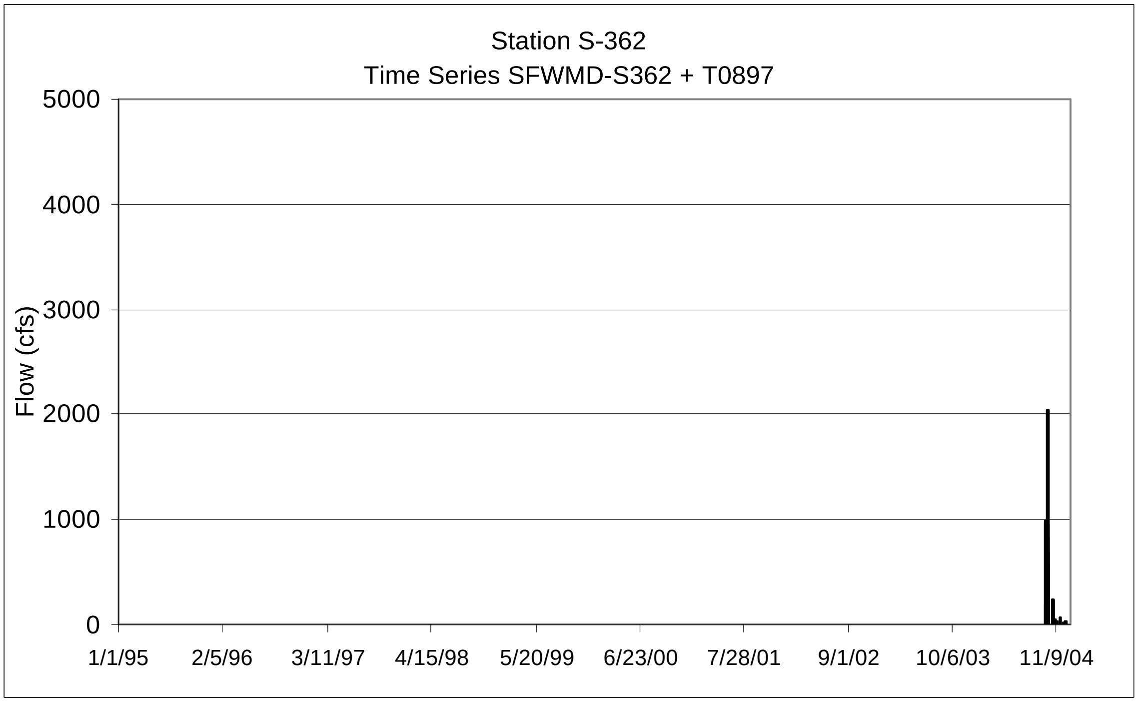

Figure B.55 S-362 Flow

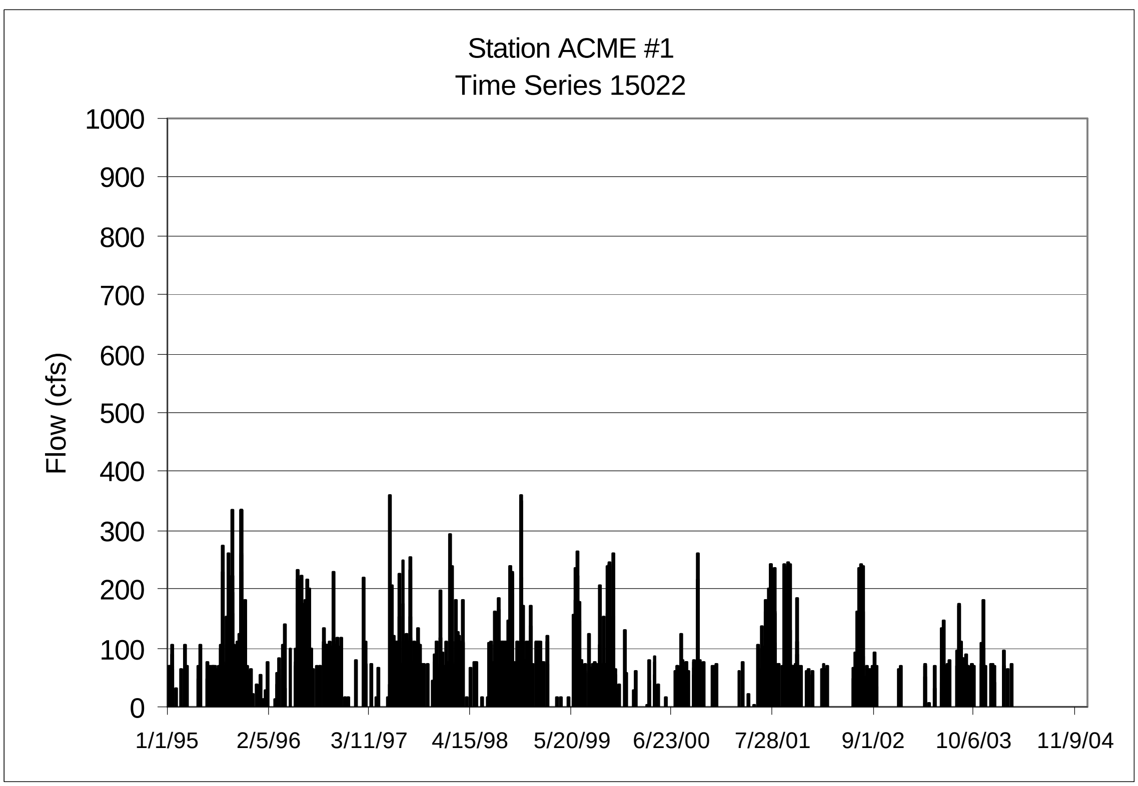

Figure B.56 ACME #1 Flow

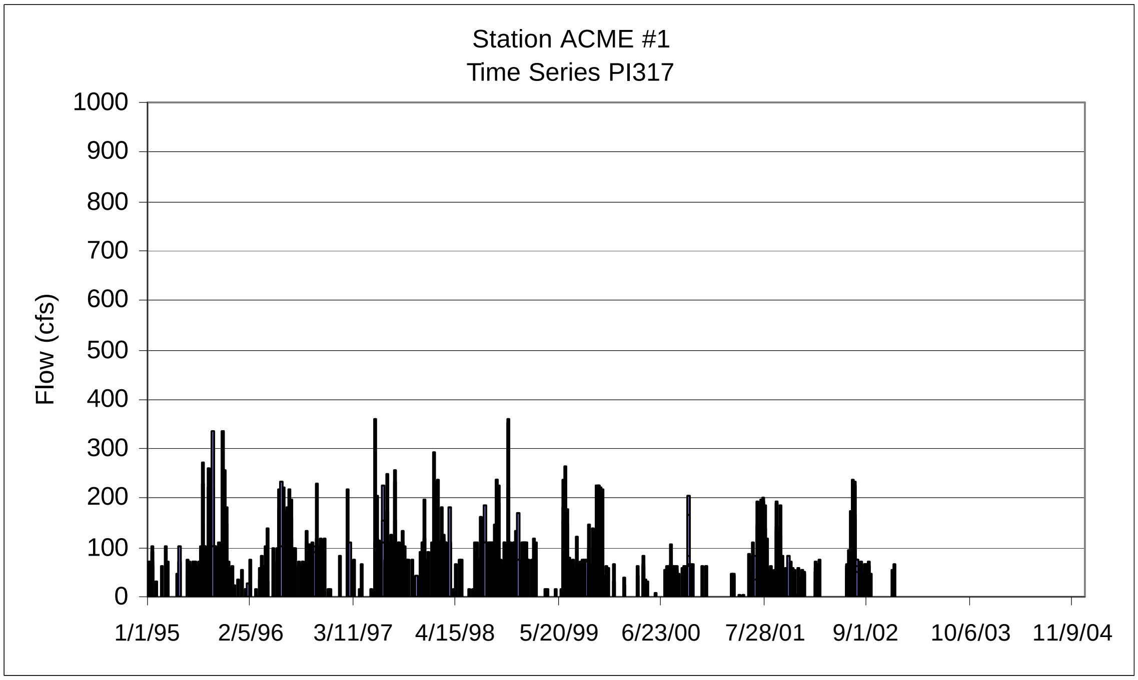

Figure B.57 ACME #1 Flow

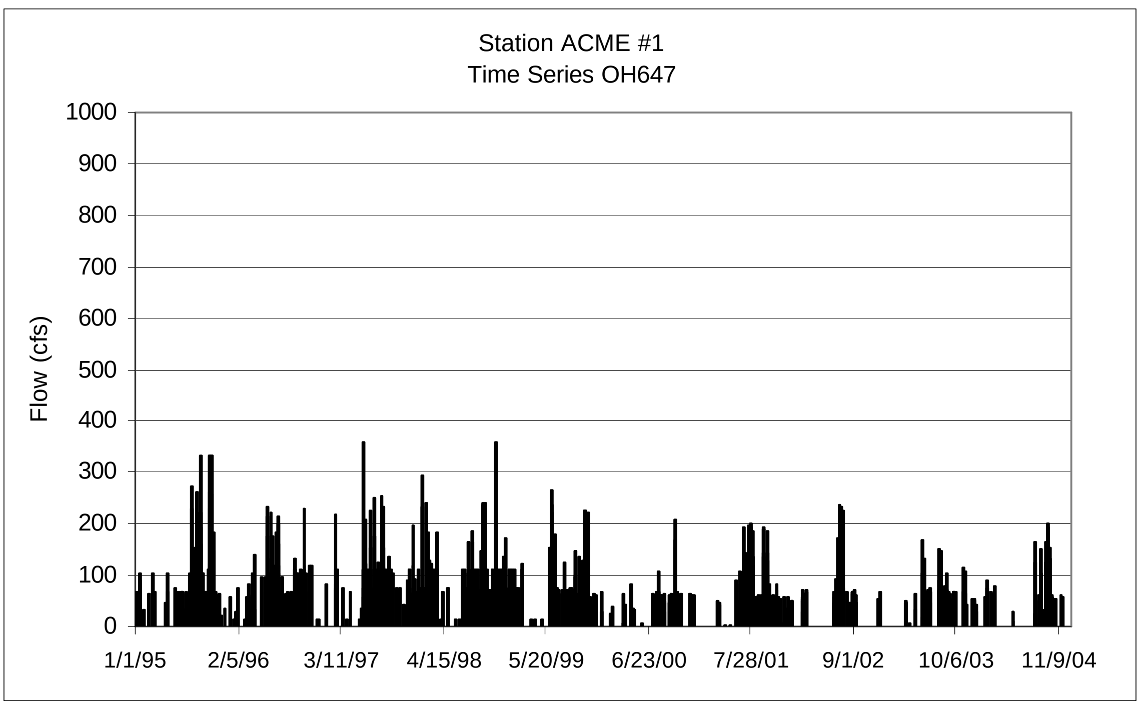

Figure B.58 ACME #1 Flow

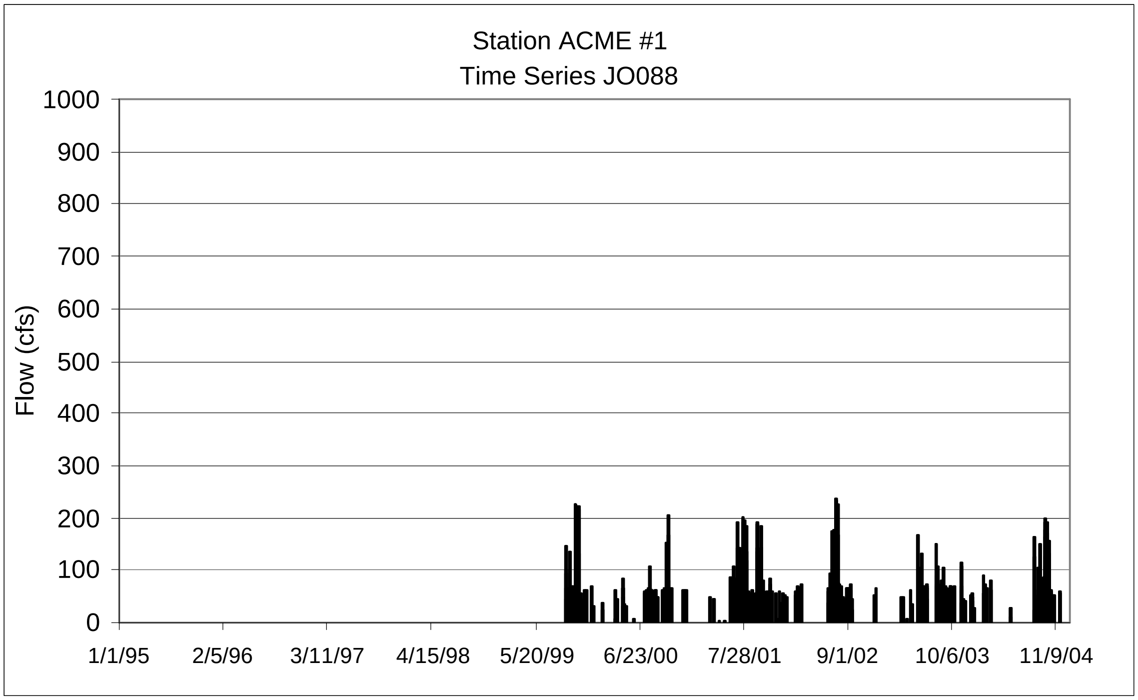

Figure B.59 ACME #1 Flow

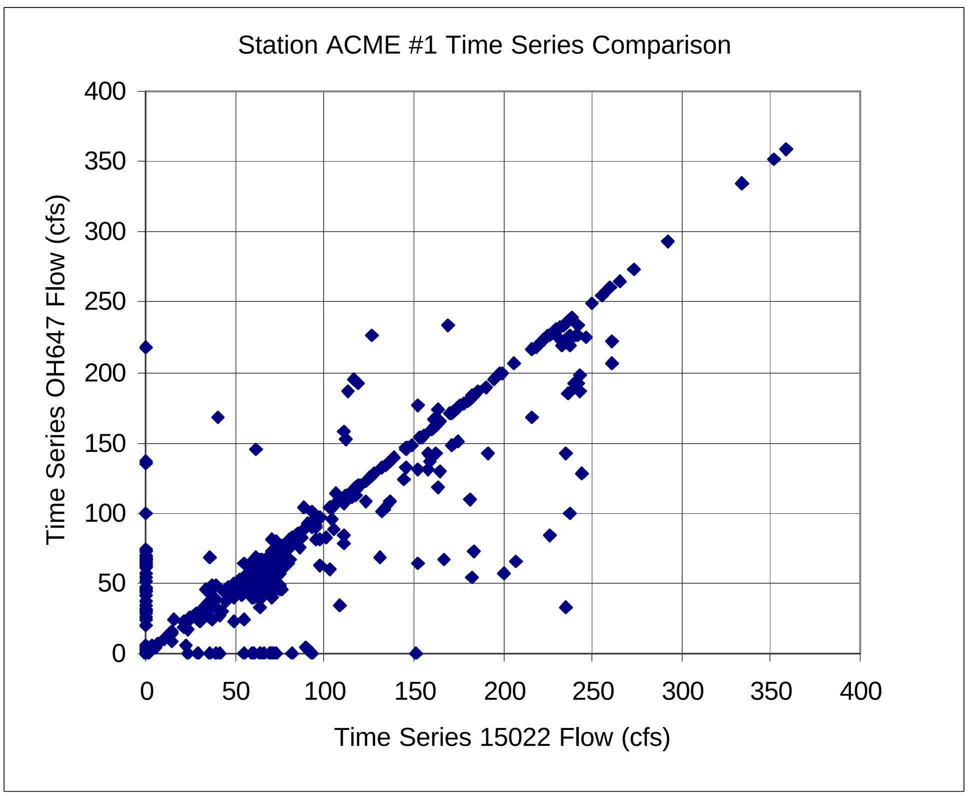

Figure B.60 ACME #1 flow time series comparison.

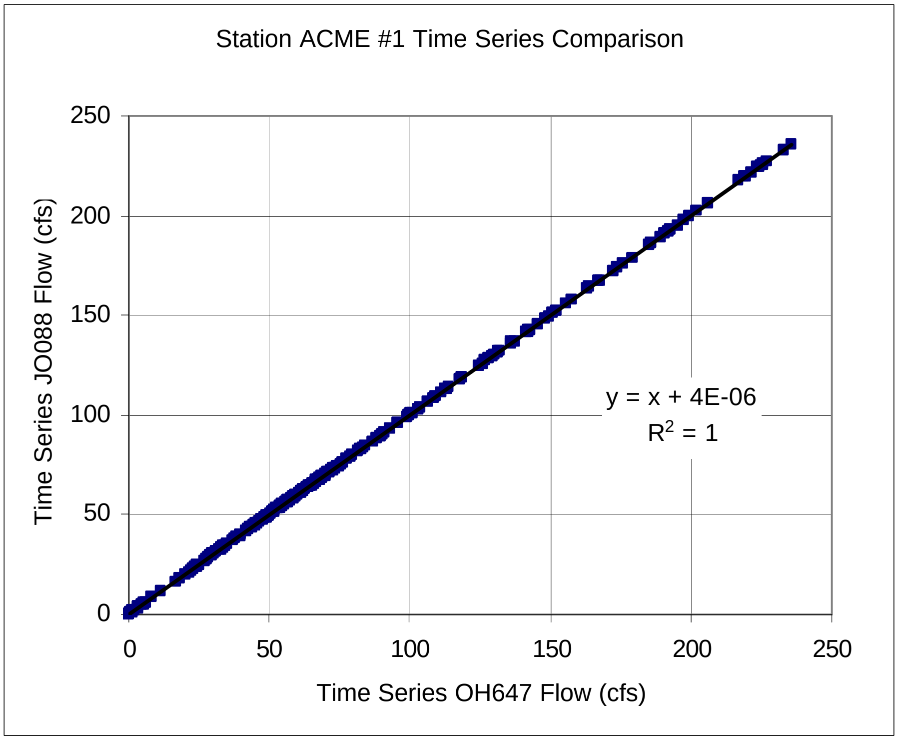

Figure B.61 ACME #1 flow time series comparison.

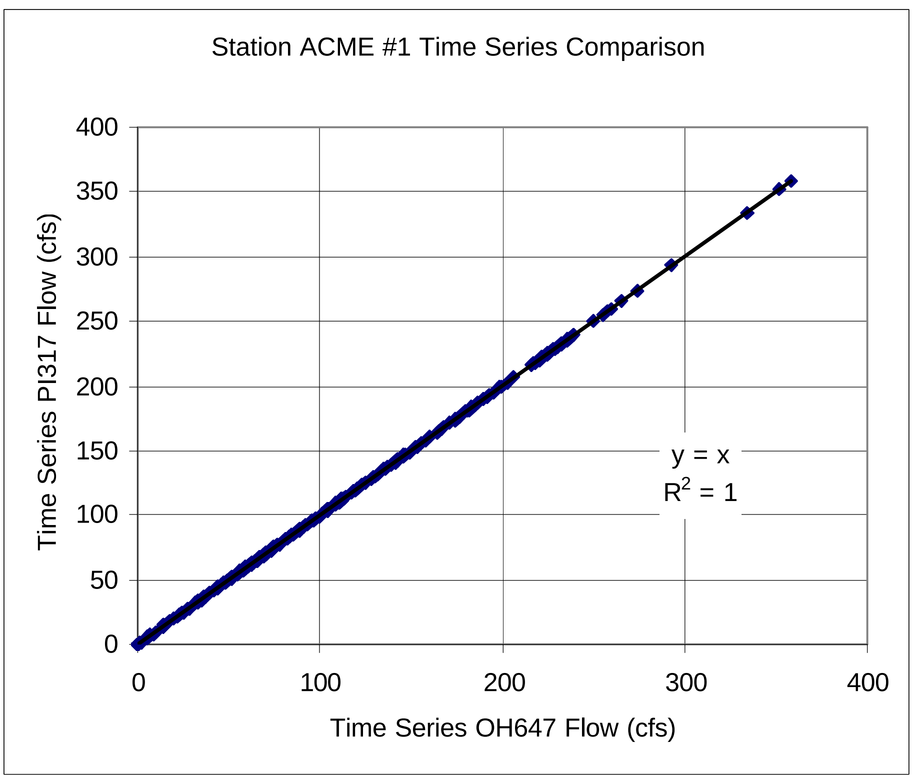

Figure B.62 ACME #1 flow time series comparison.

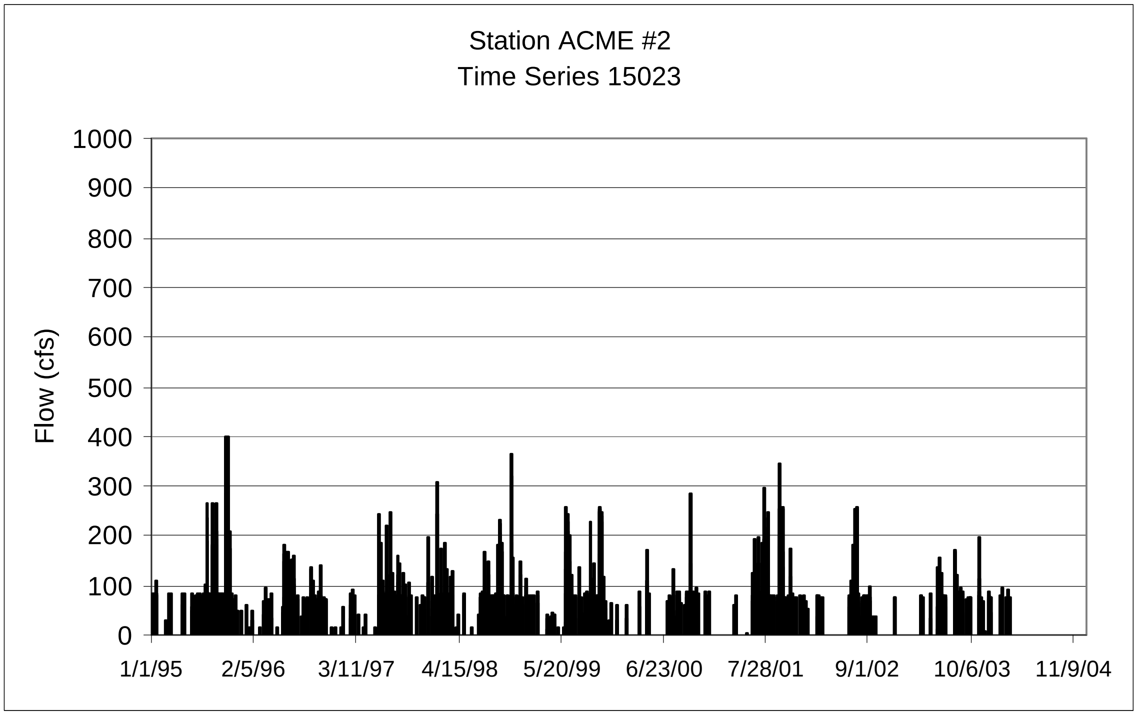

Figure B.63 ACME #2 (G-94D) Flow

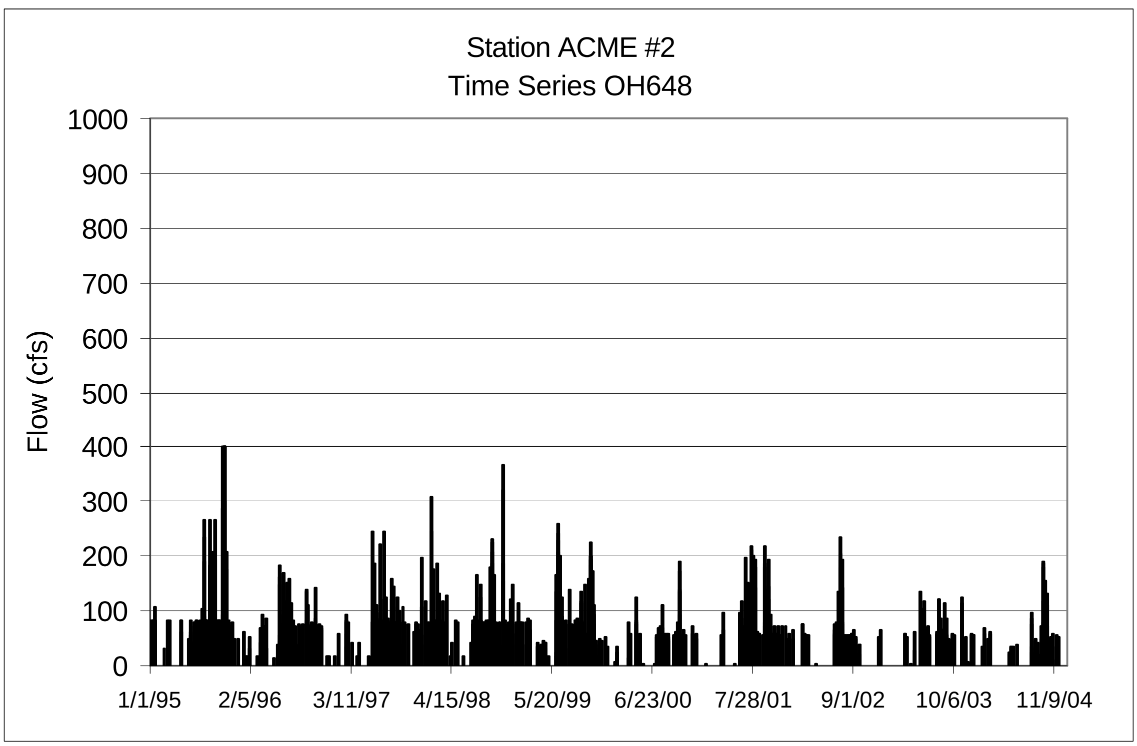

Figure B.64 ACME #2 (G-94D) Flow

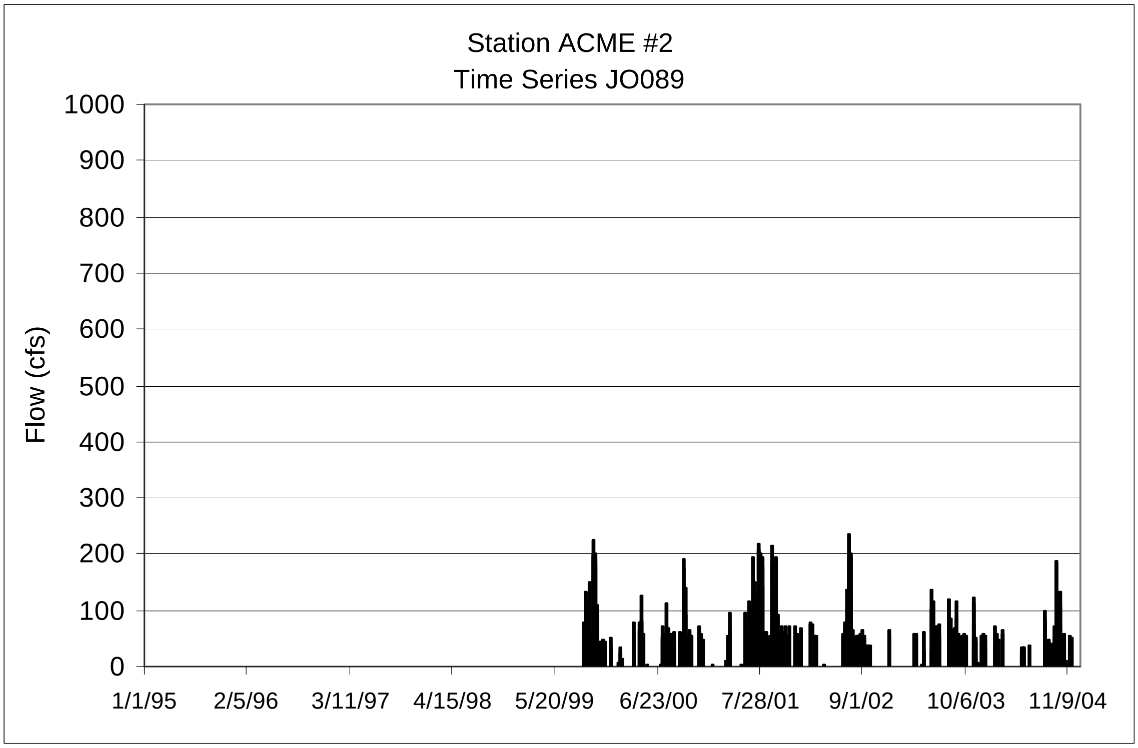

Figure B.65 ACME #2 (G-94D) Flow

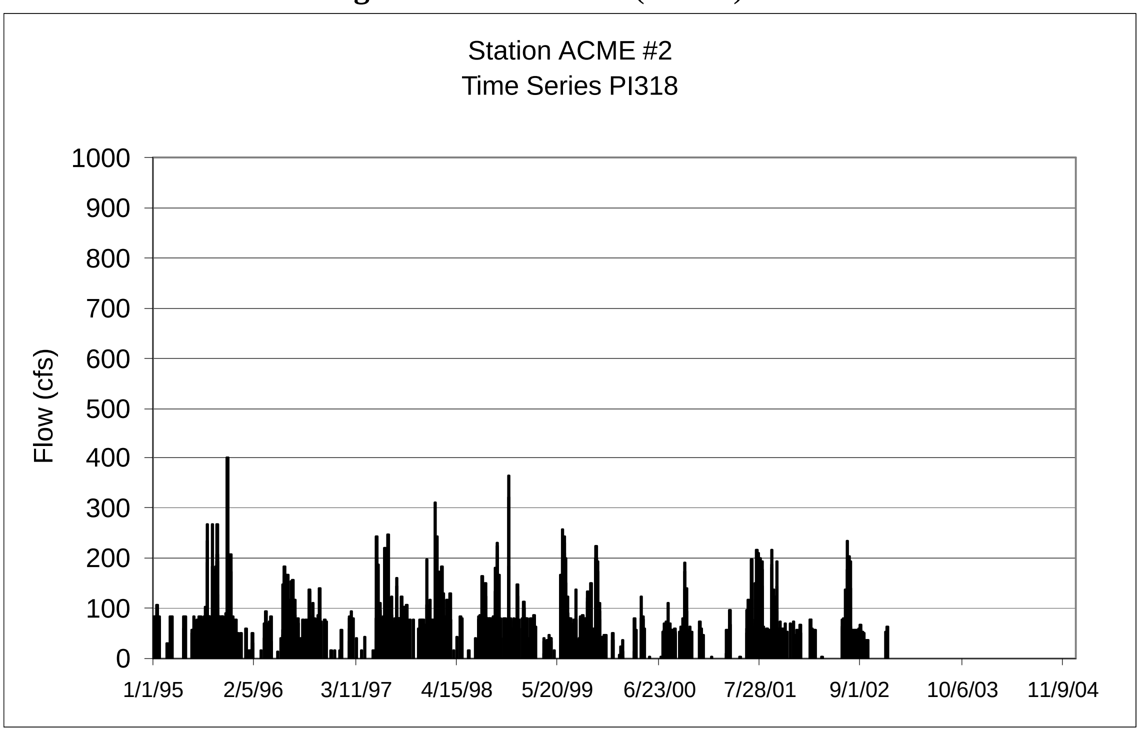

Figure B.66 ACME #2 (G-94D) Flow

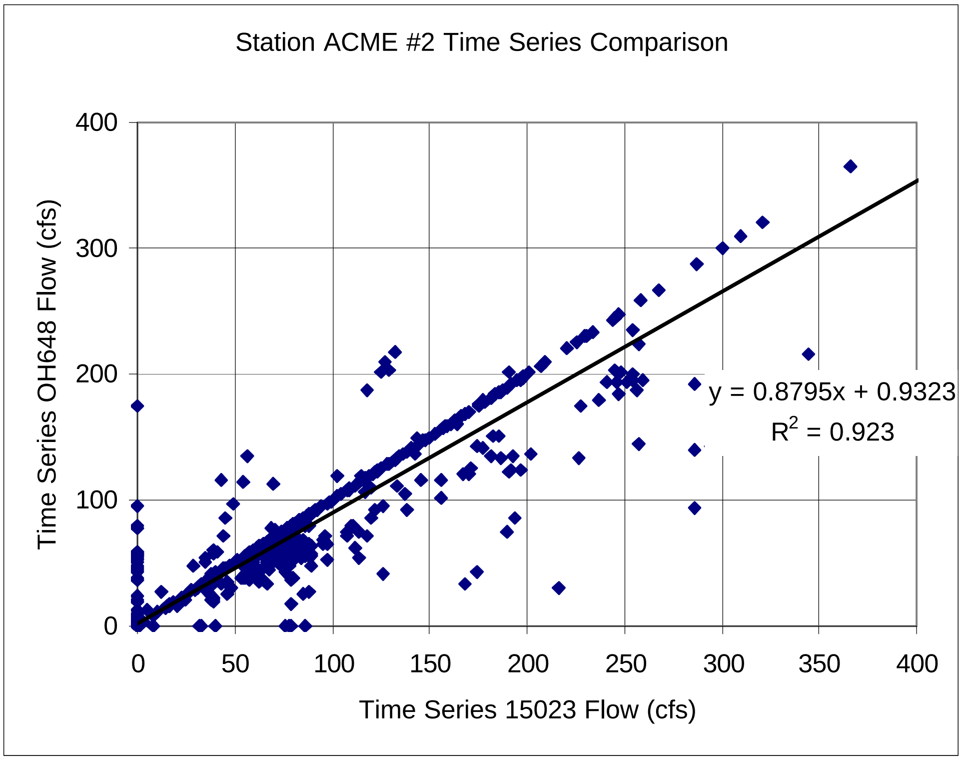

Figure B.67 ACME #2(G-94D) flow time series comparison.

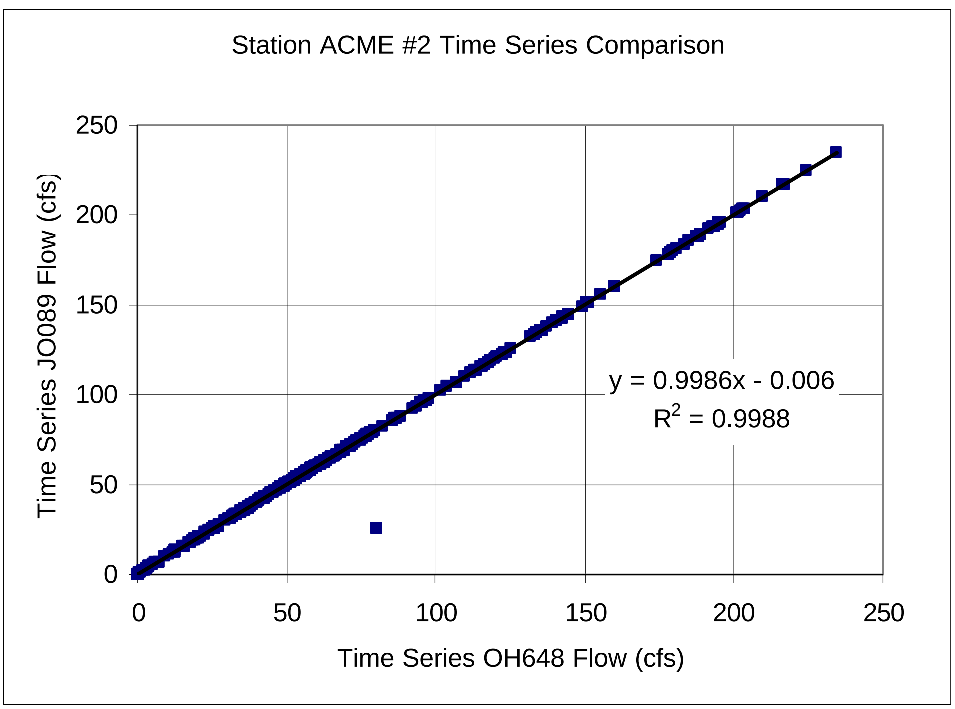

Figure B.68 ACME #2(G-94D) flow time series comparison.

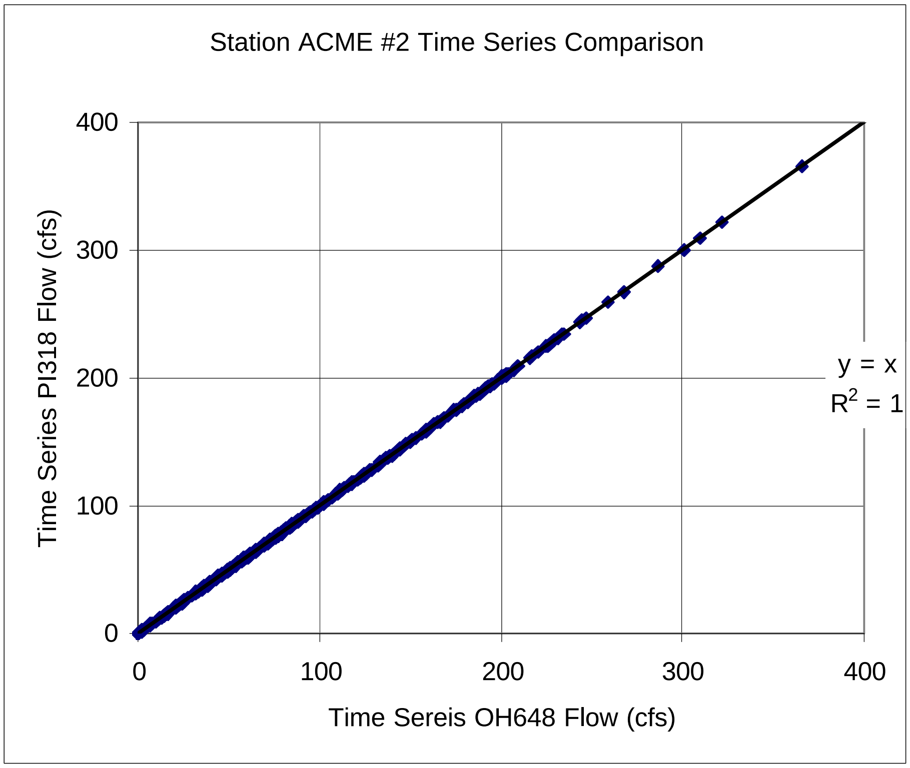

Figure B.69 ACME #2(G-94D) flow time series comparison.

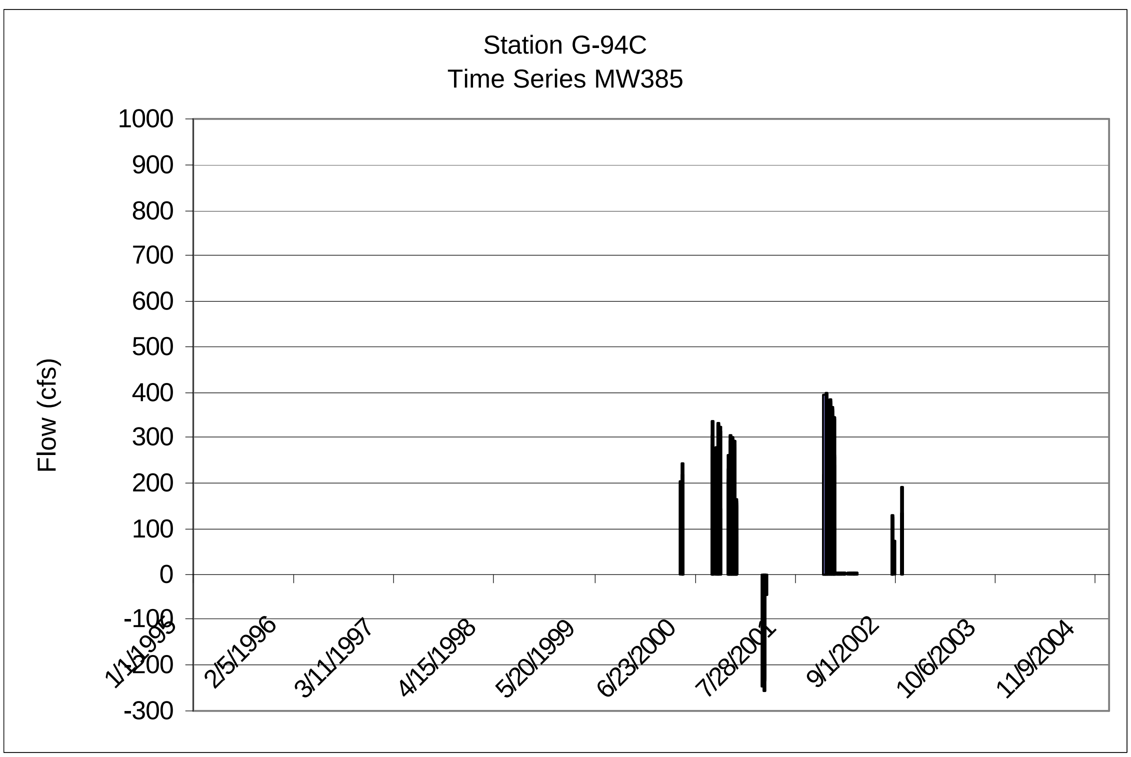

Figure B.70 G-94C Flow

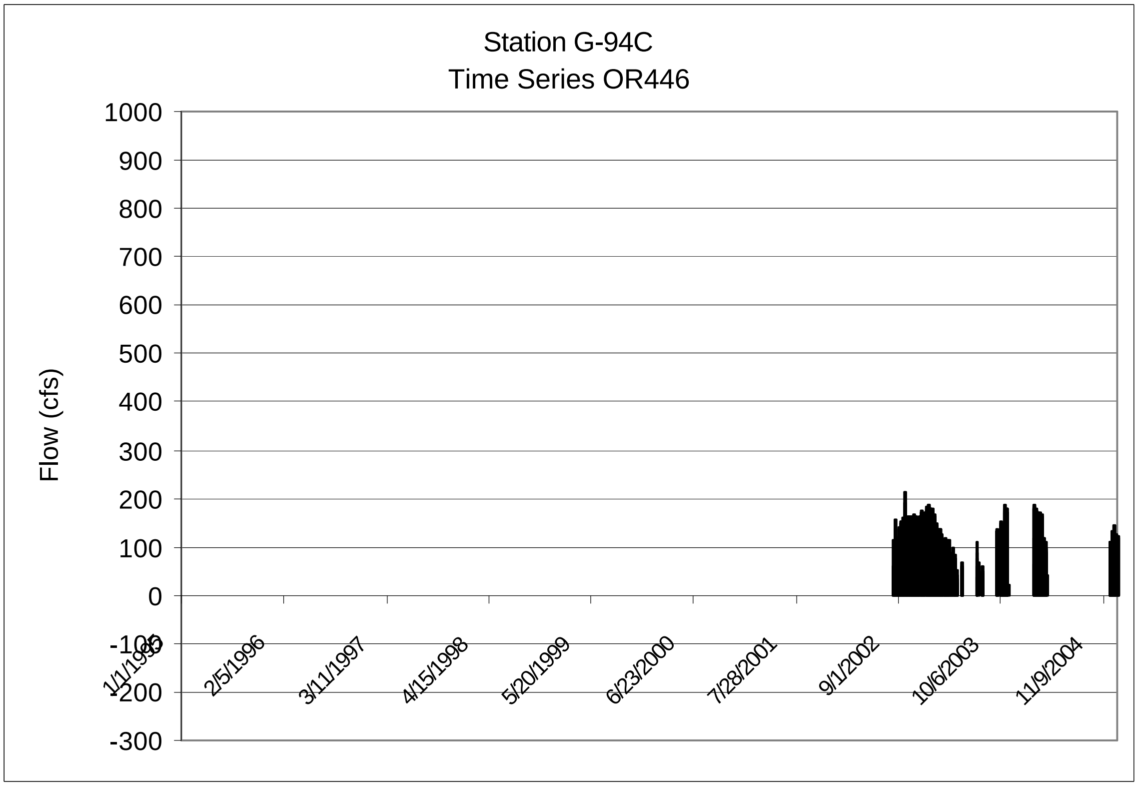

Figure B.71 G-94C Flow

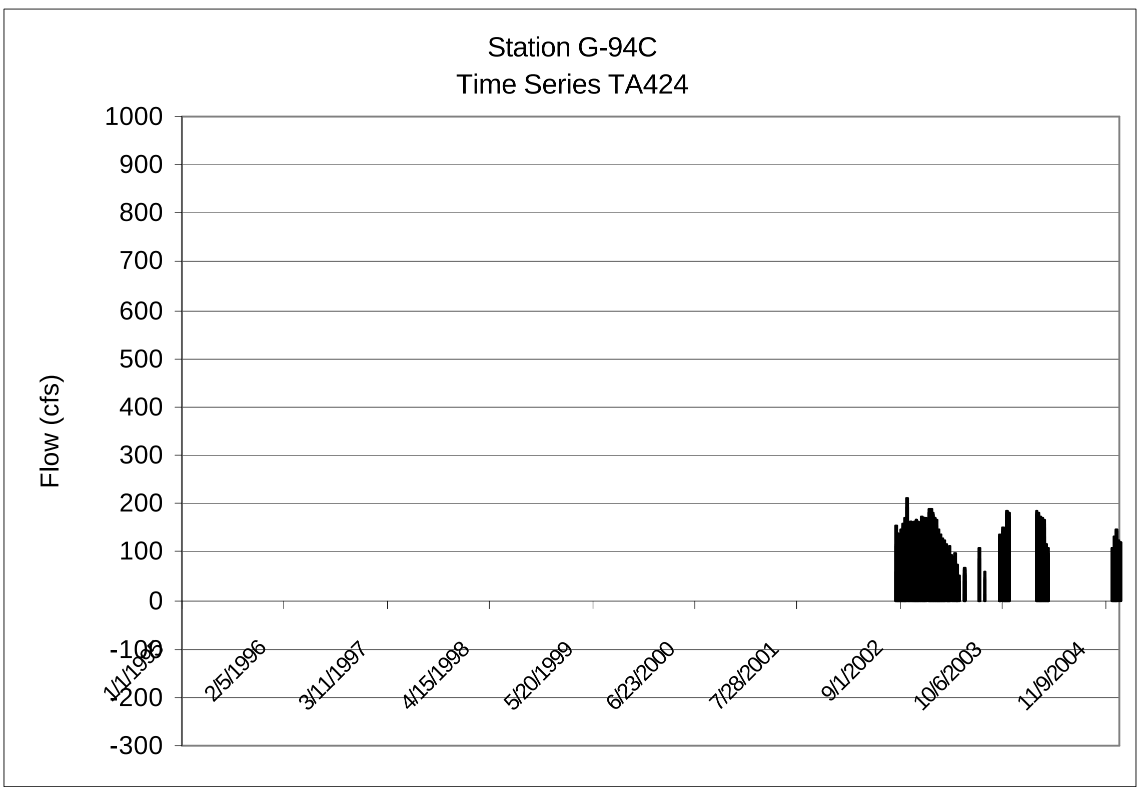

Figure B.72 G-94C Flow

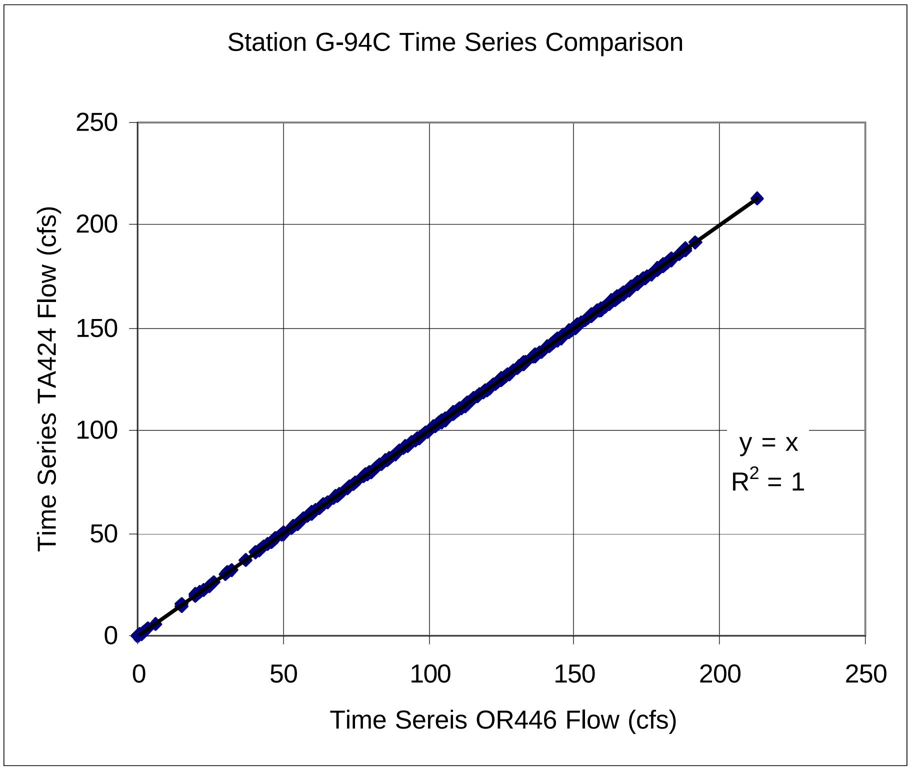

Figure B.73 G-94C flow time series comparison.

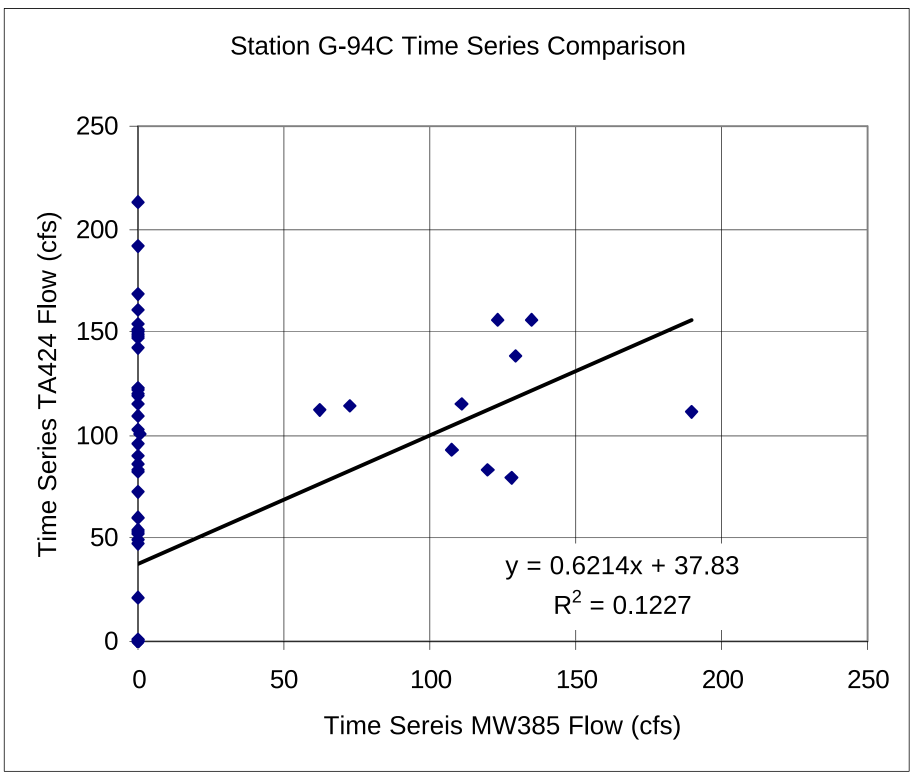

Figure B.74 G-94C flow time series comparison.

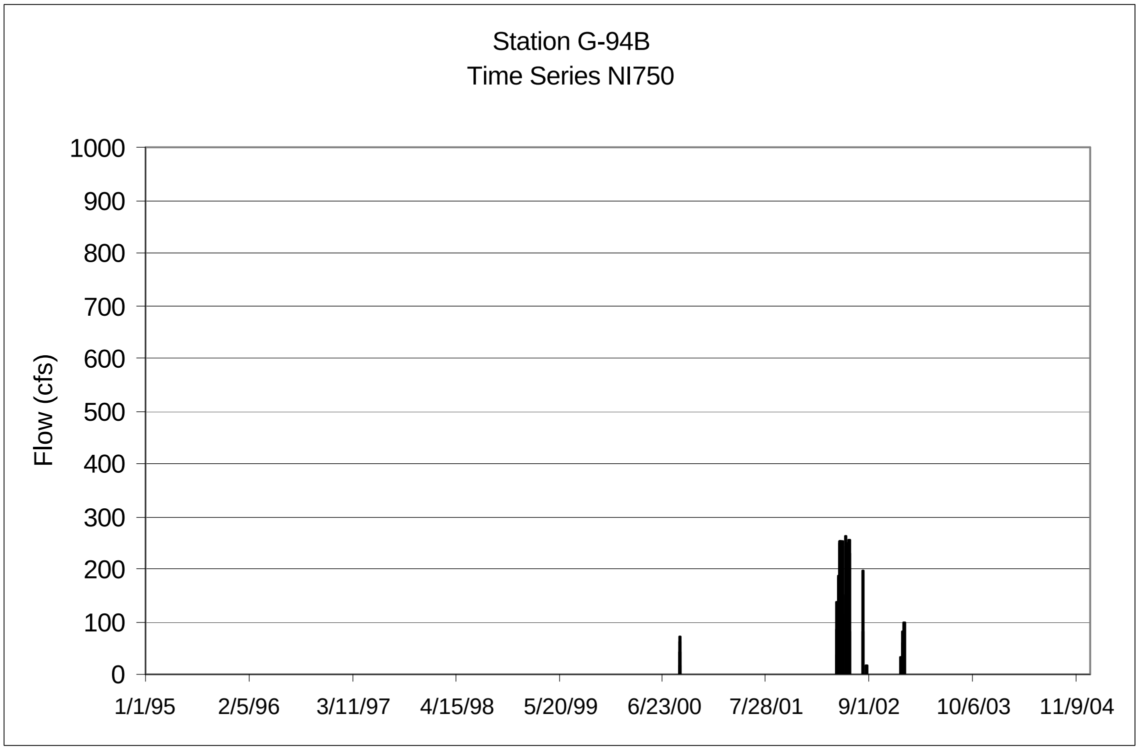

Figure B.75 G-94B Flow

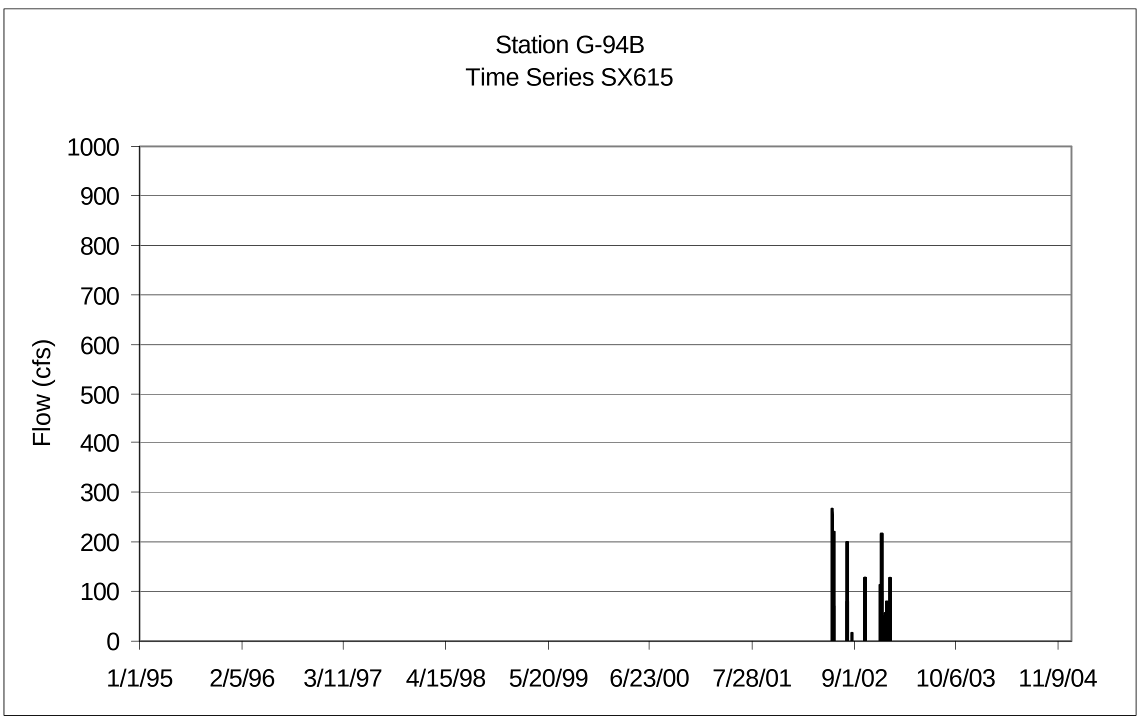

Figure B.76 G-94B Flow

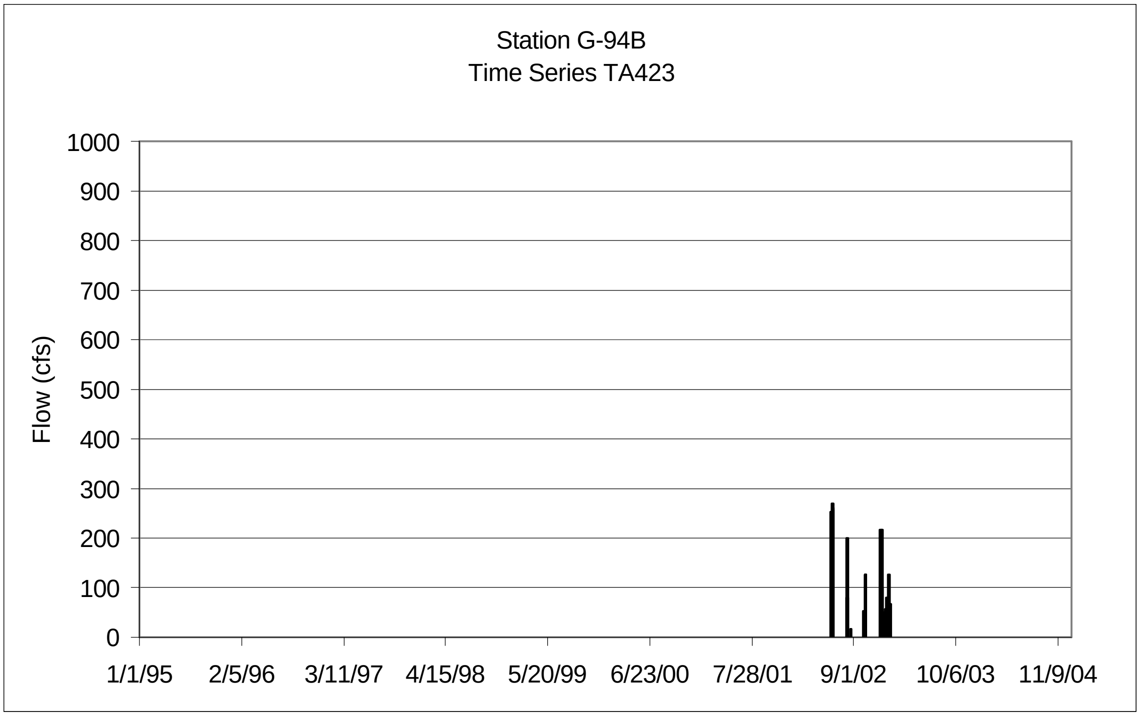

Figure B.77 G-94B Flow

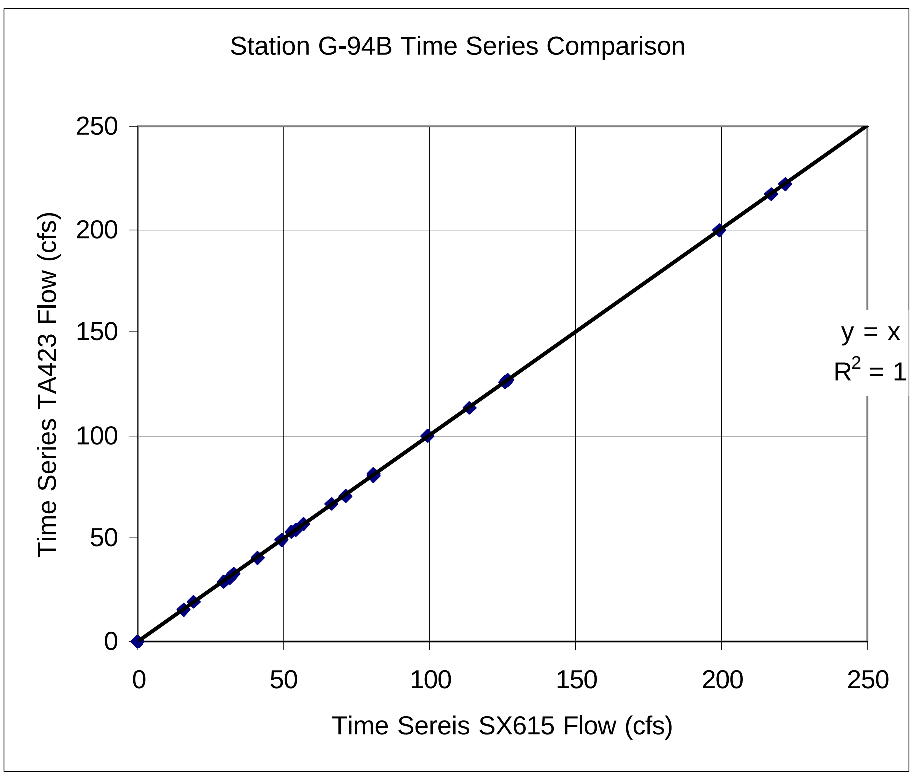

Figure B.78 G-94B flow time series comparison.

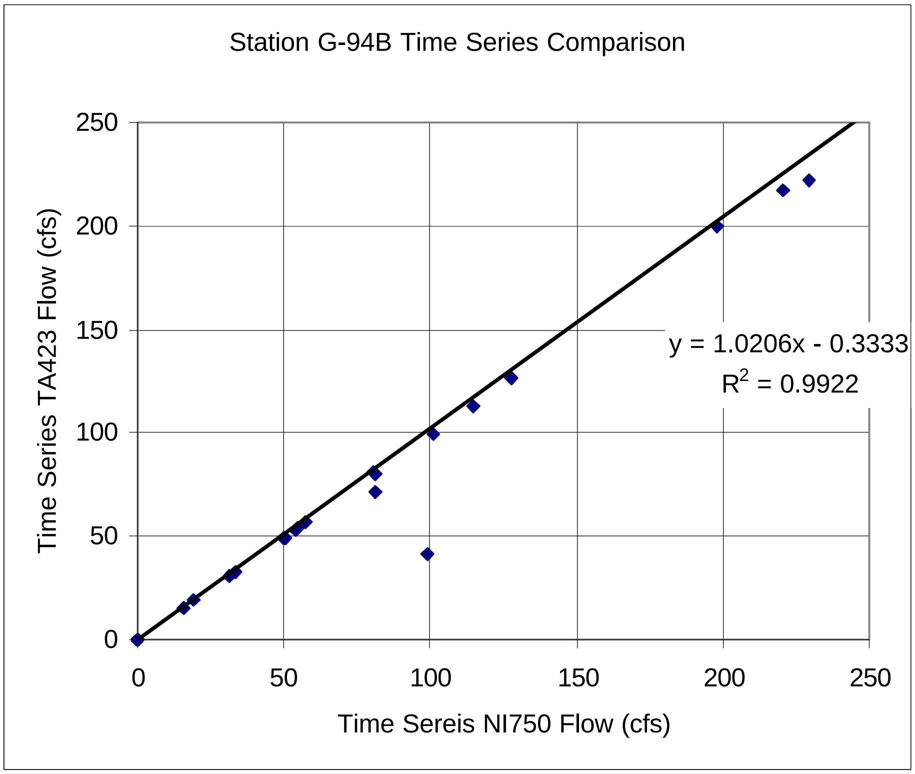

Figure B.79 G-94B flow time series comparison.

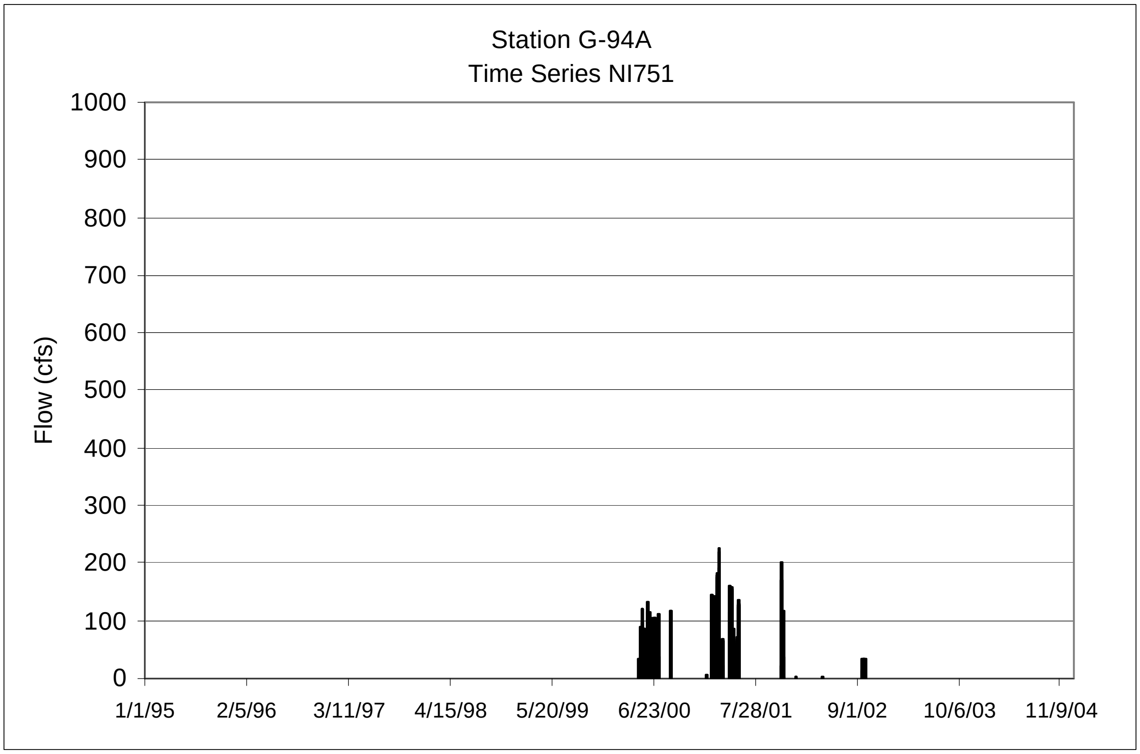

Figure B.80 G-94A Flow

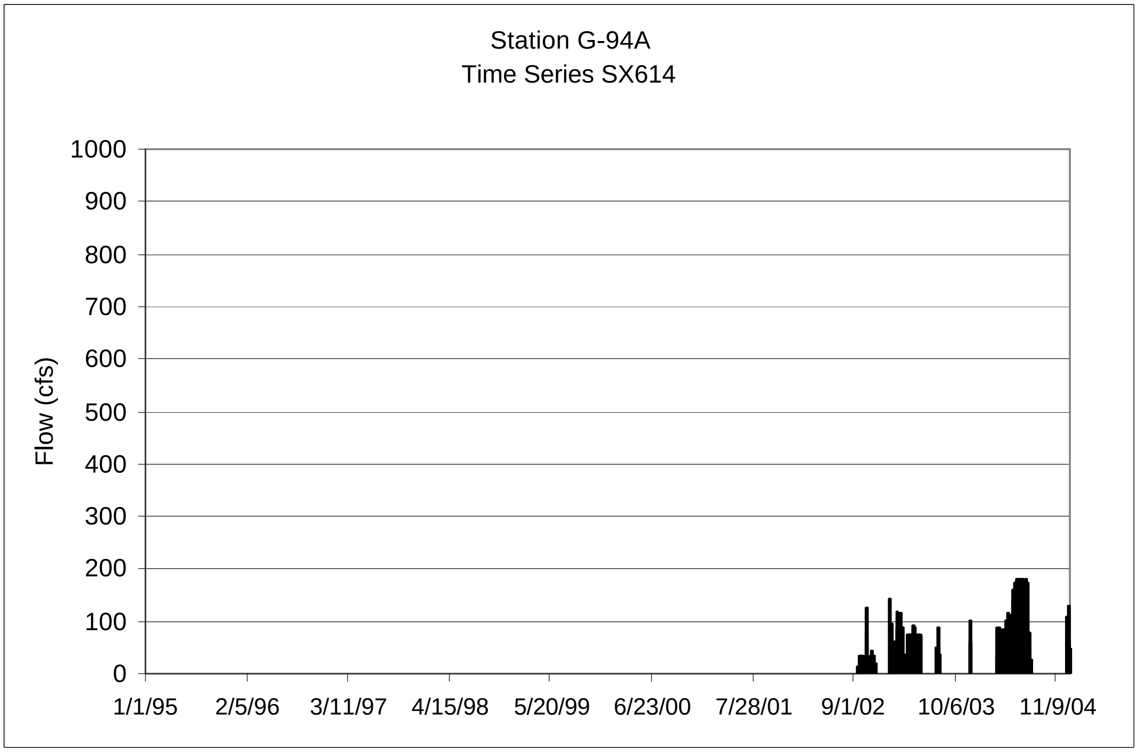

Figure B.81 G-94A Flow

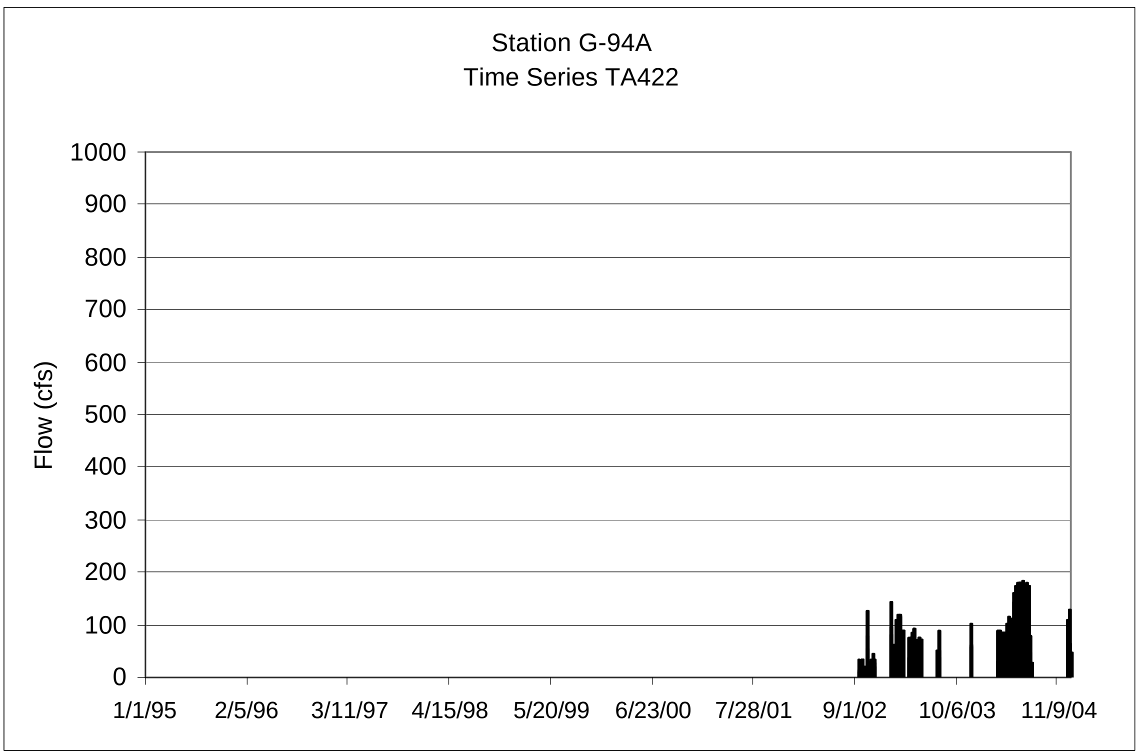

Figure B.82 G-94A Flow

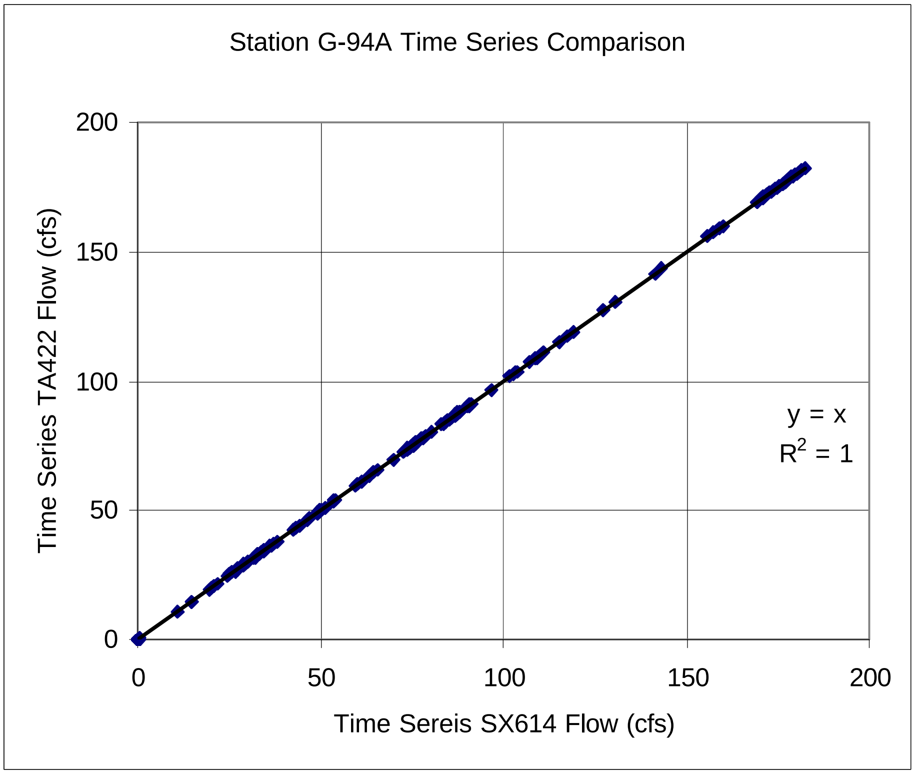

Figure B.83 G-94A flow time series comparison.

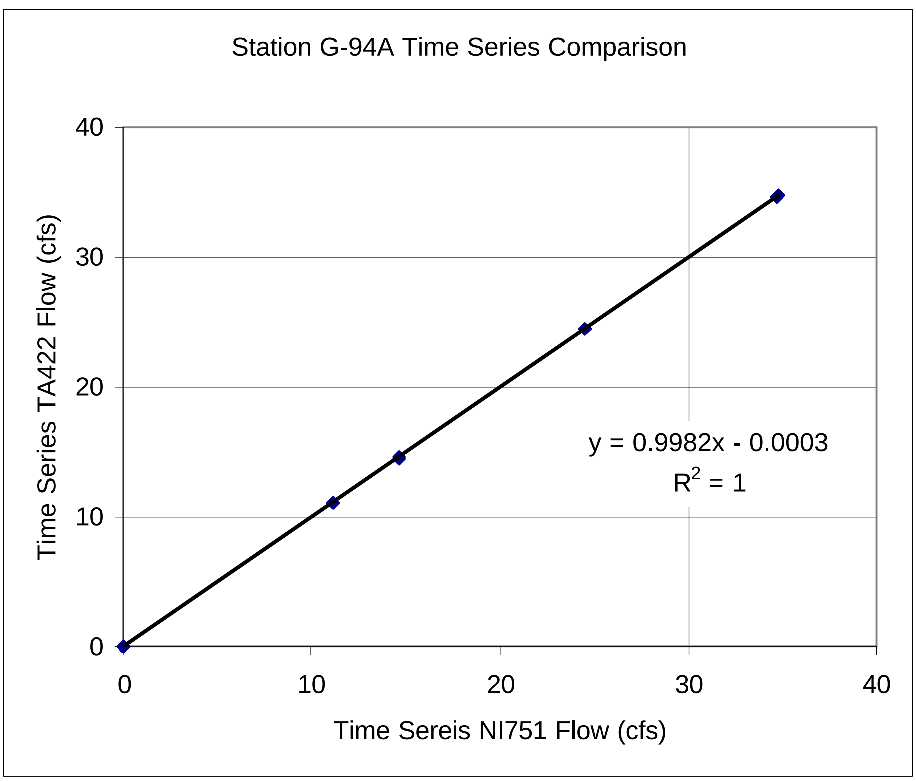

Figure B.84 G-94A flow time series comparison.

Appendix C
(Rainfall Measurements)

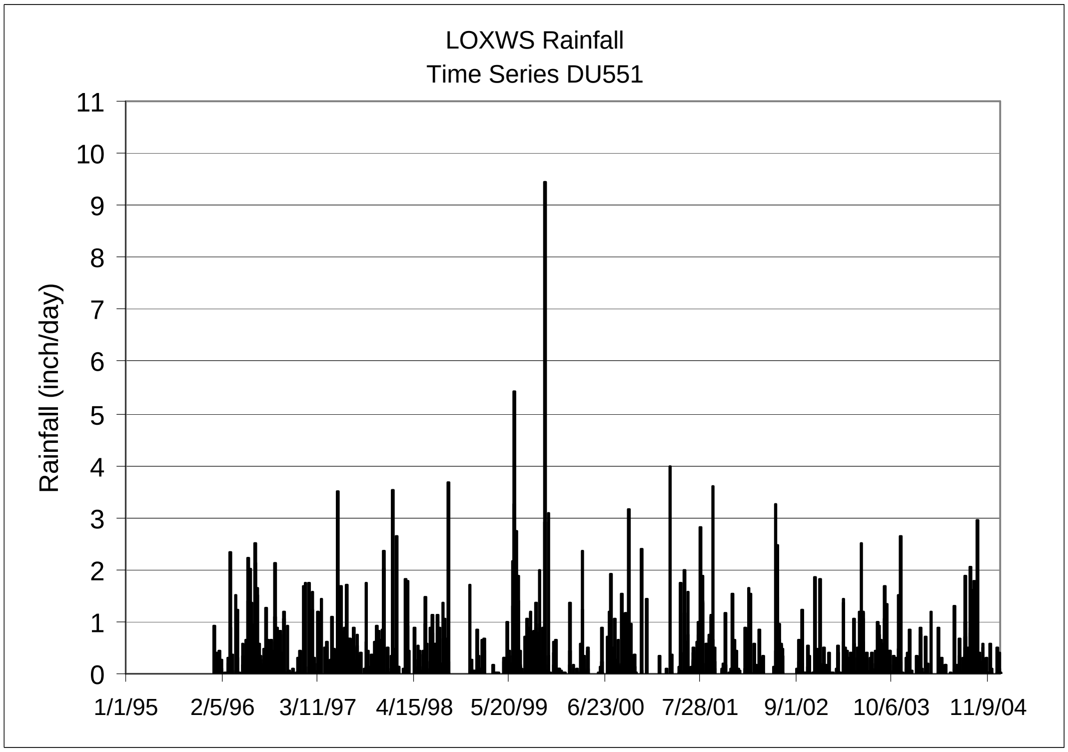

Figure C.1 LOXWS Rain Measurements

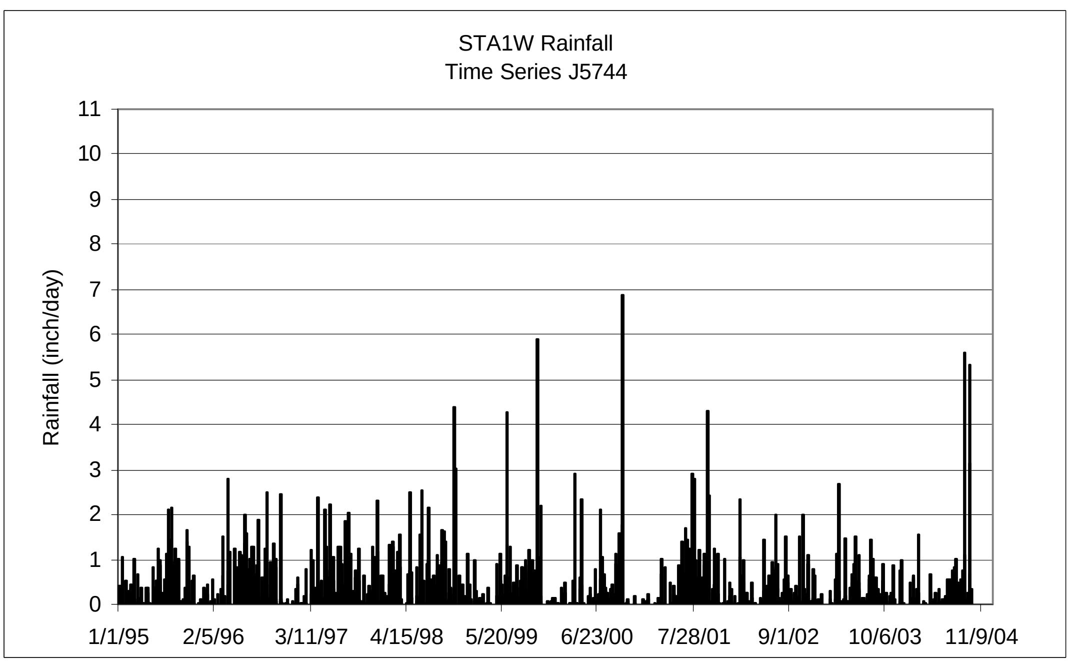

Figure C.2 STA1W Rain Measurements

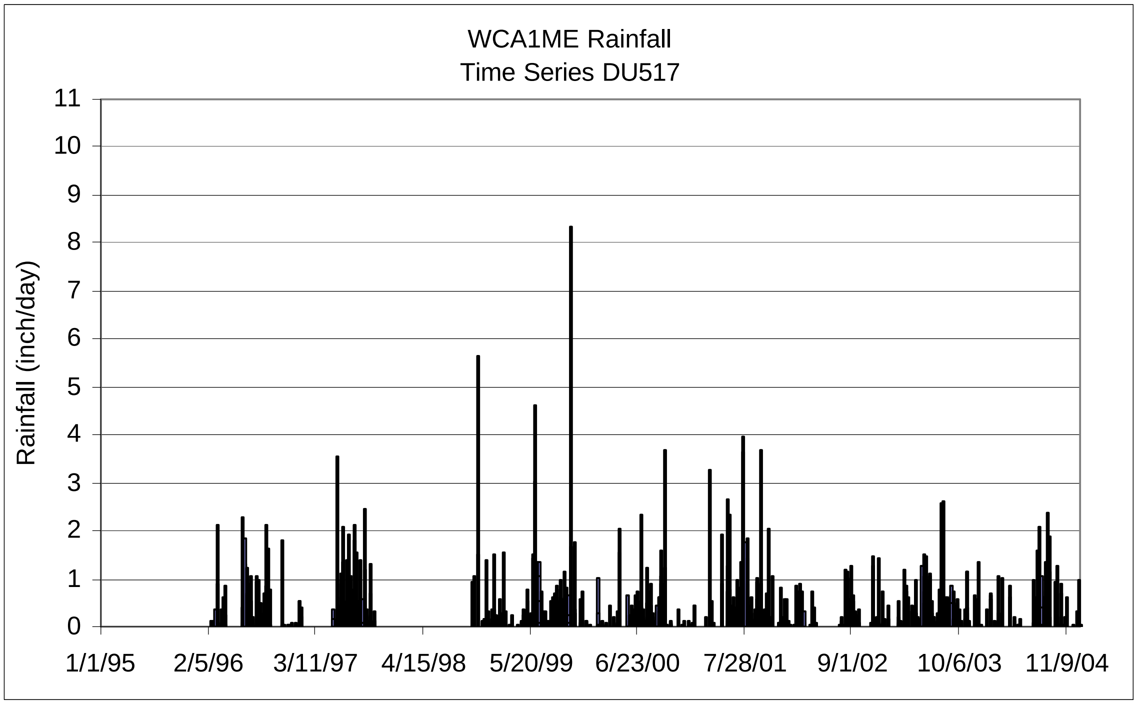

Figure C.3 WCA1ME Rain Measurements

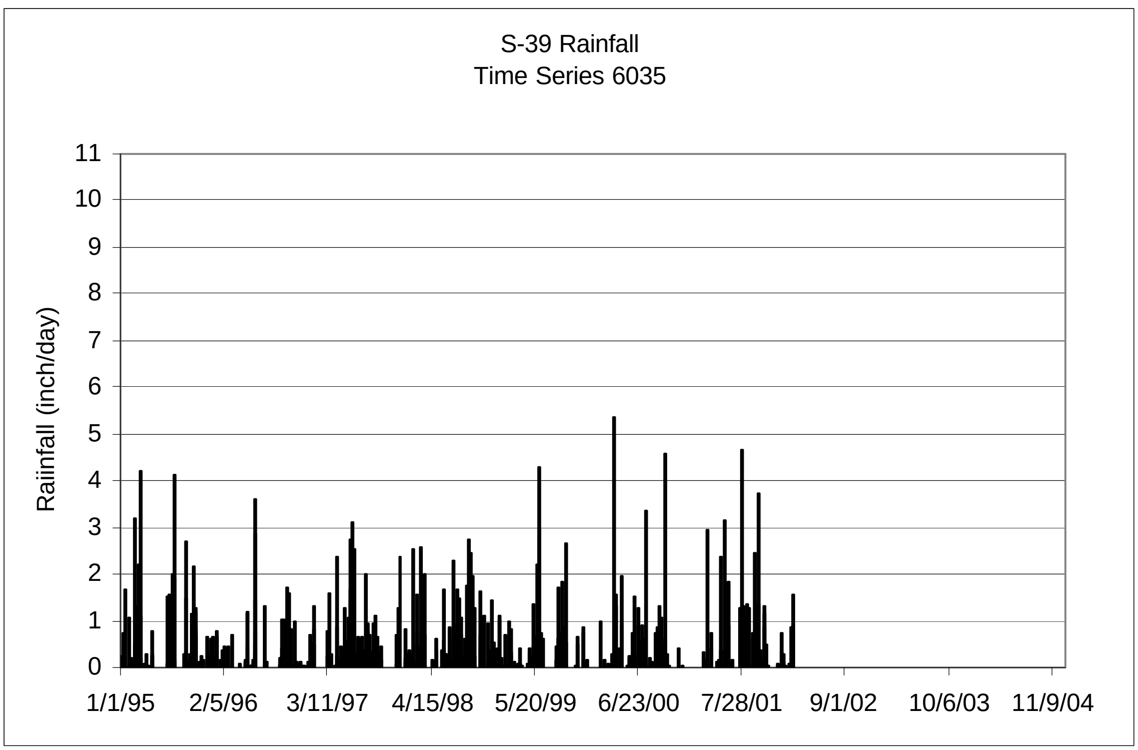

Figure C.4 S-39 Rain Measurements

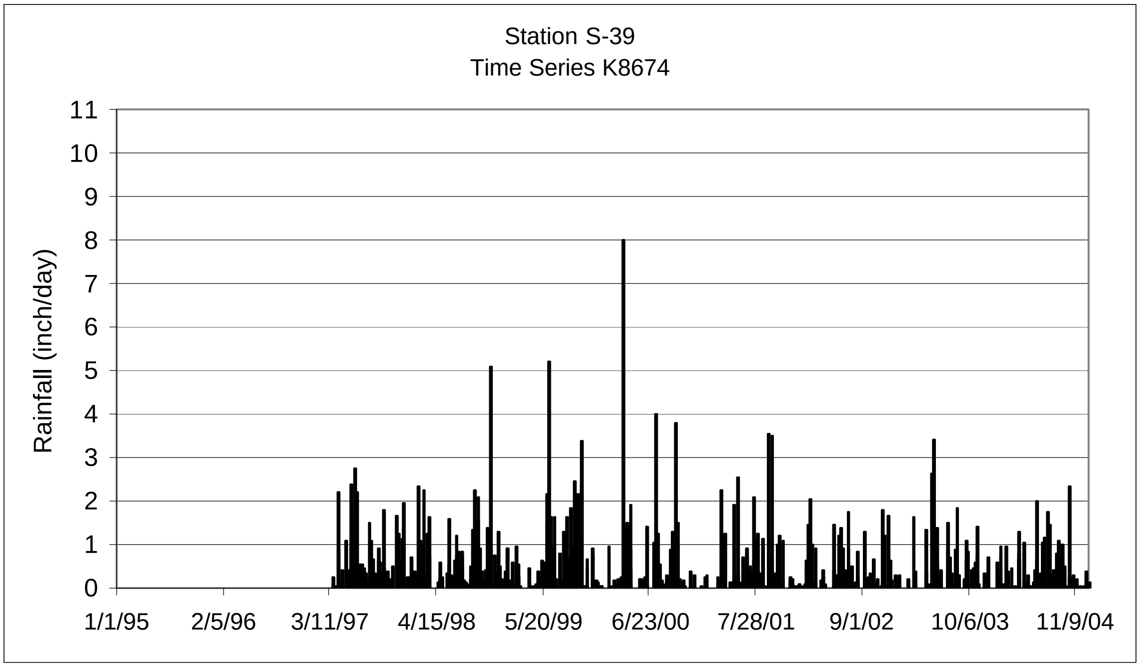

Figure C.5 S-39 Rain Measurements

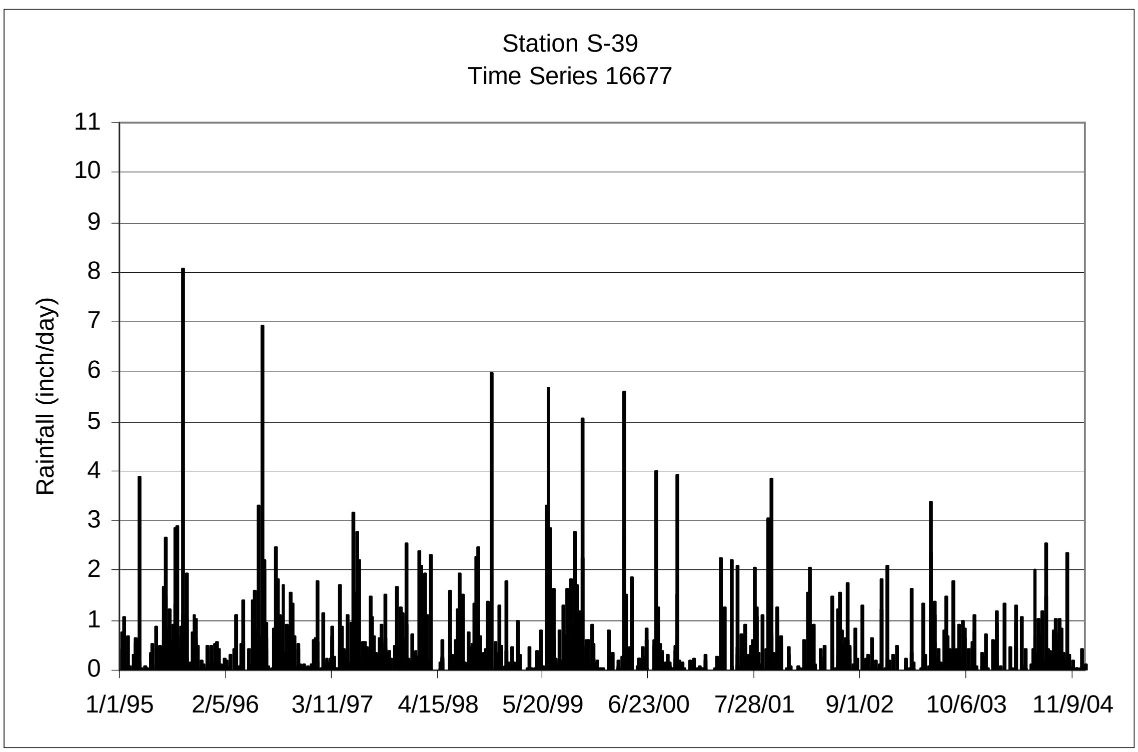

Figure C.6 S-39 Rain Measurements

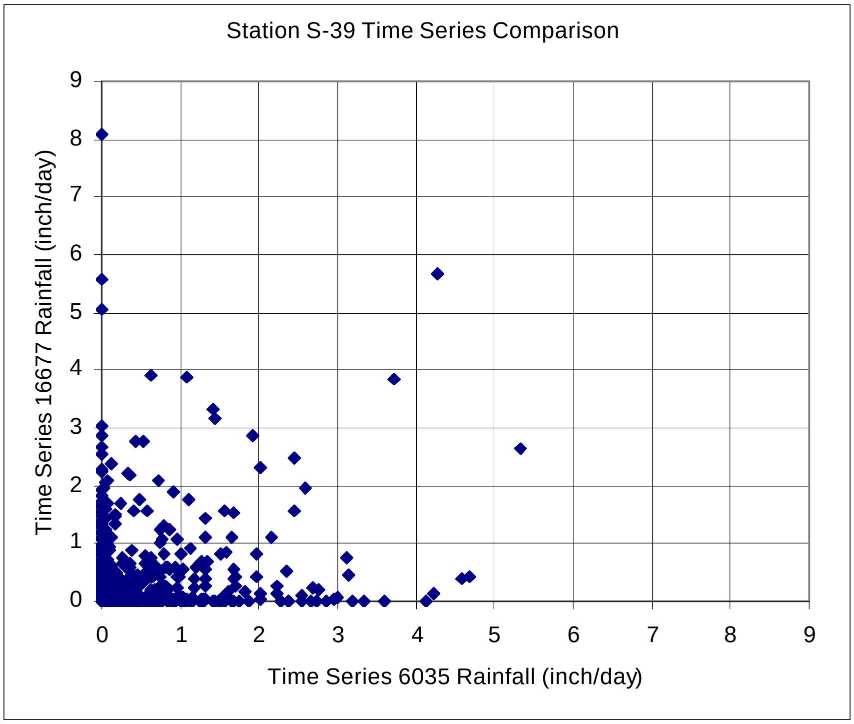

Figure C.7 S-39 rainfall time series comparison (daily)

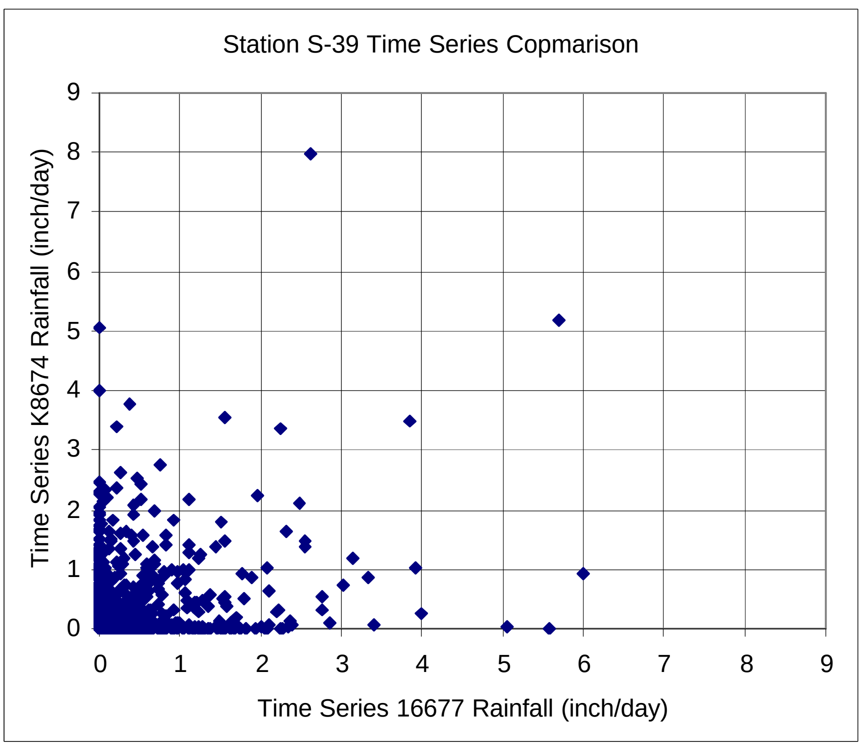

Figure C.8 S-39 rainfall time series comparison (daily).

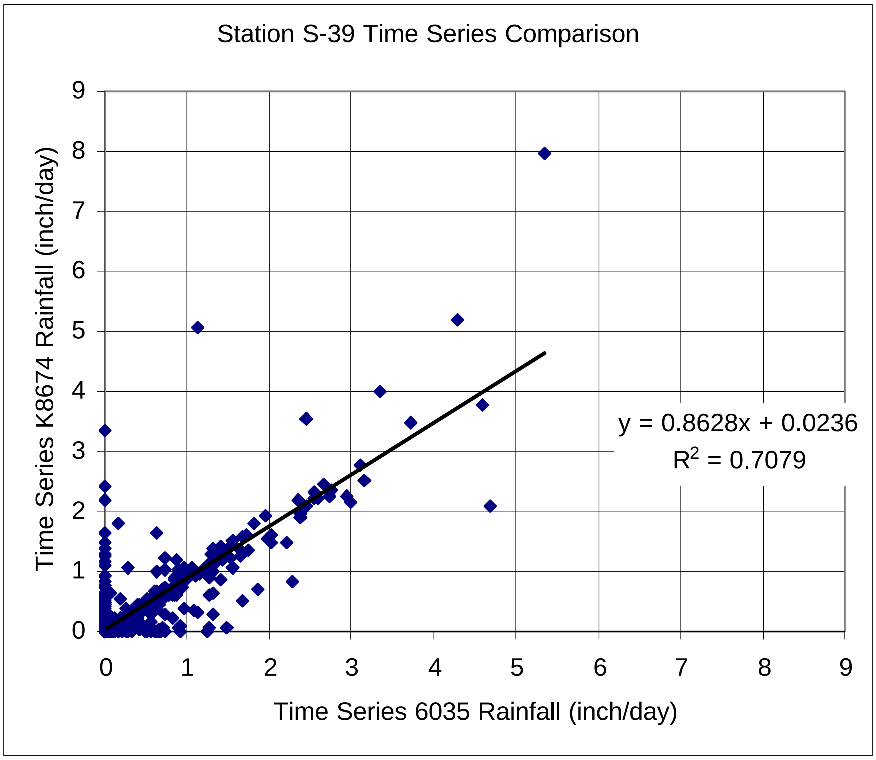

Figure C.9 S-39 rainfall time comparison (daily).

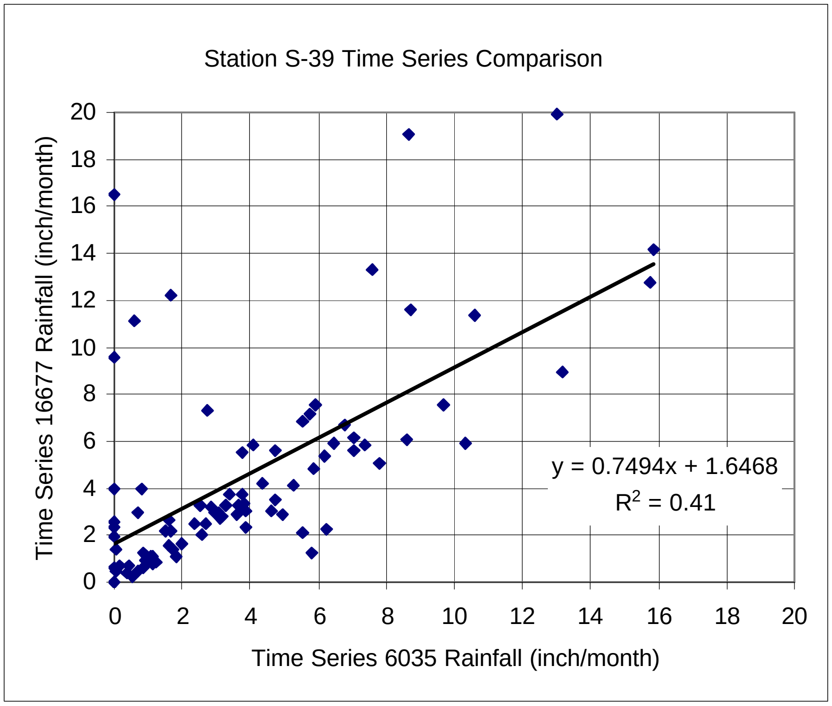

Figure C.10 S-39 rainfall time comparison (monthly).

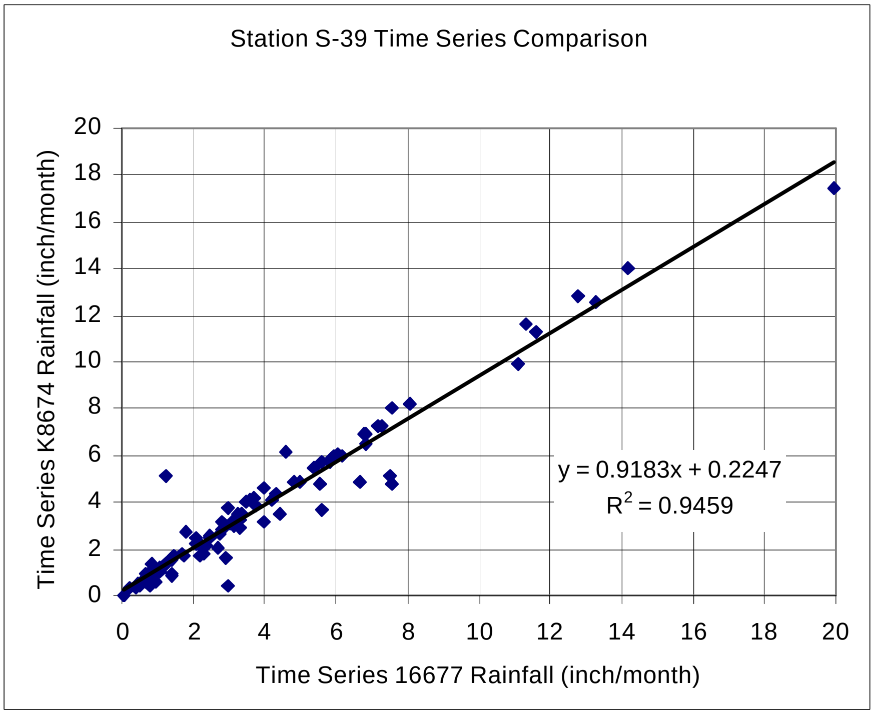

Figure C.11 S-39 rainfall time comparison (monthly).

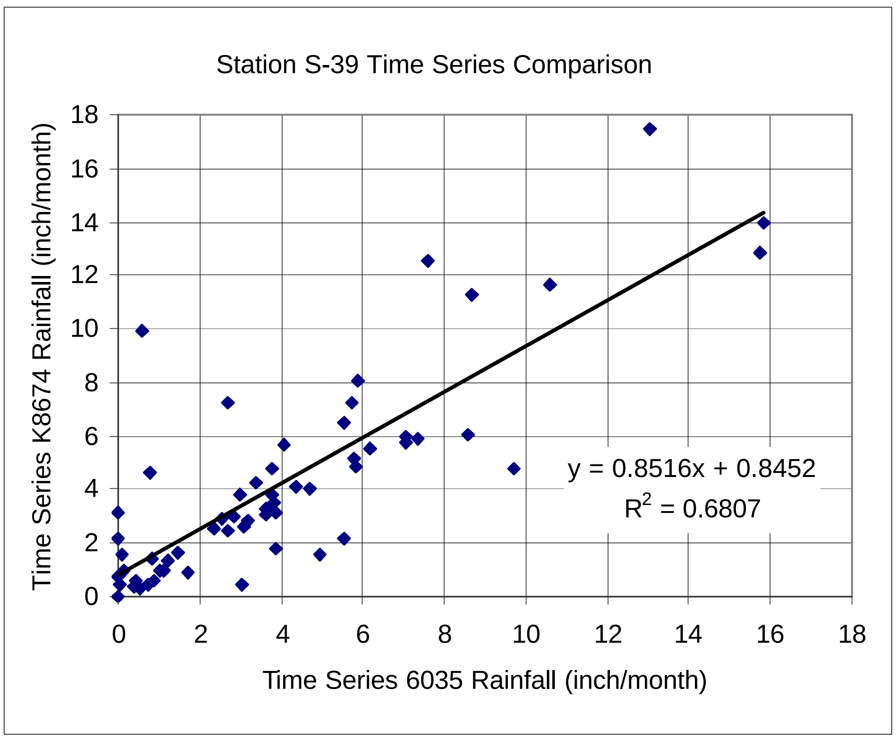

Figure C.12 S-39 rainfall time comparison (monthly).

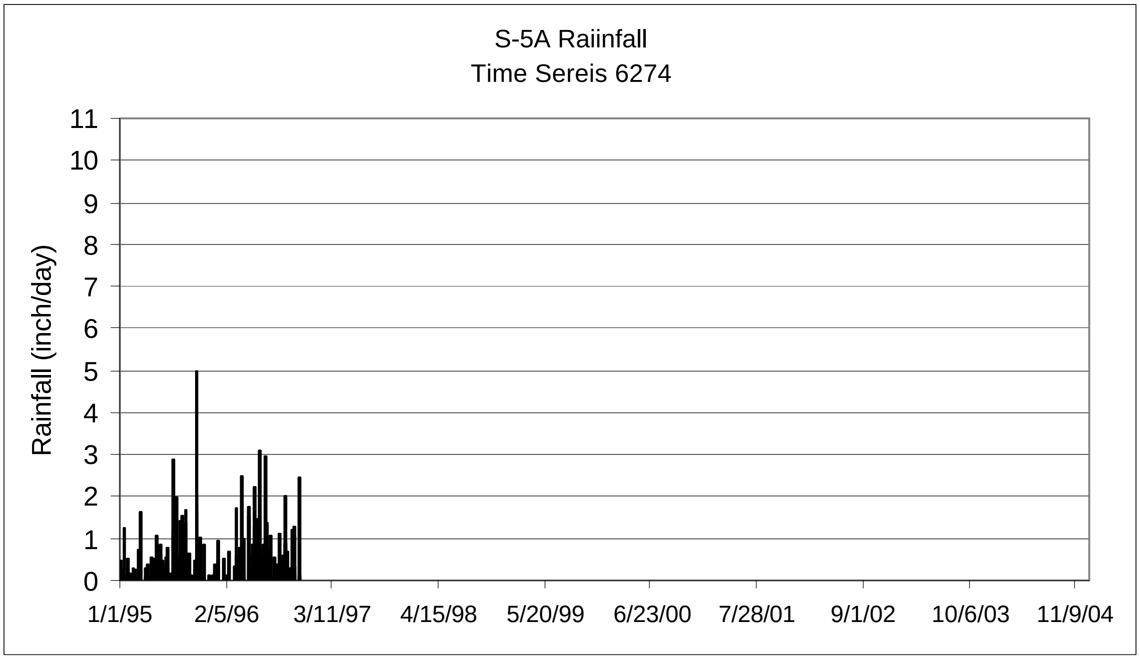

Figure C.13 S-5A Rain Measurements

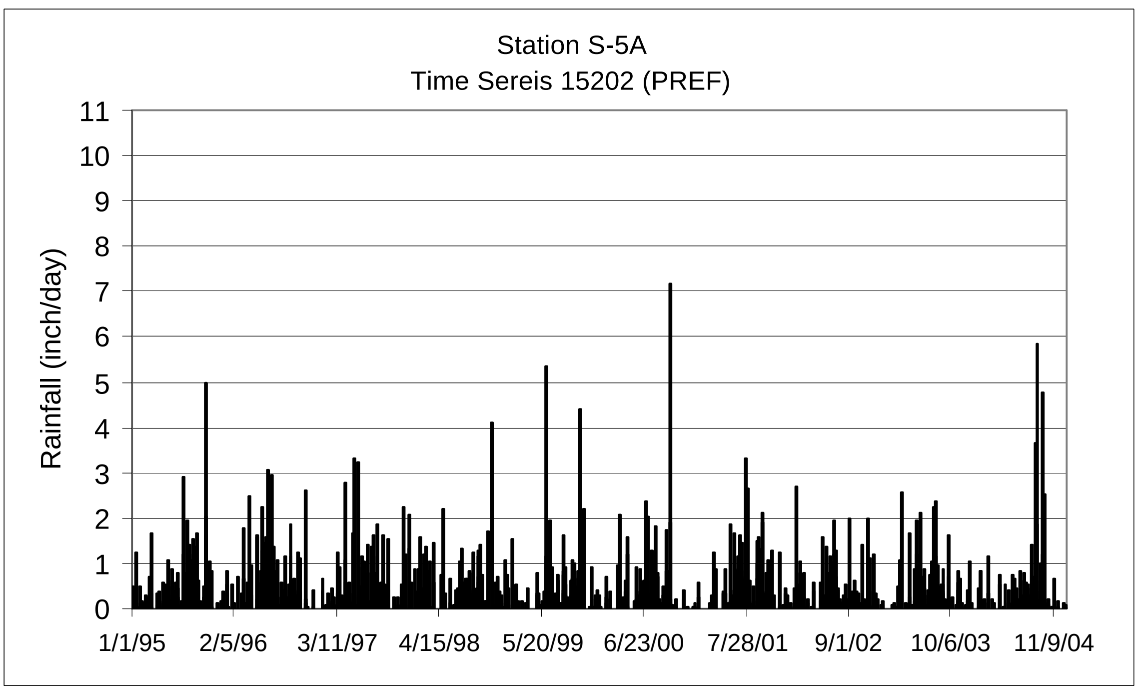

Figure C.14 S-5A Rain Measurements

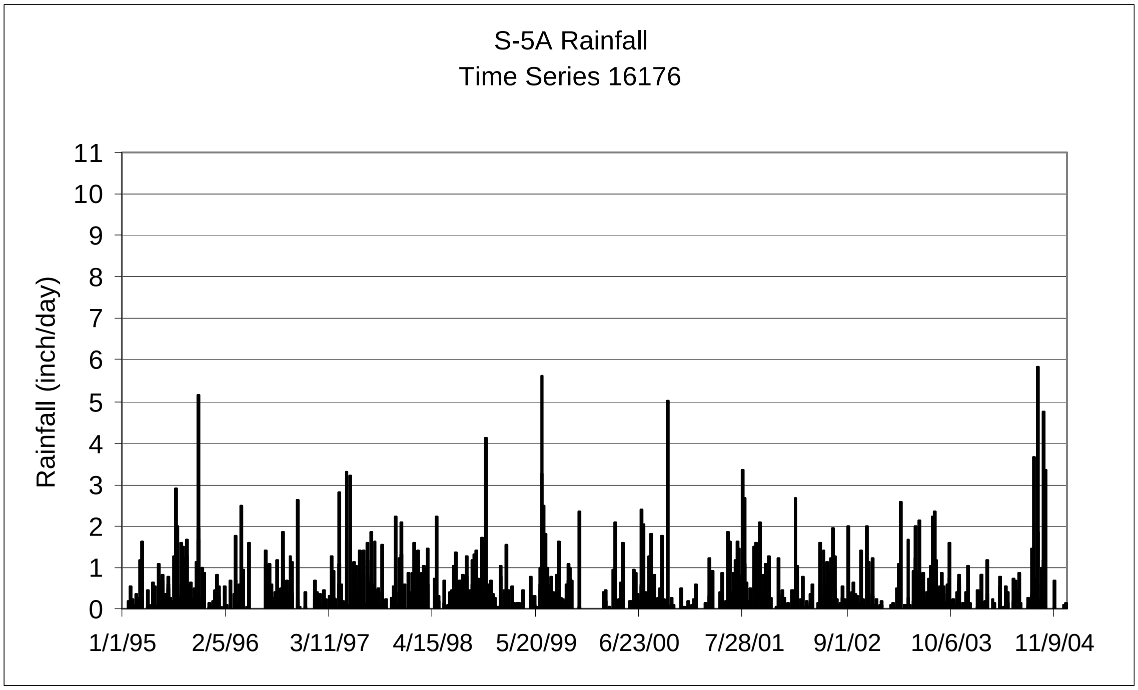

Figure C.15 S-5A Rain Measurements

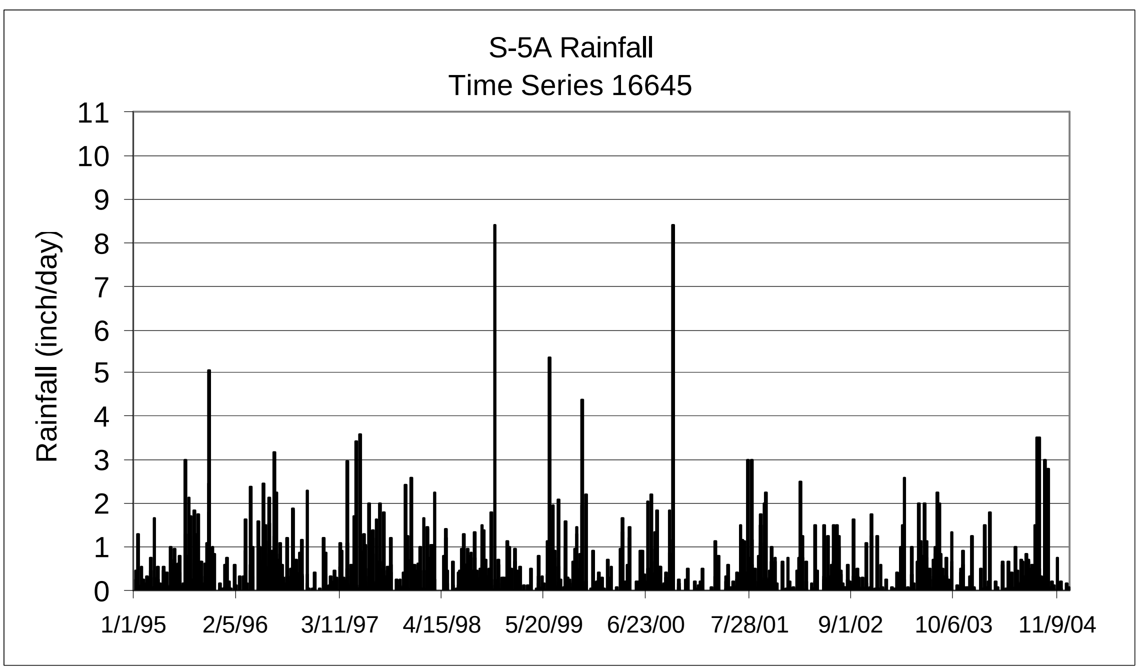

Figure C.16 S-5A Rain Measurements

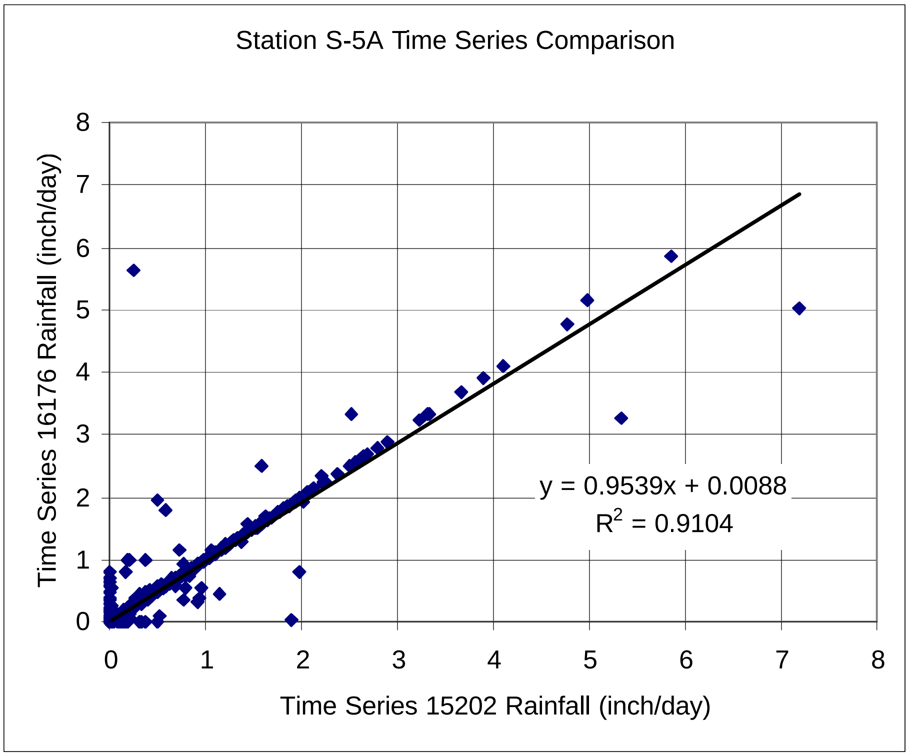

Figure C.17 S-5A rainfall time series comparison (daily).

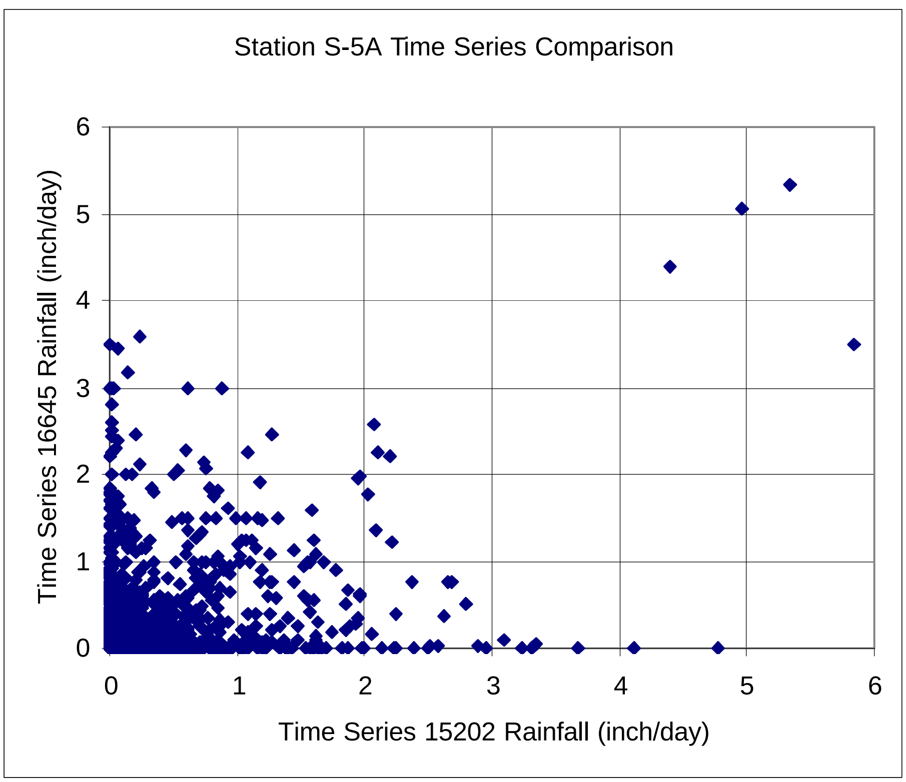

Figure C.18 S-5A rainfall time series comparison (daily).

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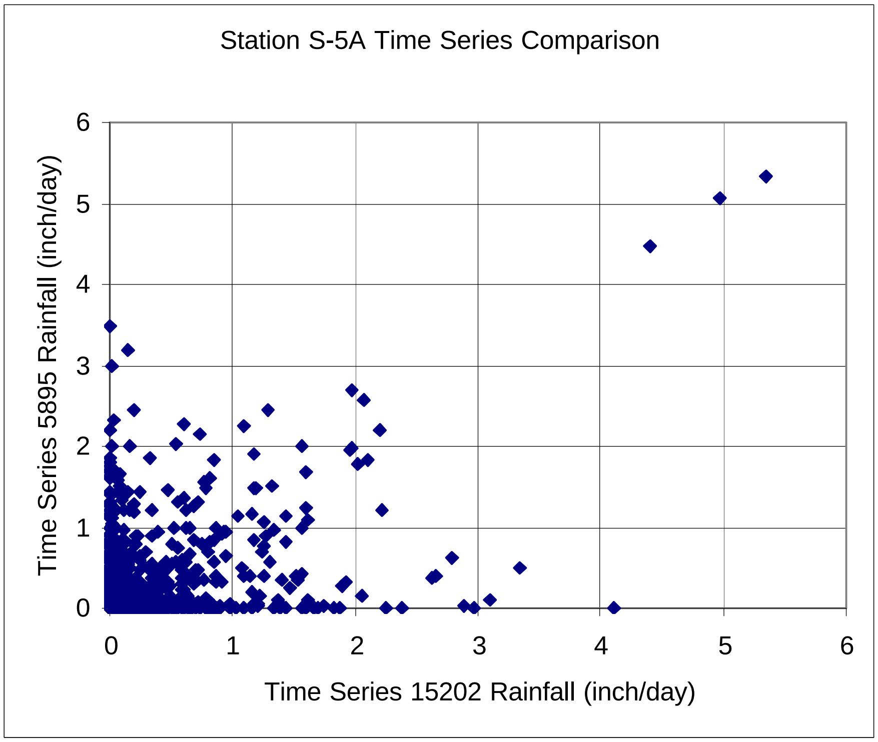

Figure C.19 S-5A rainfall time series comparison (daily).

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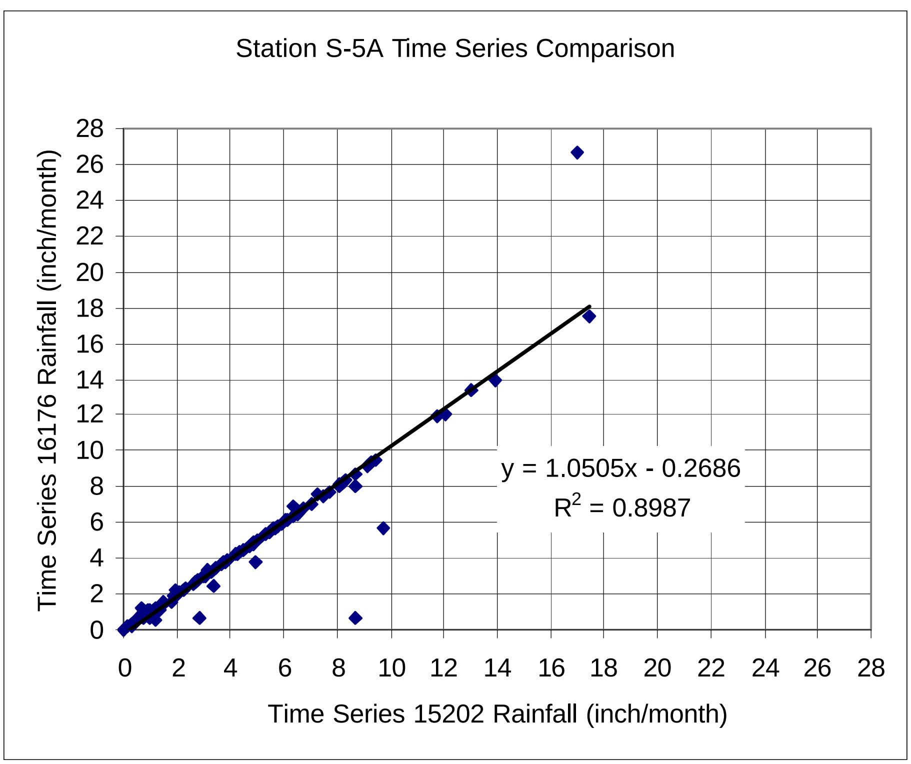

Figure C.20 S-5A rainfall time series comparison (monthly).

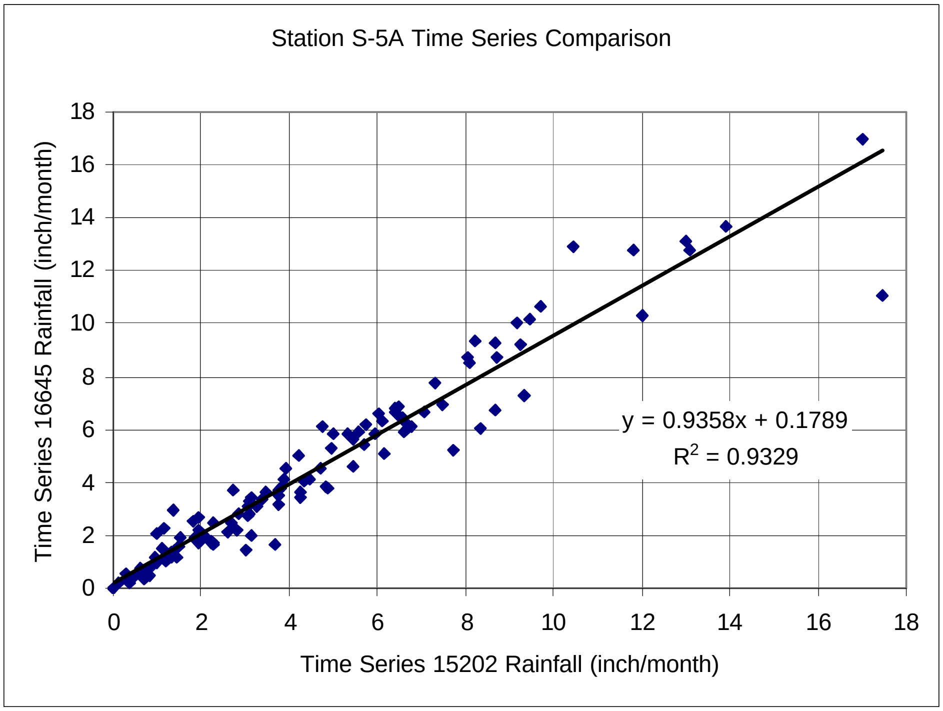

Figure C.21 S-5A rainfall time series comparison (monthly).

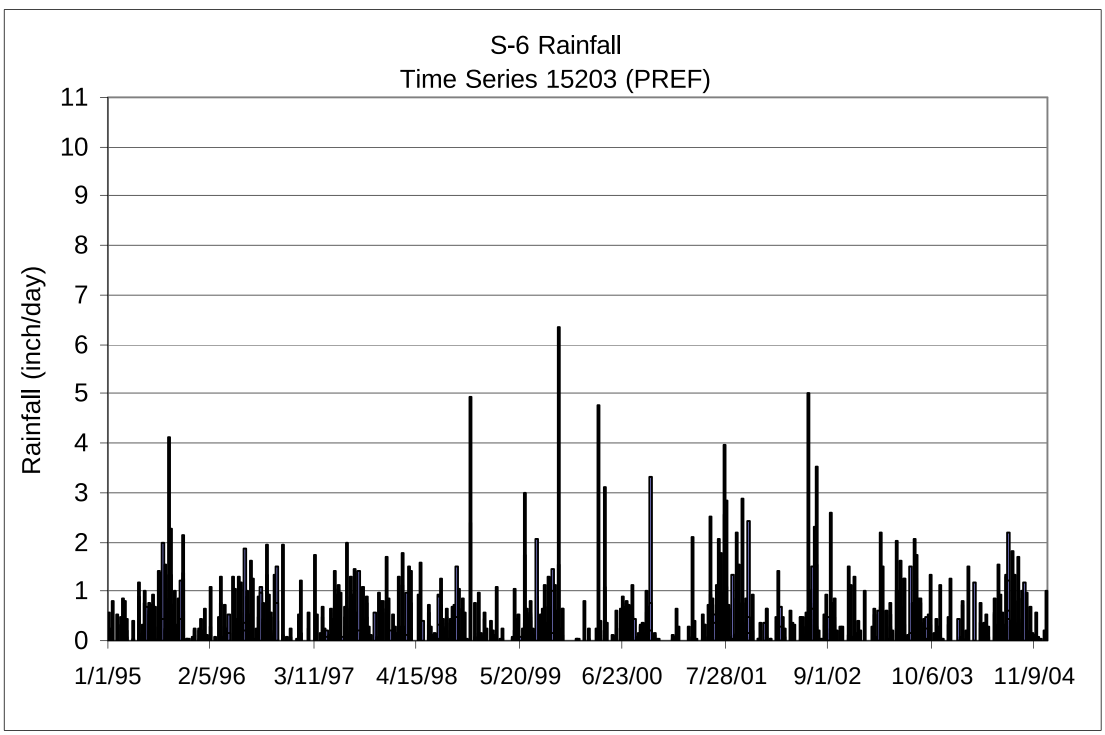

Figure C.22 S-6 Rain Measurements

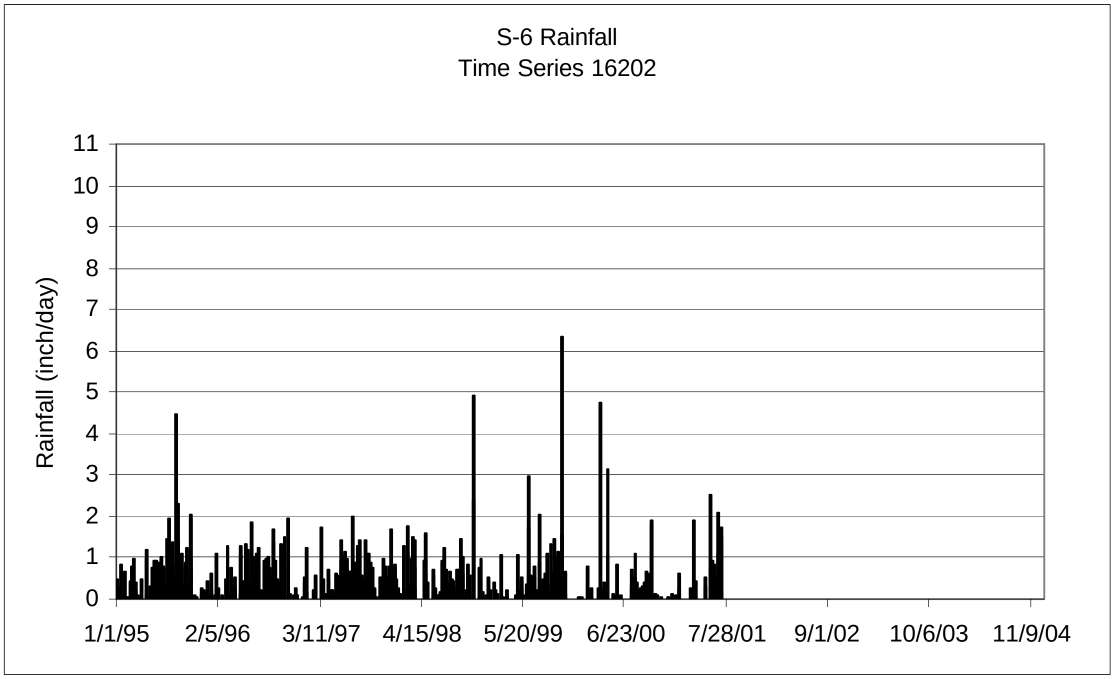

Figure C.23 S-6 Rain Measurements

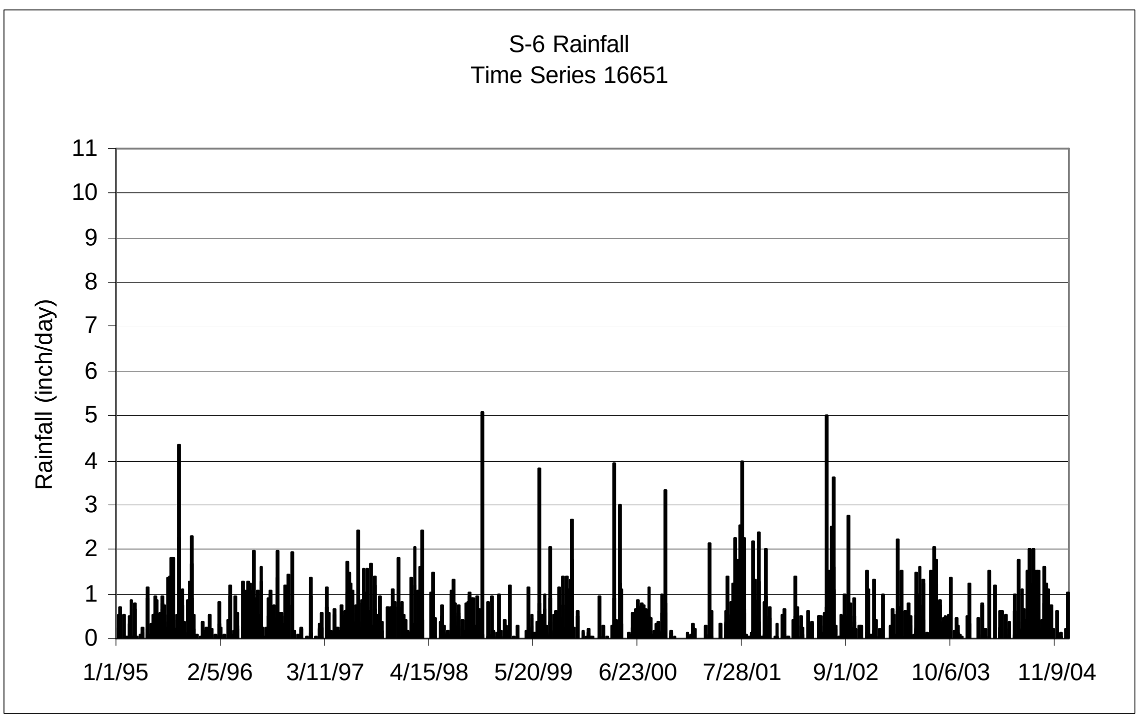

Figure C.24 S-6 Rain Measurements

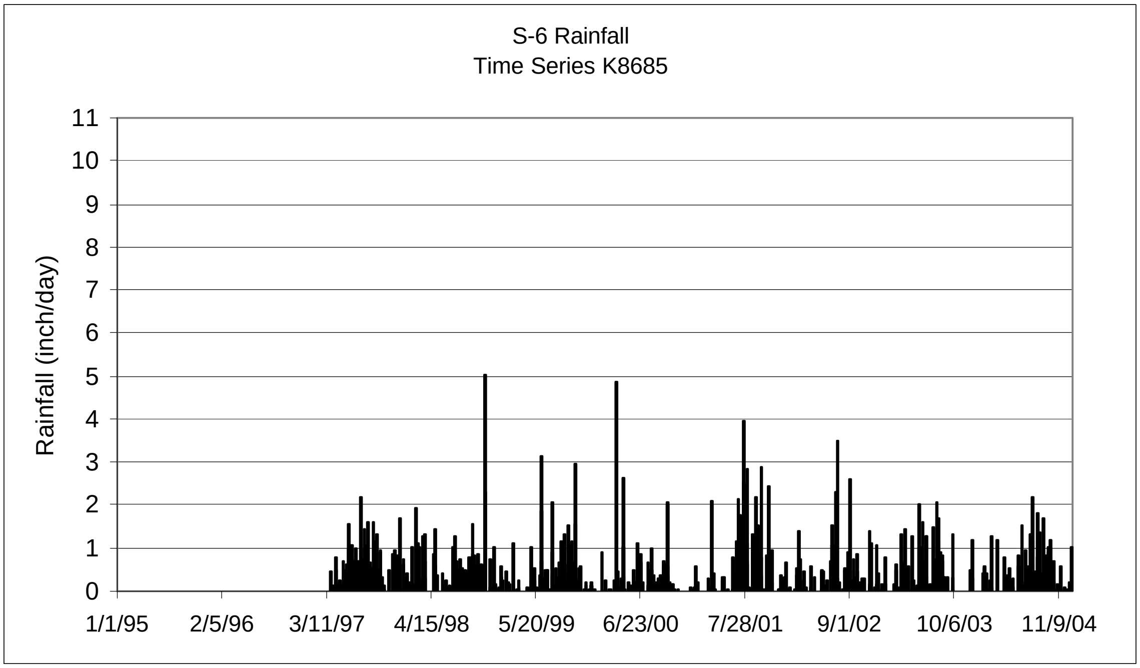

Figure C.25 S-6 Rain Measurements

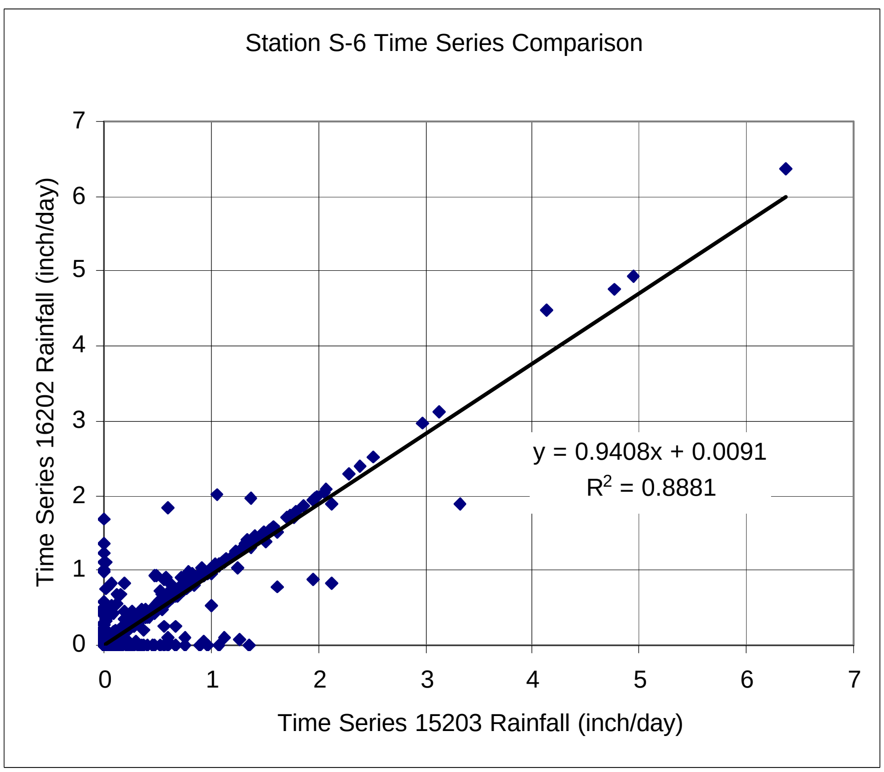

Figure C.26 S-6 rainfall time series comparison (daily).

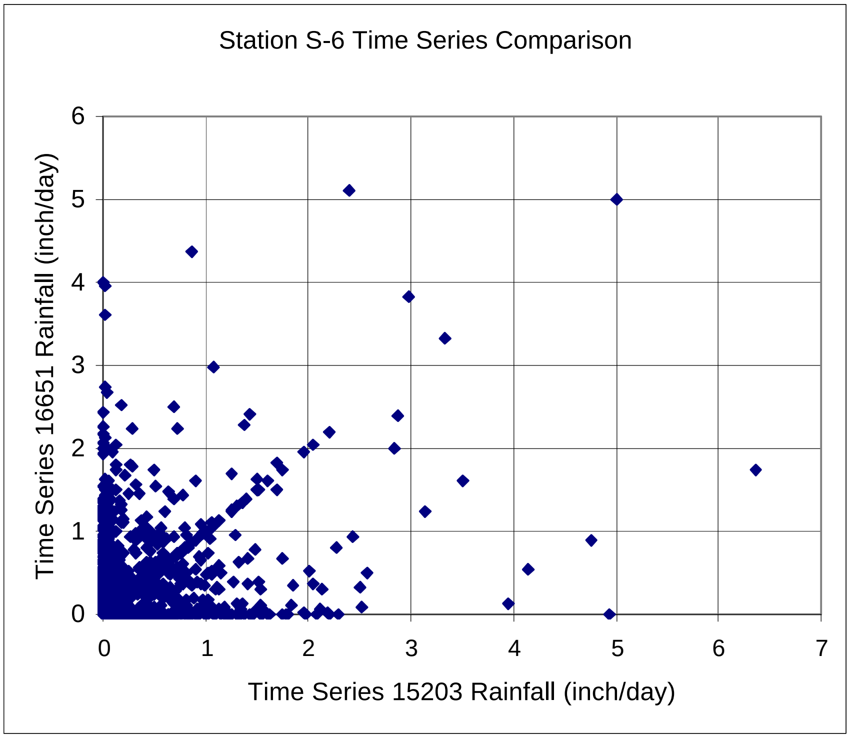

Figure C.27 S-6 rainfall time series comparison (daily).

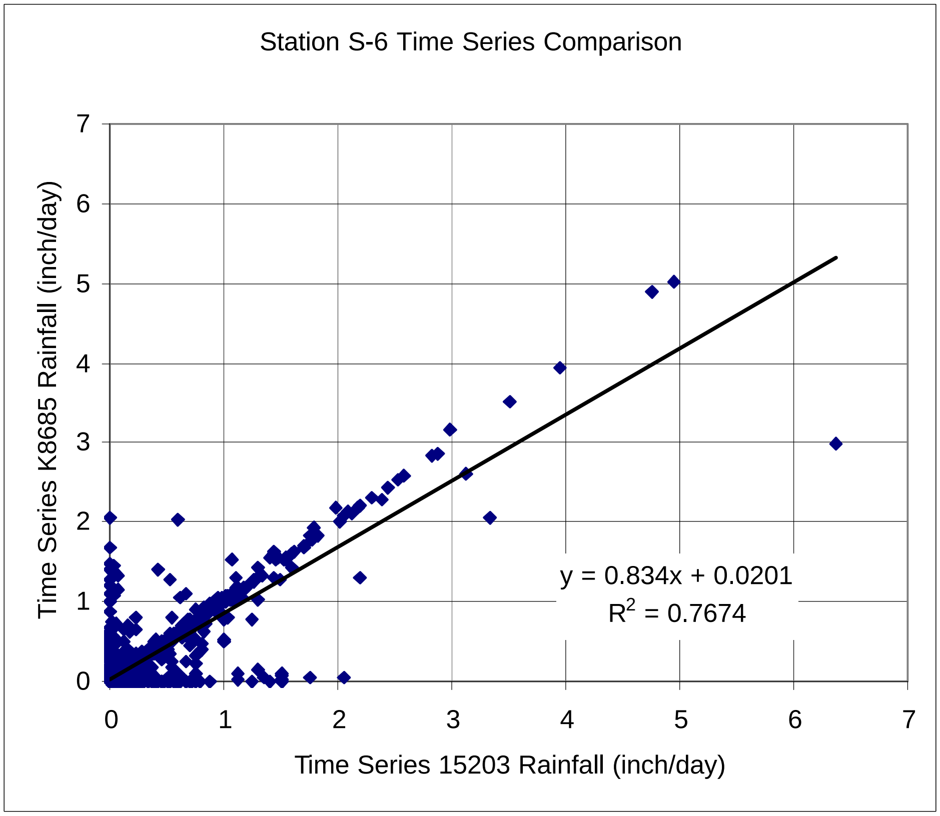

Figure C.28 S-6 rainfall time series comparison (daily)

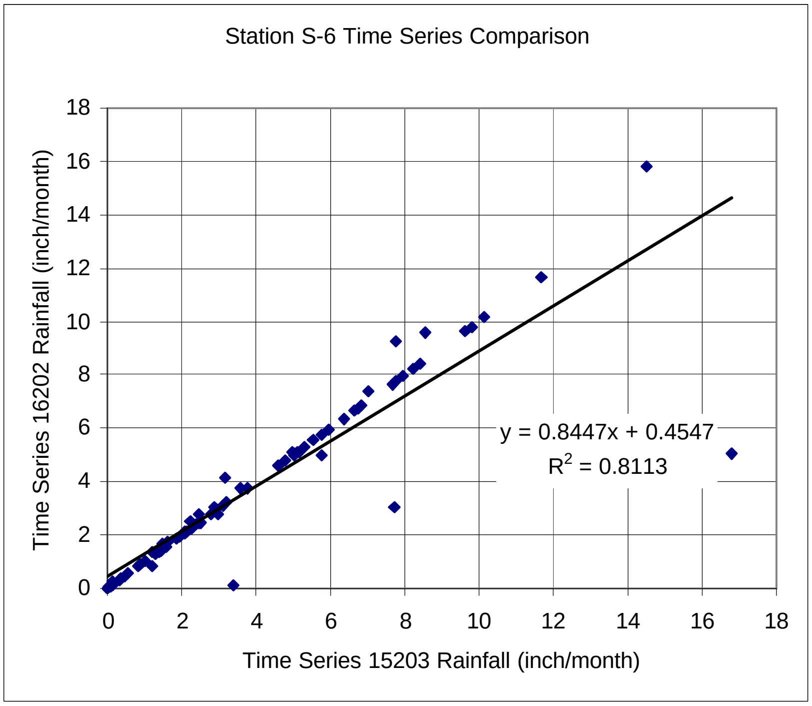

Figure C.29 S-6 rainfall time series comparison (monthly)

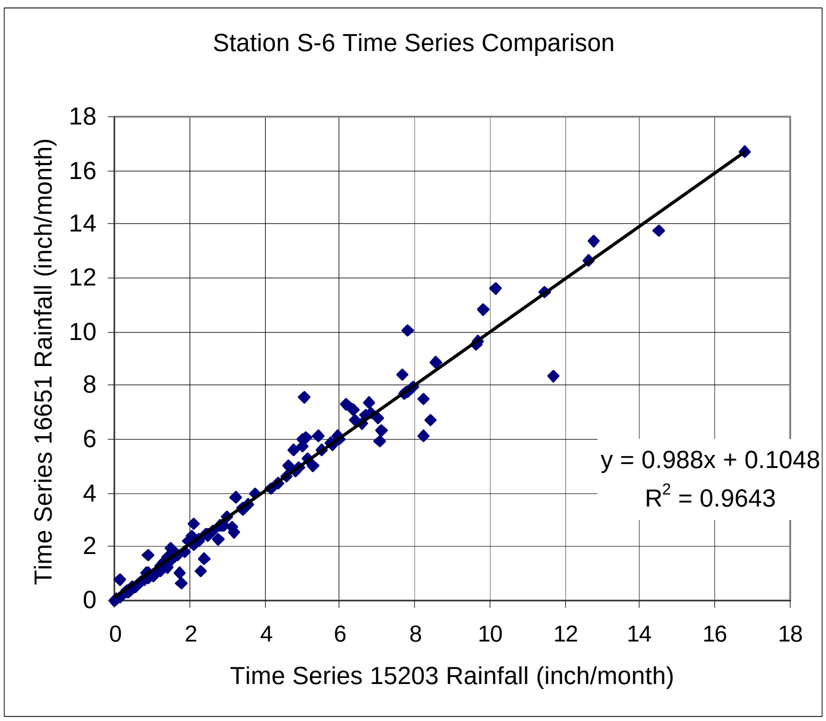

Figure C.30 S-6 rainfall time series comparison (monthly)

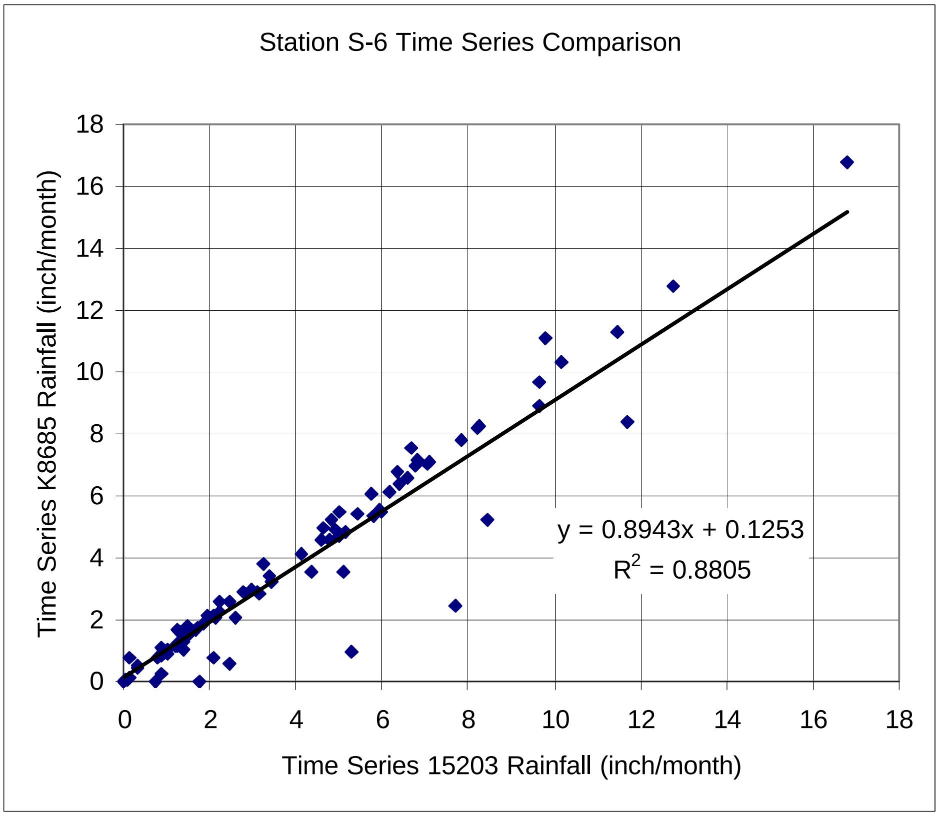

Figure C.31 S-6 rainfall time series comparison (monthly)

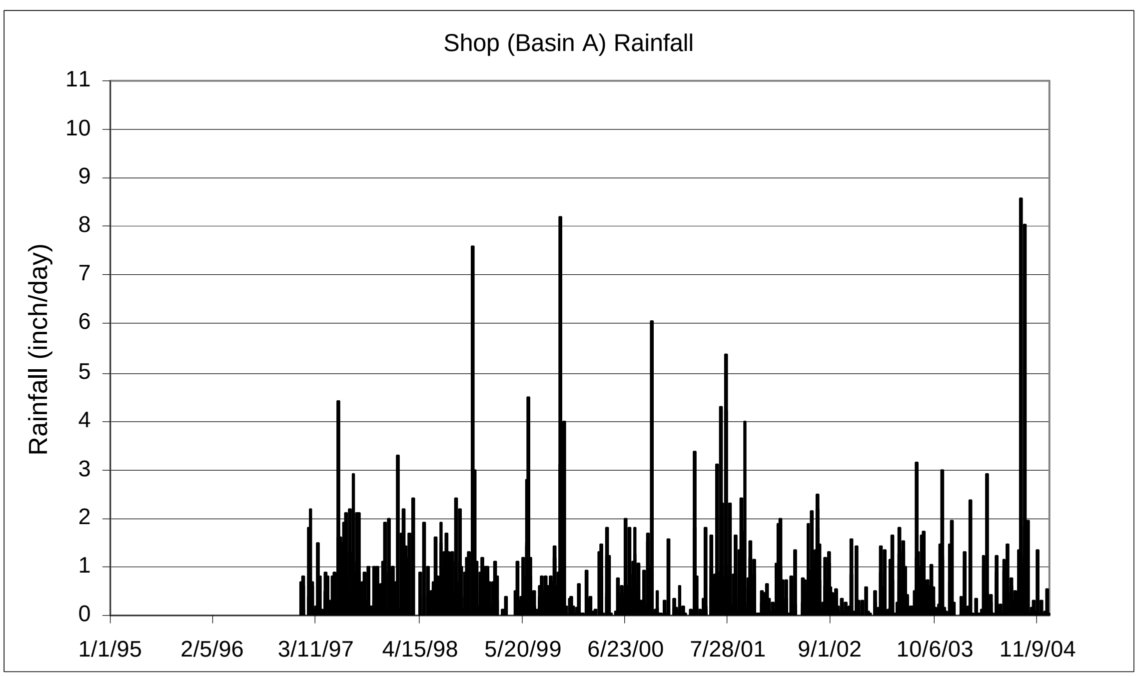

Figure C.32 Shop (Basin A) Rain Measurements

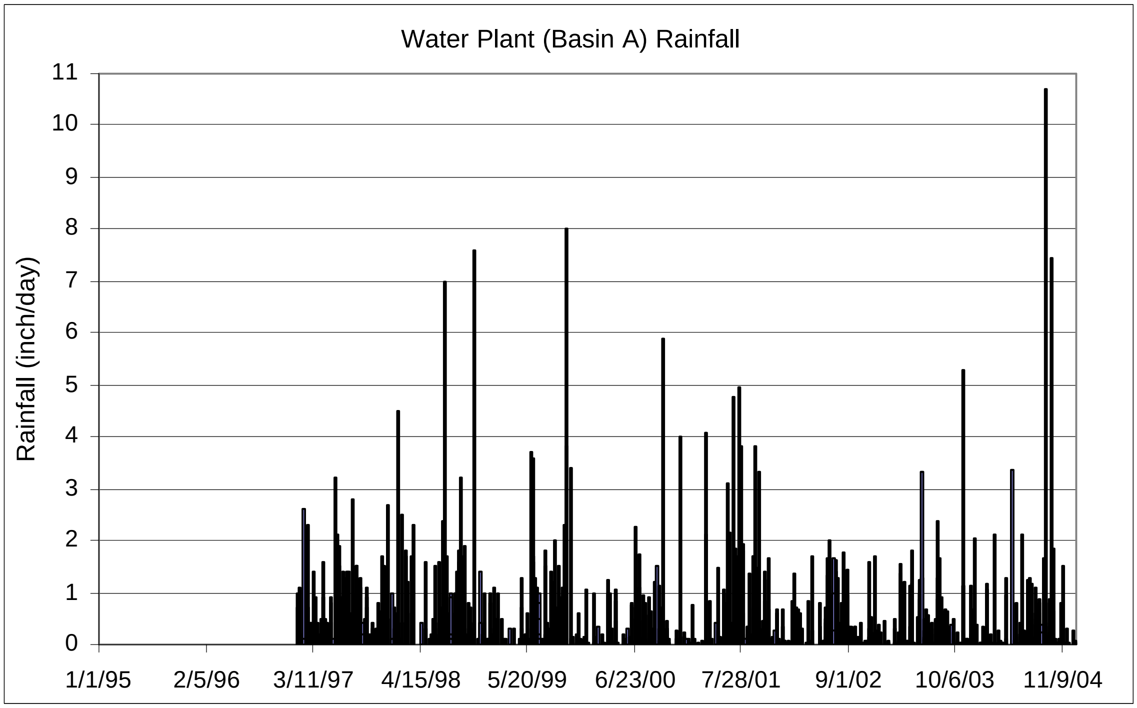

Figure C.33 Water Plant (Basin A) Rain Measurements

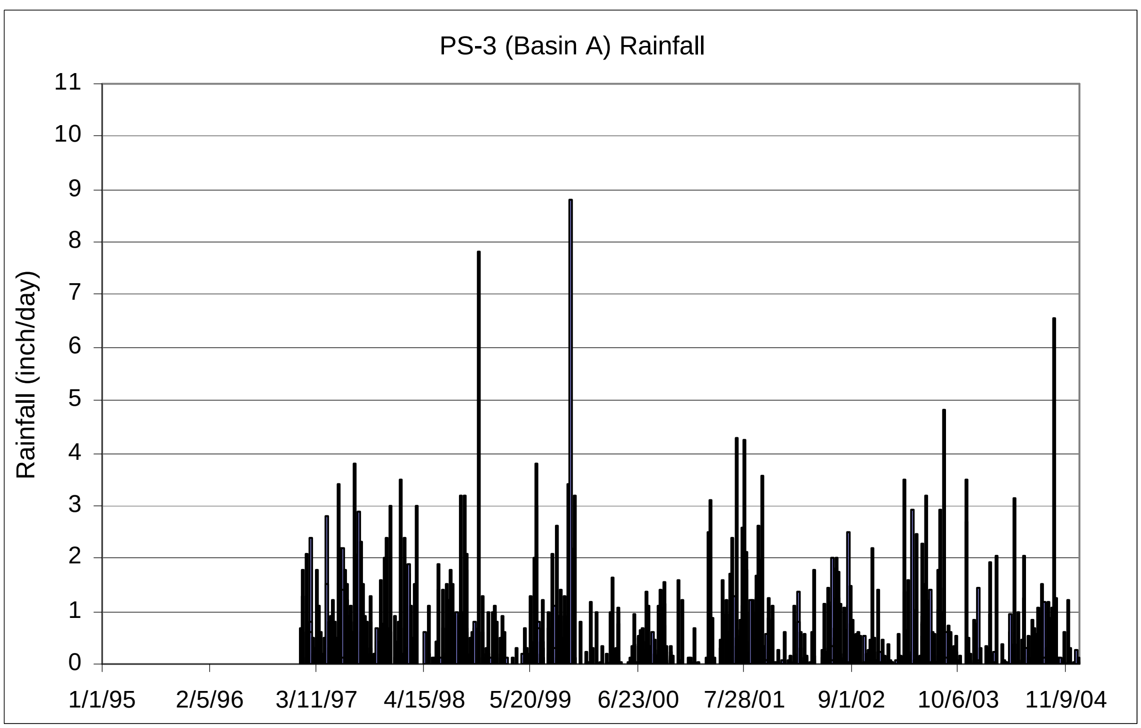

Figure C.34 PS-3 (Basin A) Rain Measurements

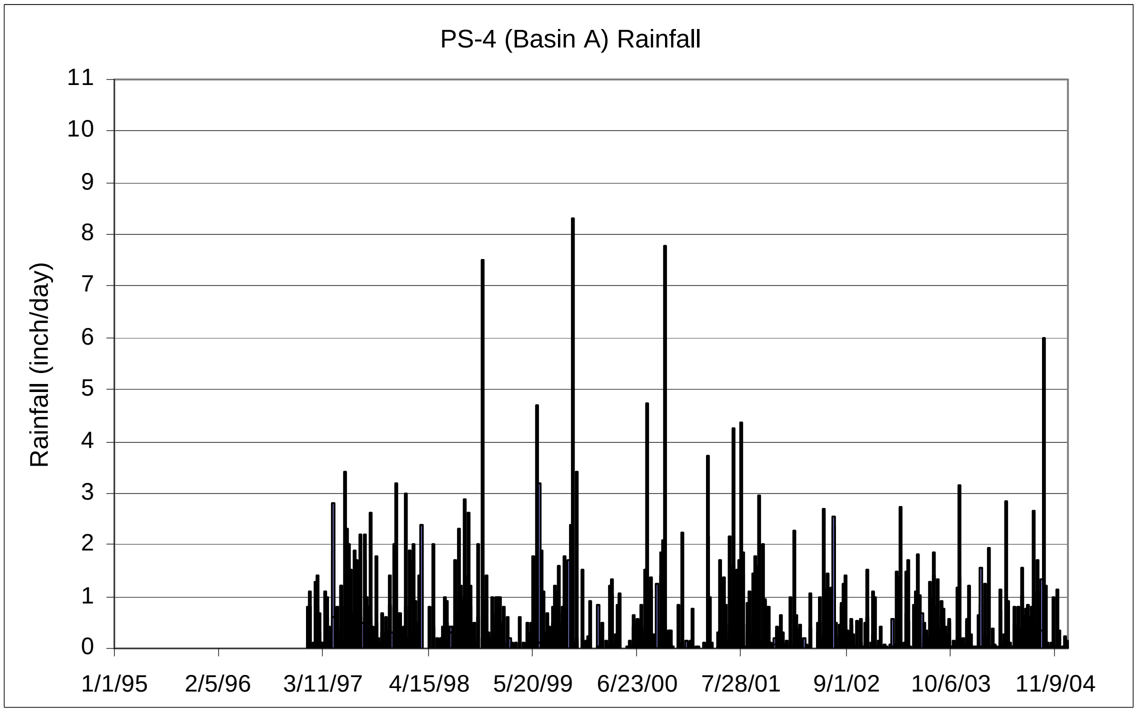

Figure C.35 PS-4 (Basin A) Rain Measurements

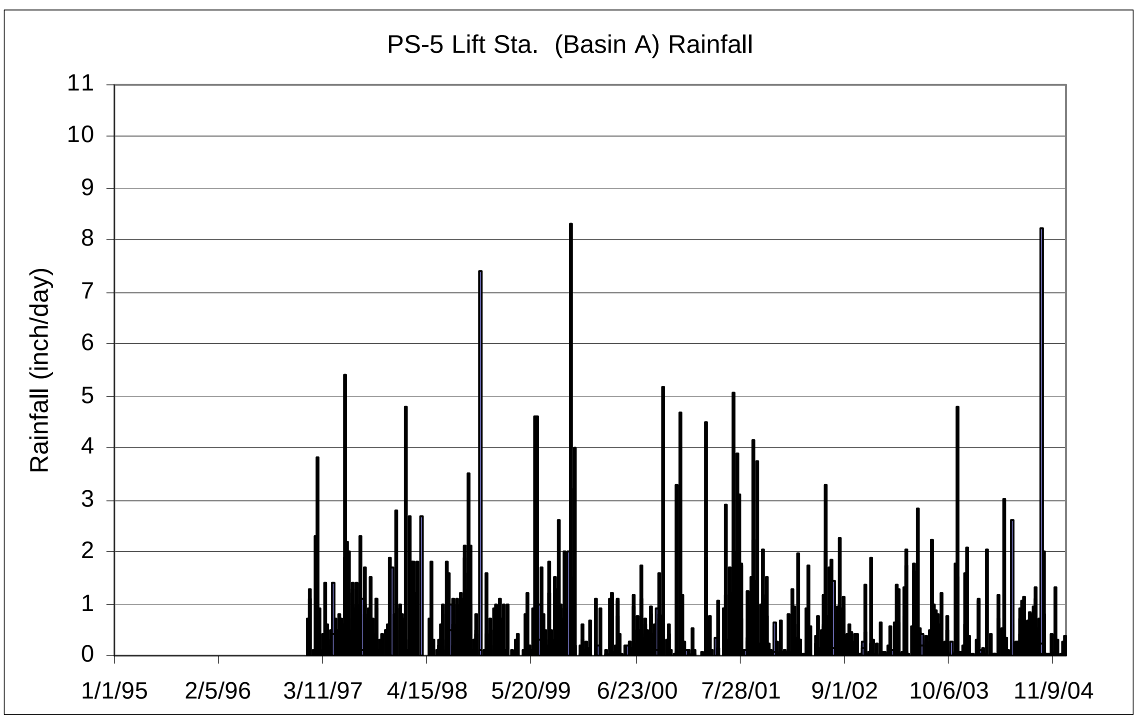

Figure C.36 PS-5 (Basin A) Rain Measurements

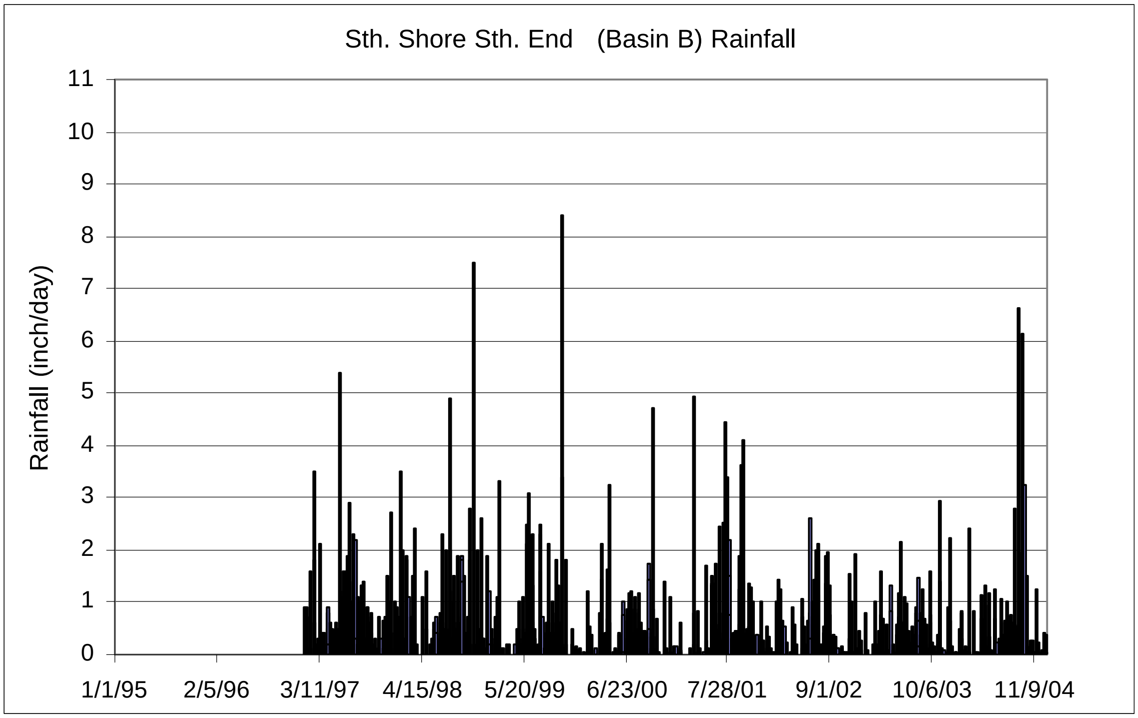

Figure C.37 Sth. Shore Sth End (Basin B) Rain Measurements

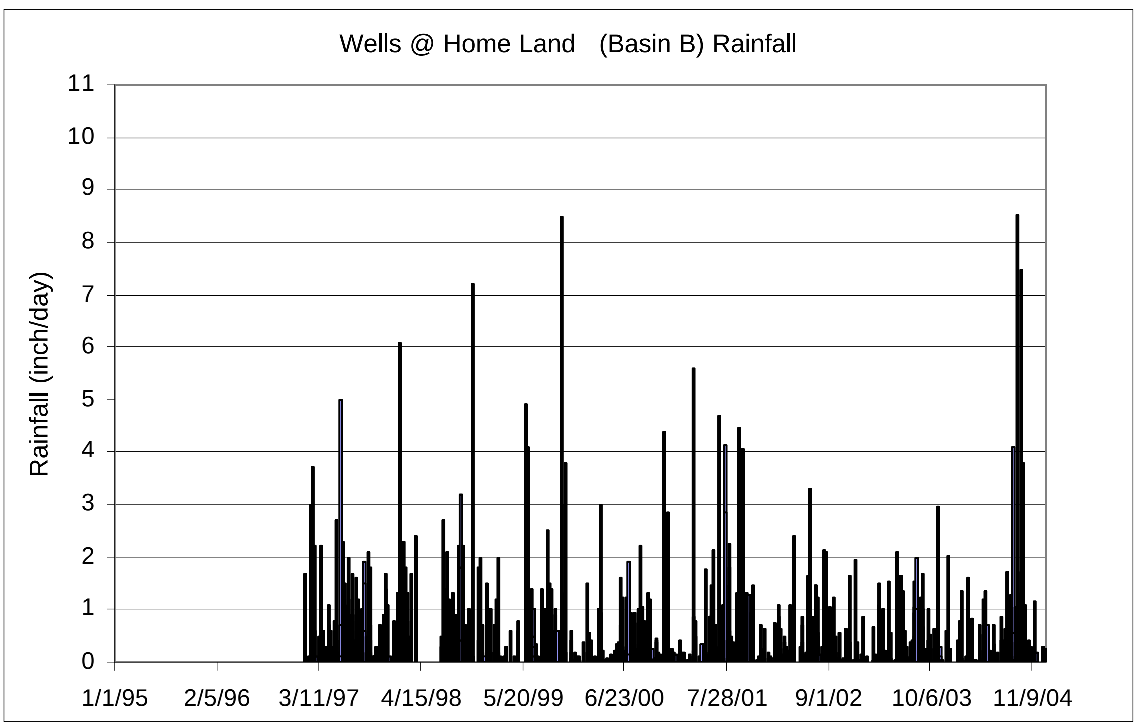

Figure C.38 Wells @ Home Land (Basin B) Rain Measurements

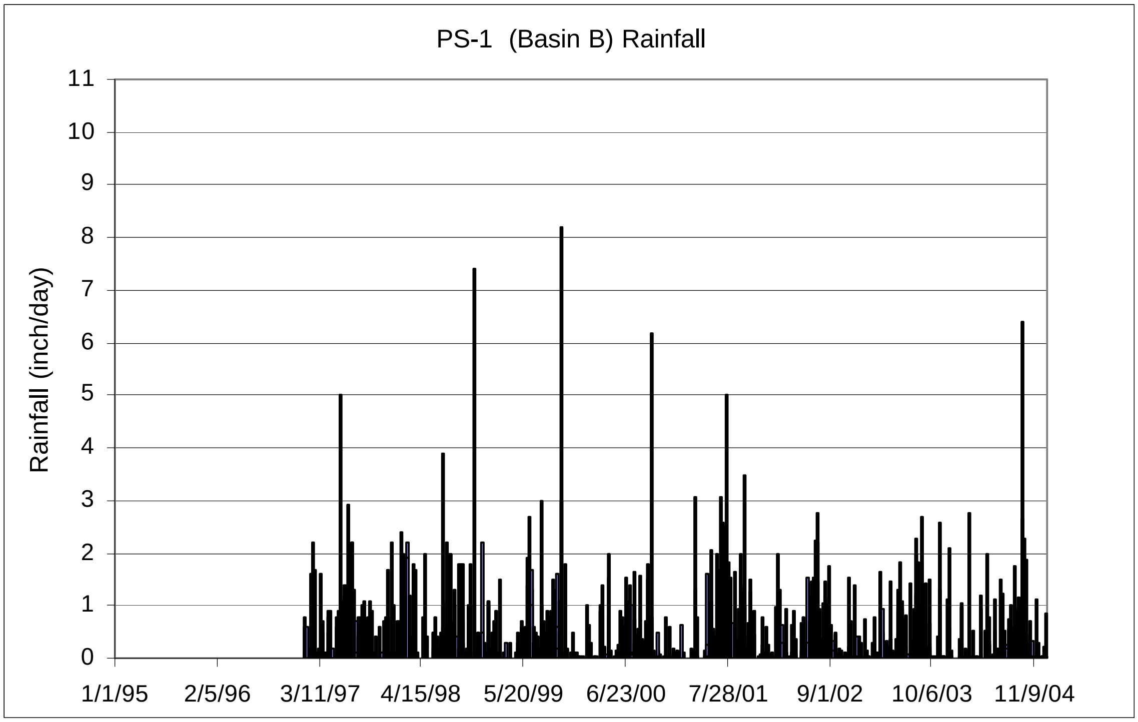

Figure C.39 PS-1 (Basin B) Rain Measurements

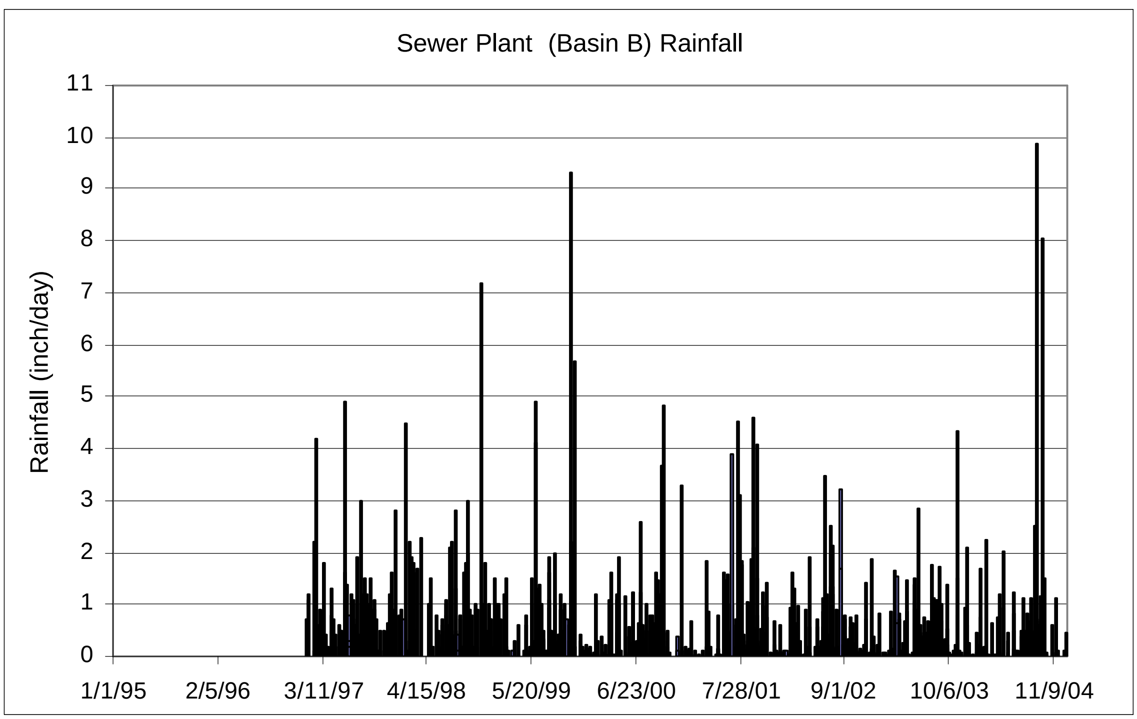

Figure C.40 Sewer Plant (Basin B) Rain Measurements

Appendix D
(Evaporation and Evapotranspiration Measurements)

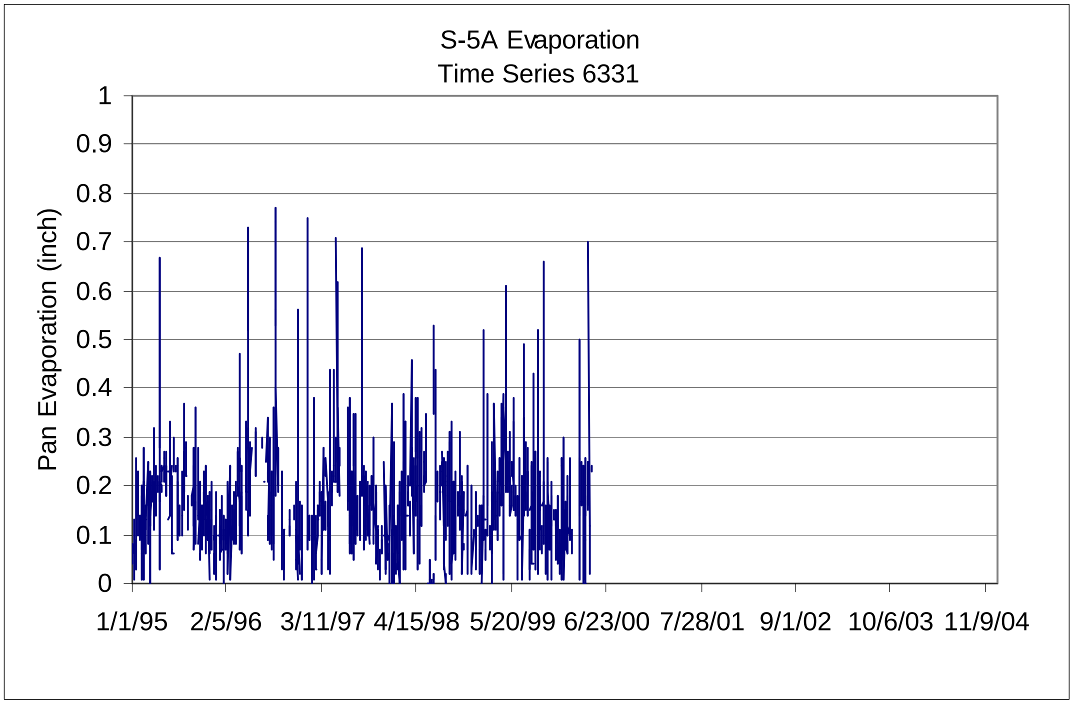

Figure D.1 S-5A Pan Evaporation

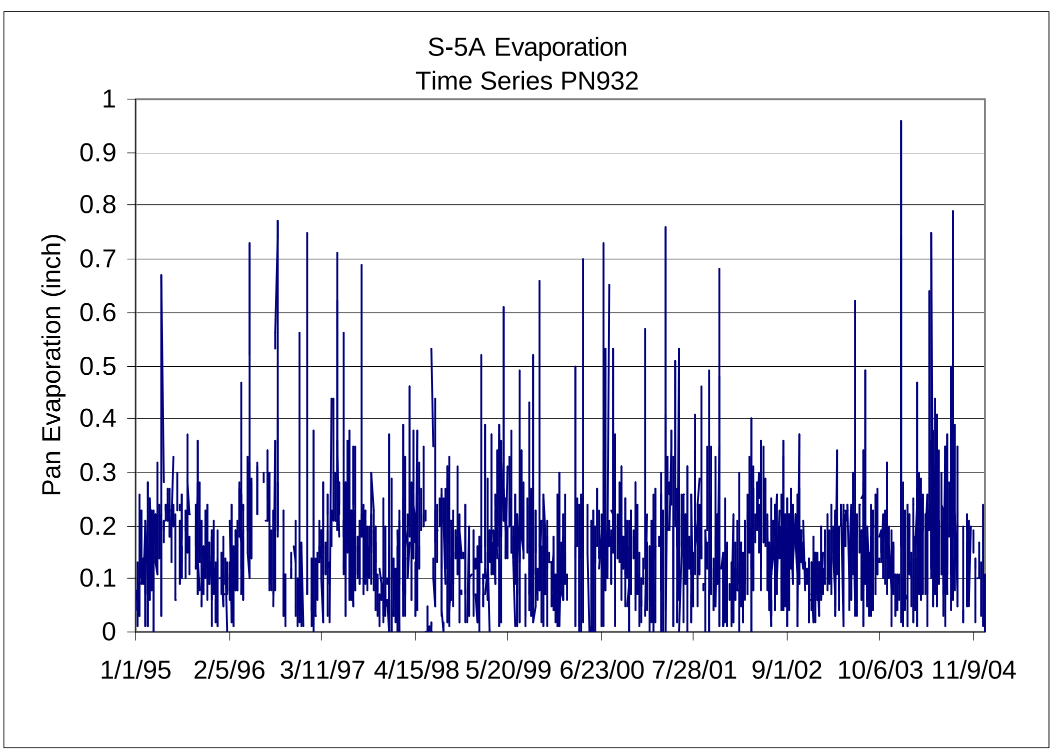

Figure D.2 S-5A Pan Evaporation

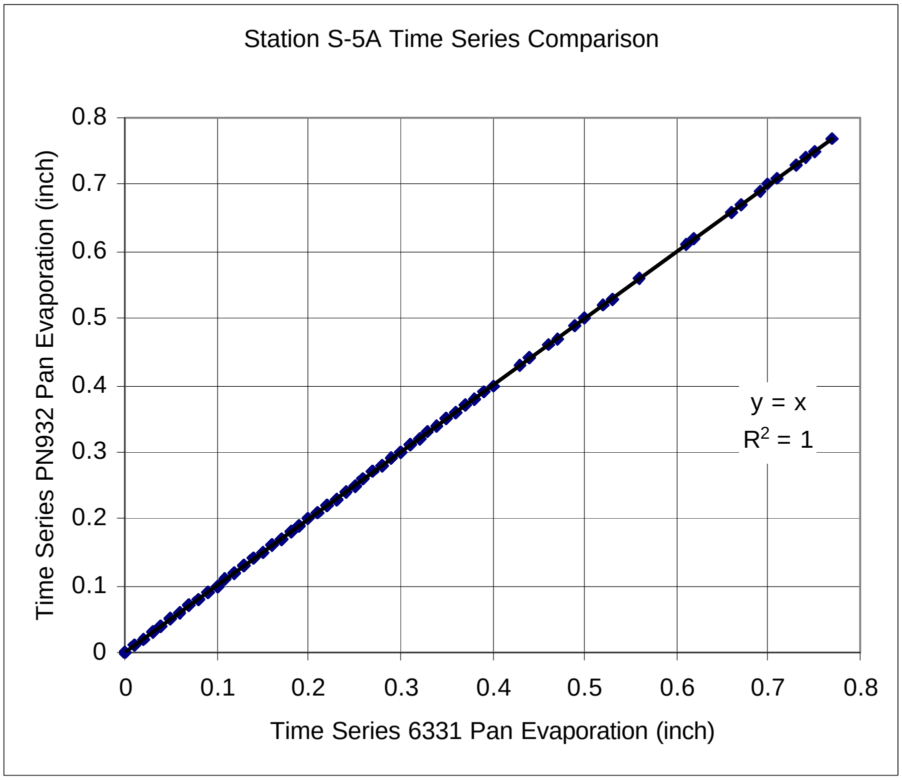

Figure D.3 S-5A Pan evaporation time series comparison.

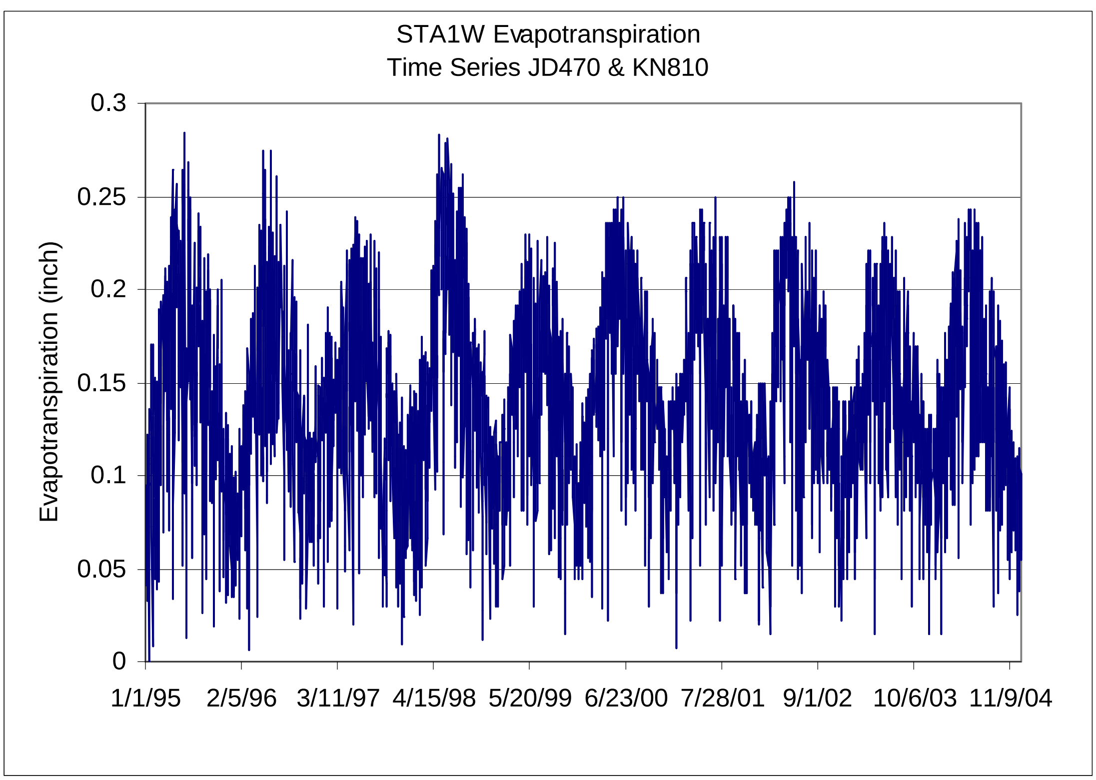

Figure D.4 S-5A Evapotranspiration

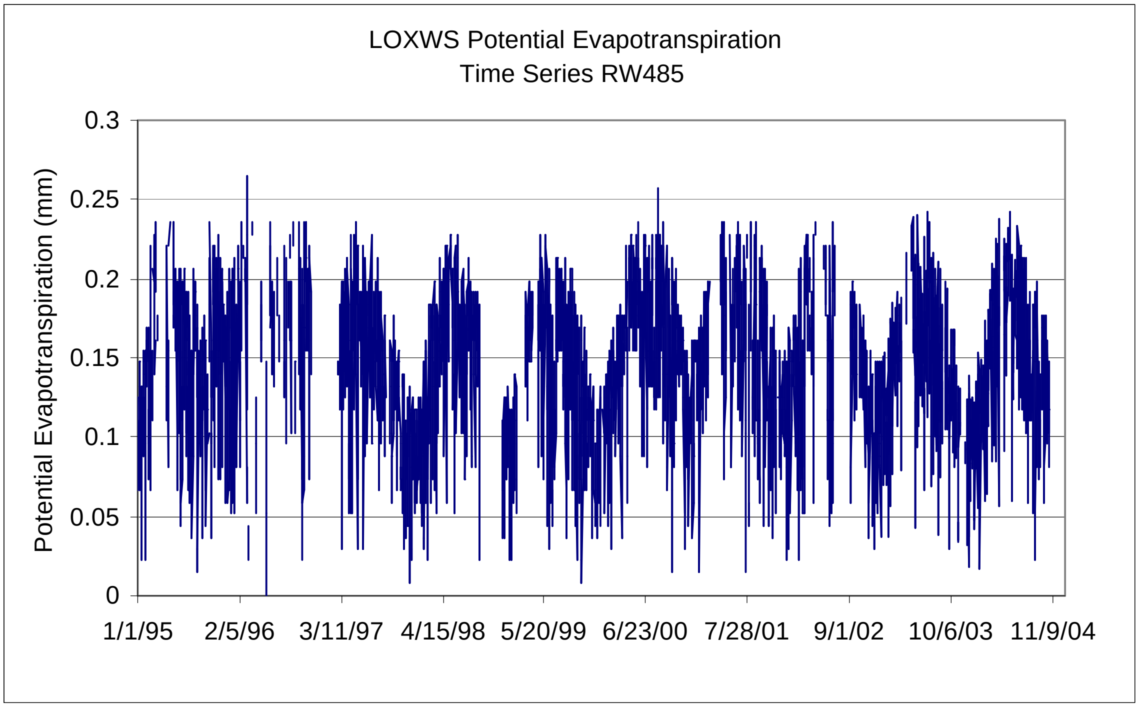

Figure D.5 LOXWS Potential Evapotranspiration

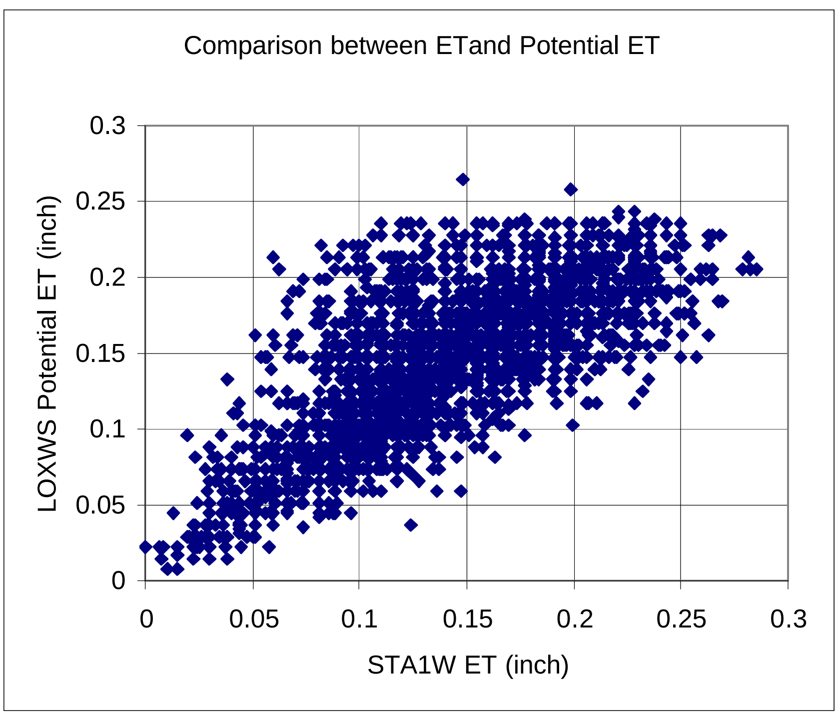

Figure D.6 Comparison between ET measurement from STA1W and Potential ET from LOXWS.

Appendix E
(Wind Speed)

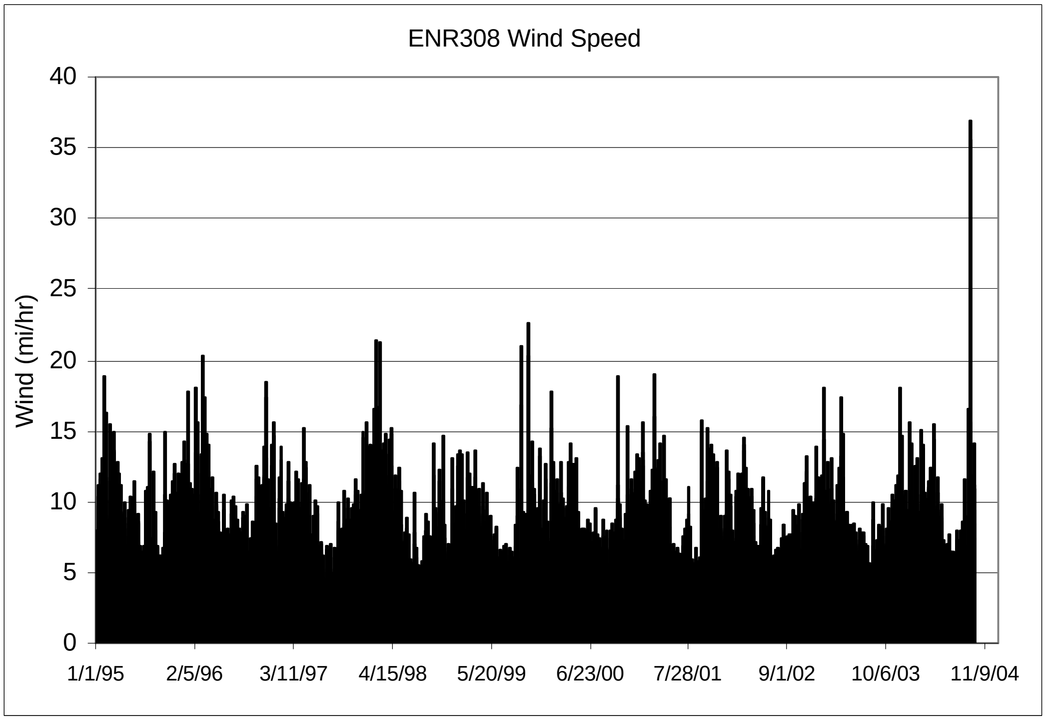

Figure E1. ENR 308 Wind Speed

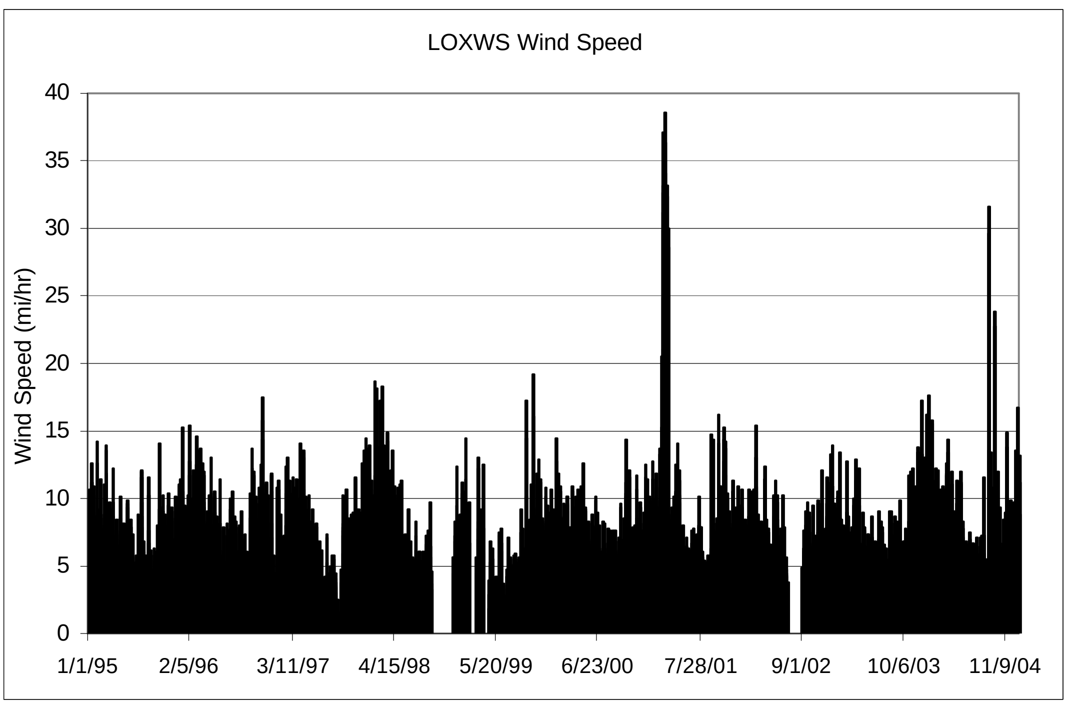

Figure E2. LOXWS Wind Speed

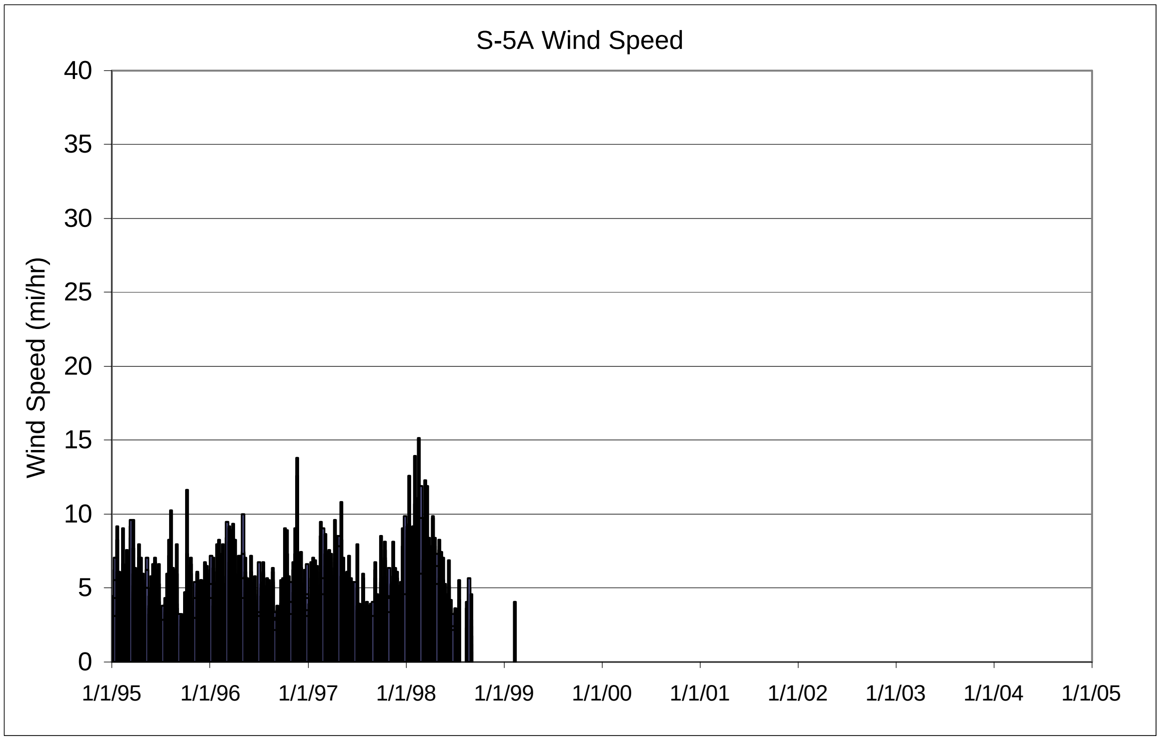

Figure E3. S-5A Wind Speed

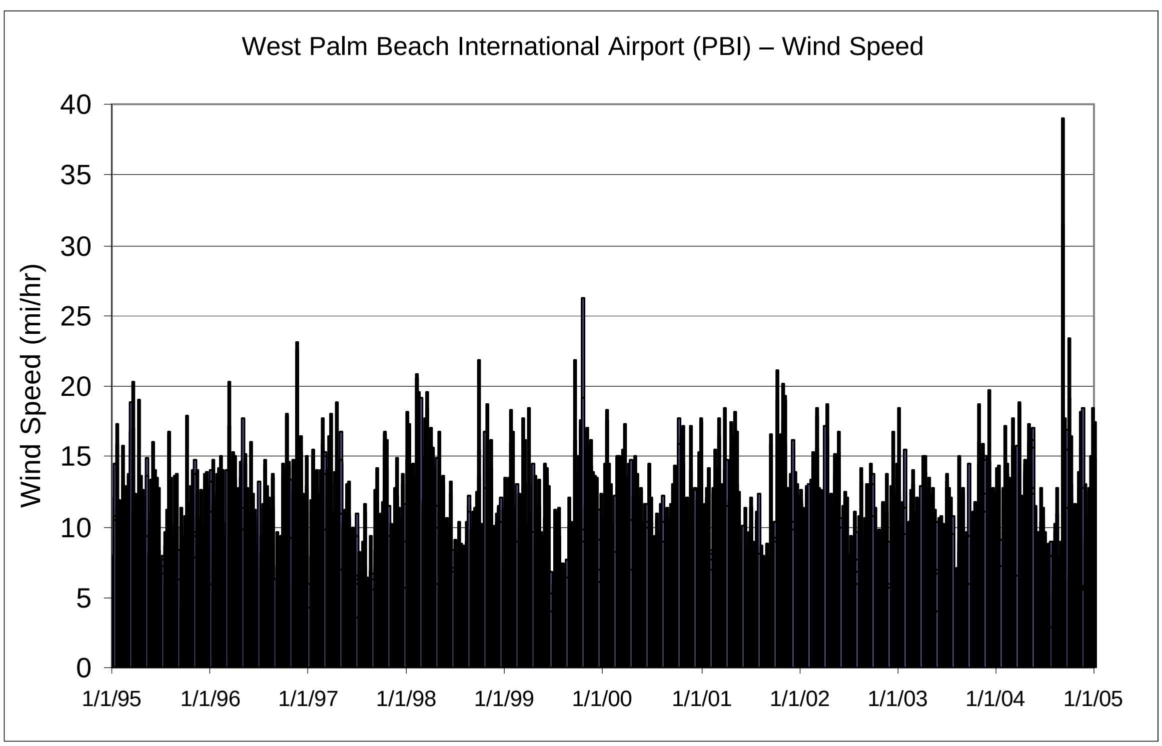

Figure E4. West Palm Beach International Airport (PBI) – Wind Speed

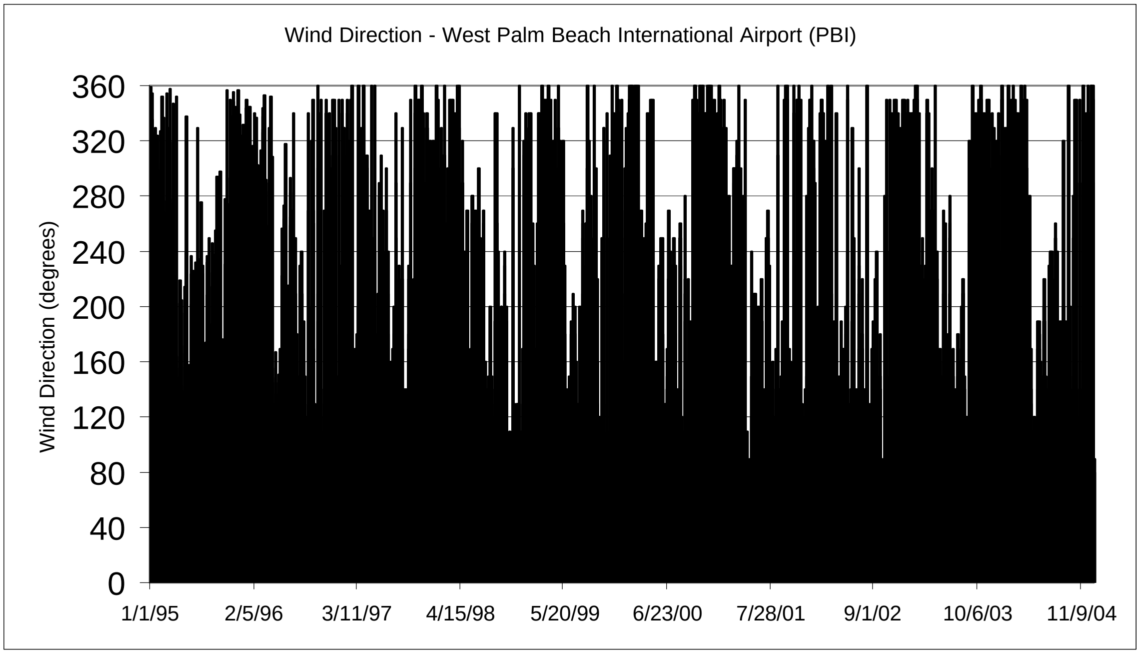

Figure E5. West Palm Beach International Airport (PBI) – Wind Direction

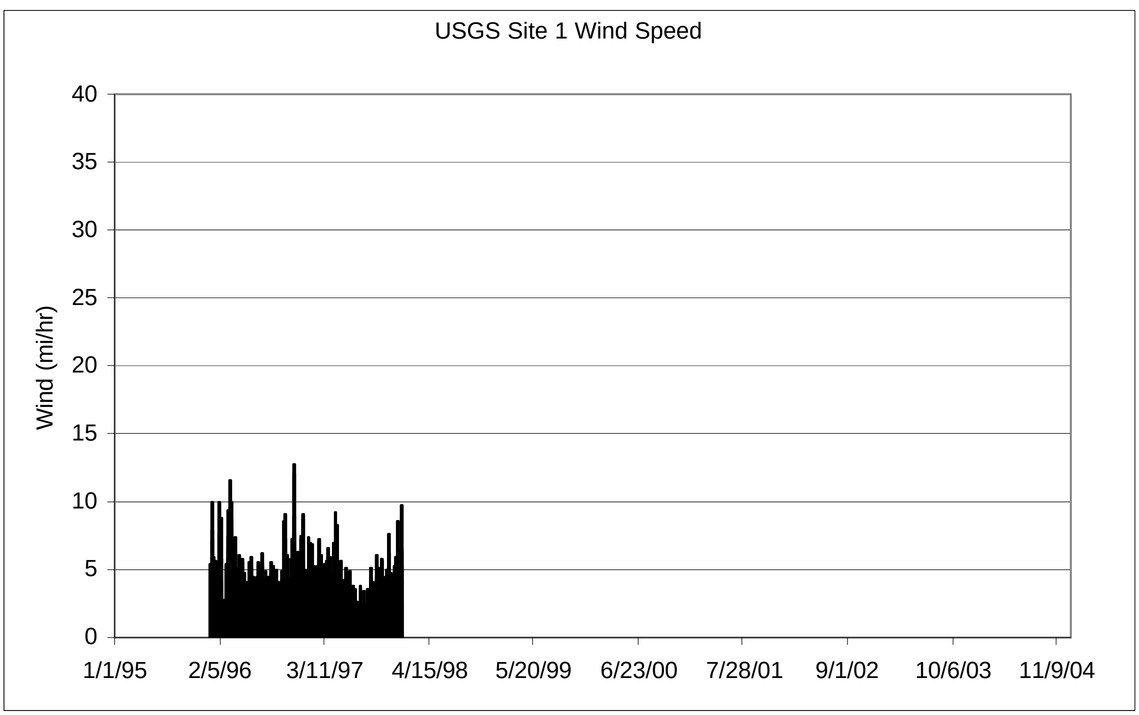

Figure E6. USGS-1 Wind Speed

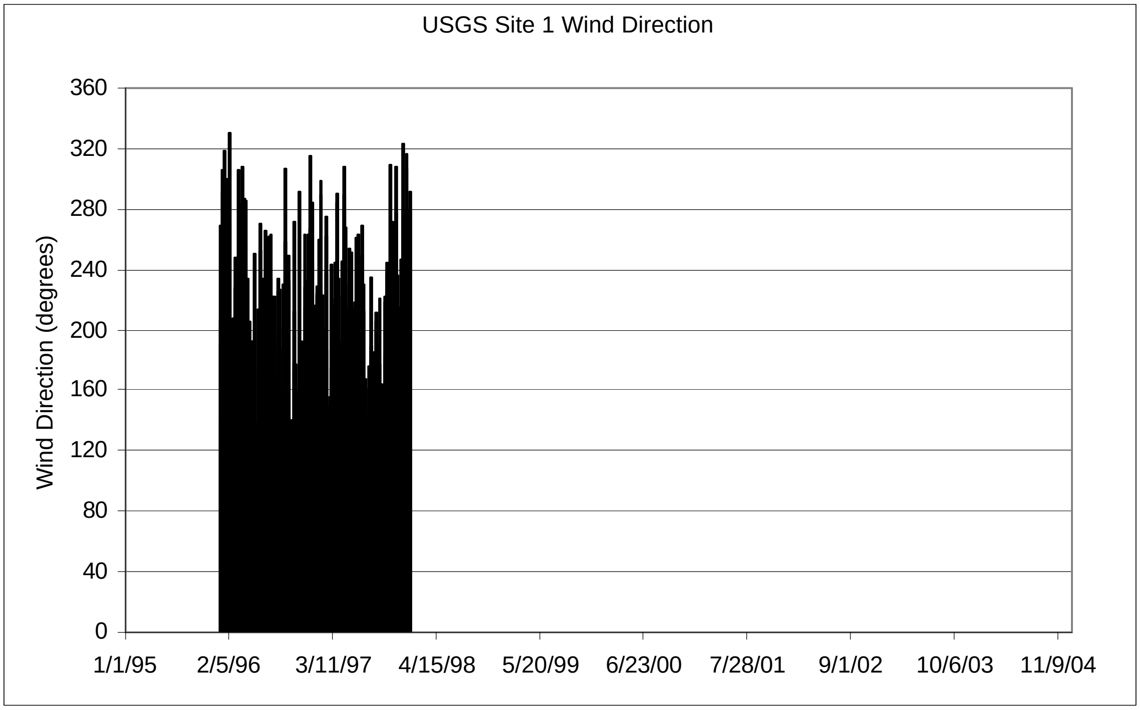

Figure E7. USGS-1 Wind Direction

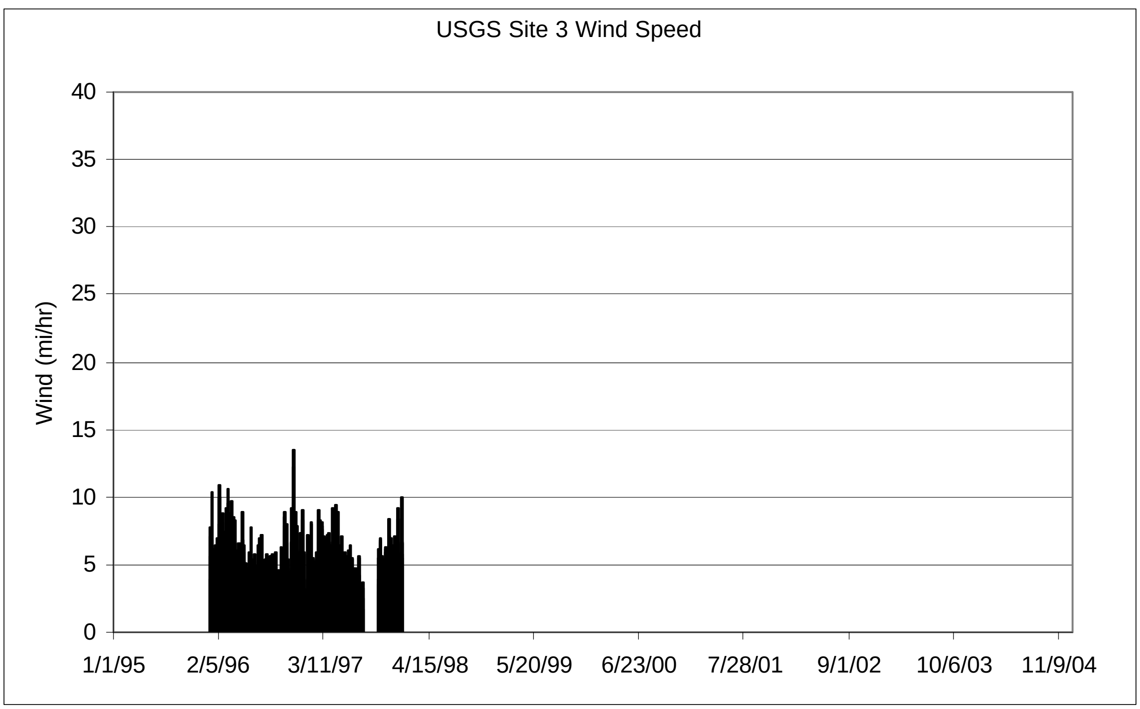

Figure E8. USGS-3 Wind Speed

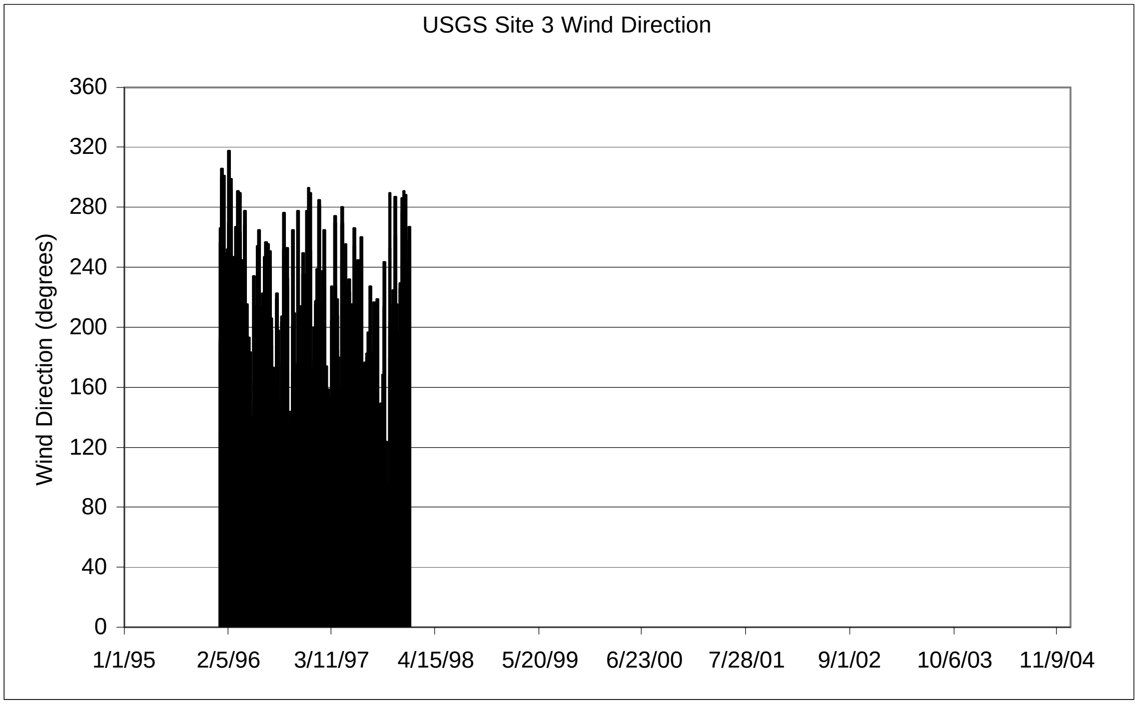

Figure E9. USGS-3 Wind Direction

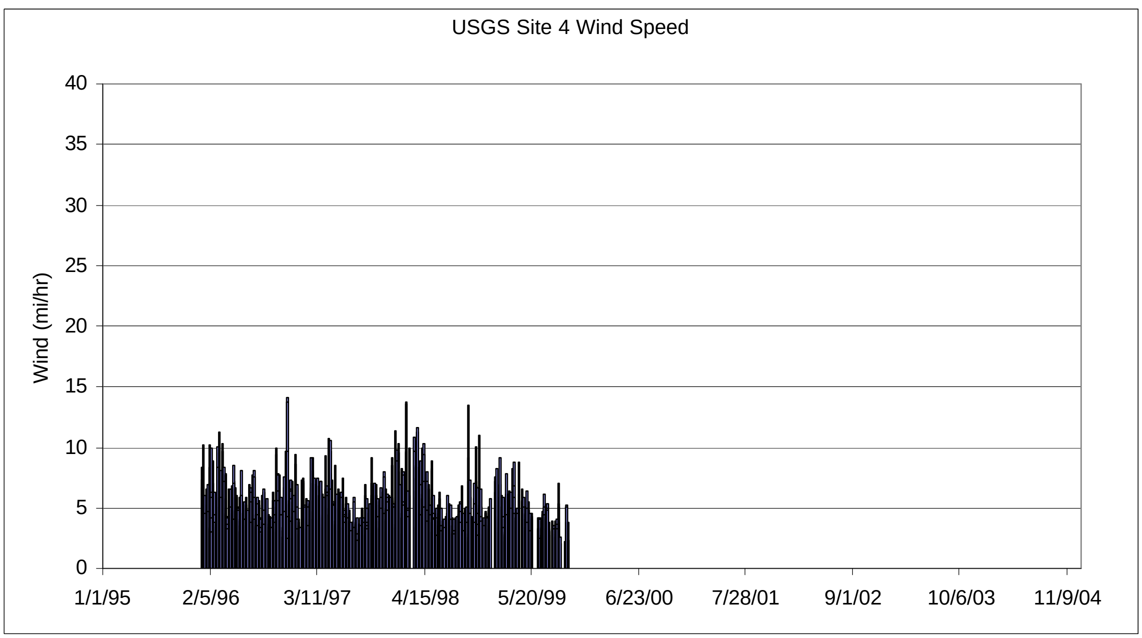

Figure E10. USGS-4 Wind Speed

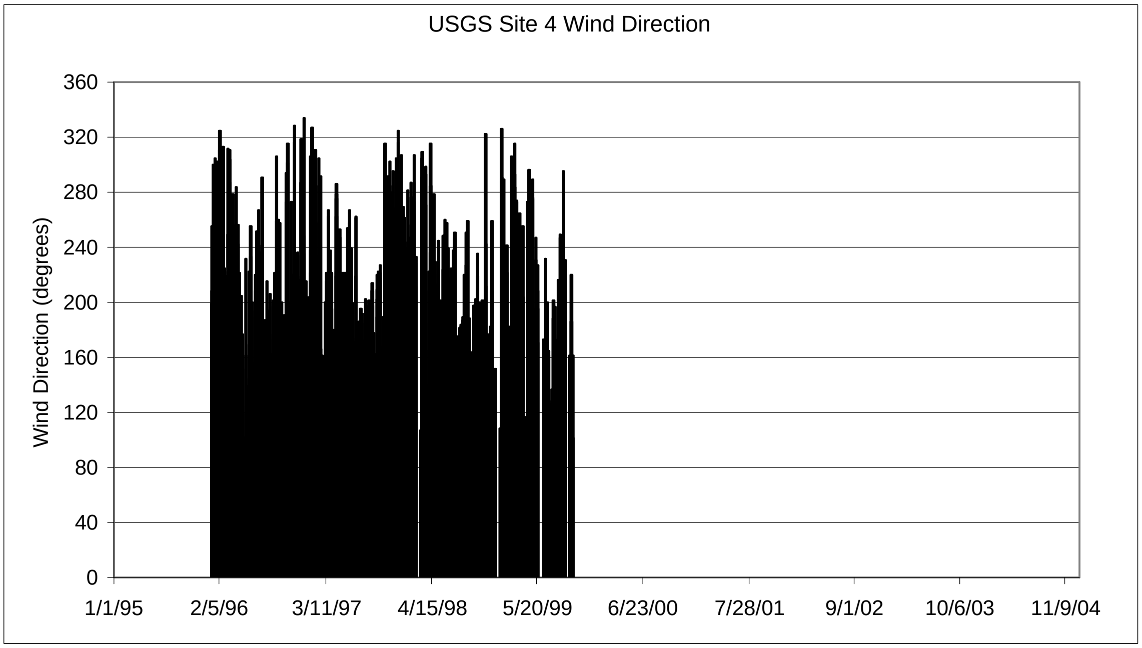

Figure E11. USGS-4 Wind Direction

APPENDIX F

(Water Quality Parameters)

APPENDIX F1

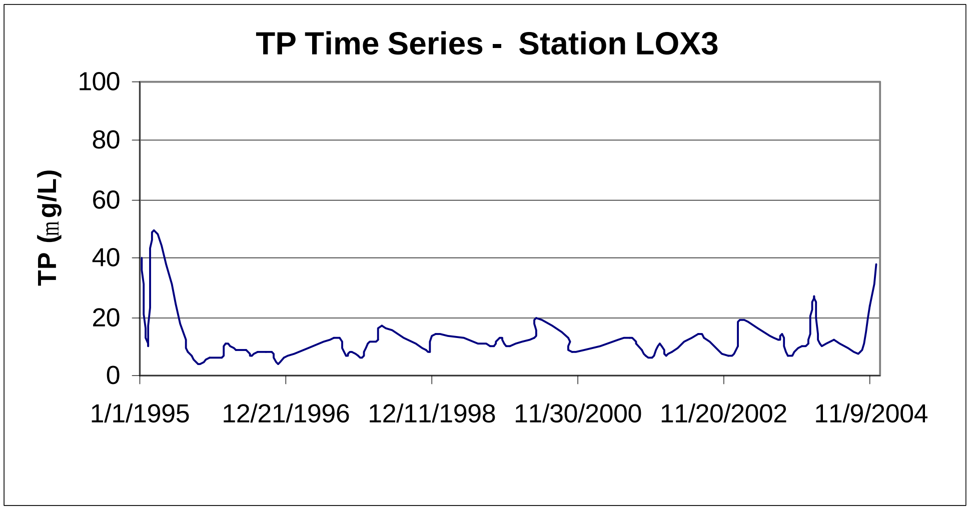

Figure F1.1 TP Time Series – EVPA Station LOX3

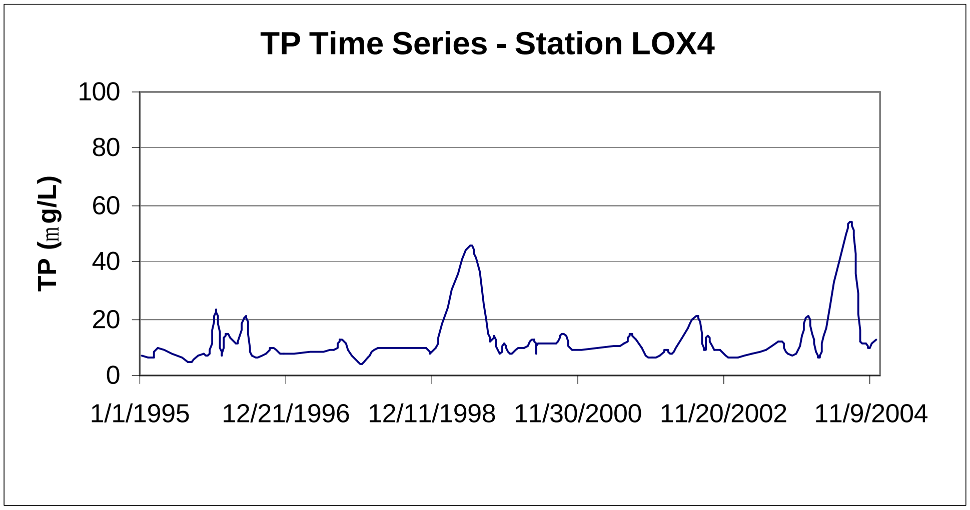

Figure F1.2 TP Time Series – EVPA Station LOX4

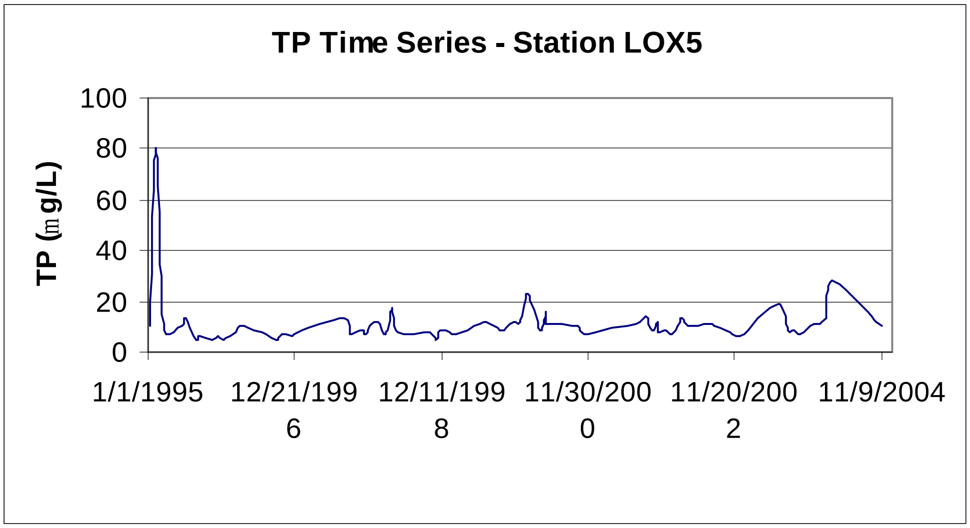

Figure F1.3 TP Time Series – EVPA Station LOX5

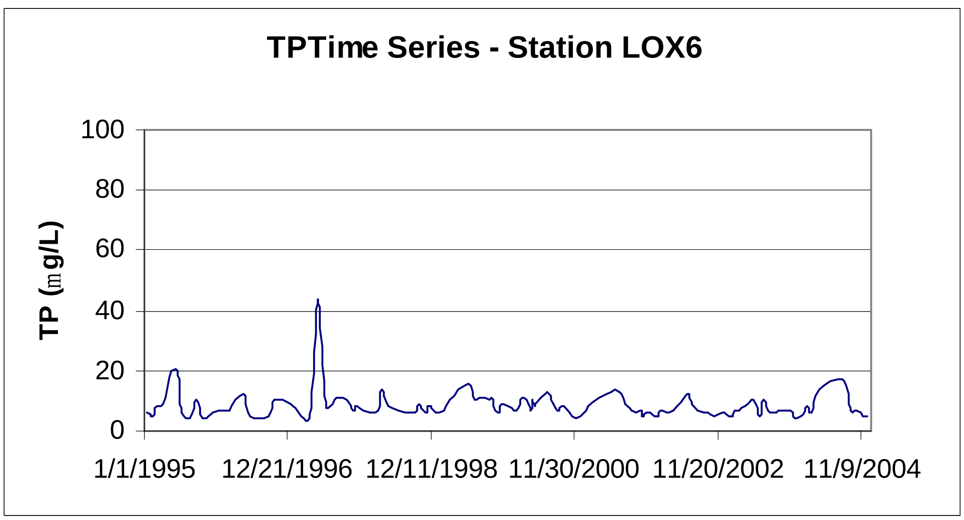

Figure F1.4 TP Time Series – EVPA Station LOX6

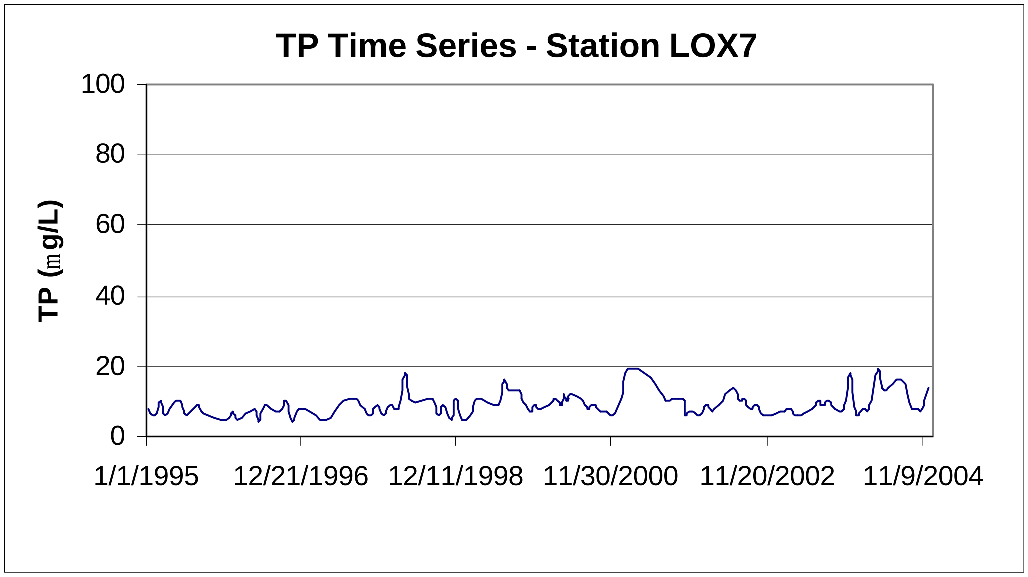

Figure F1.5 TP Time Series – EVPA Station LOX7

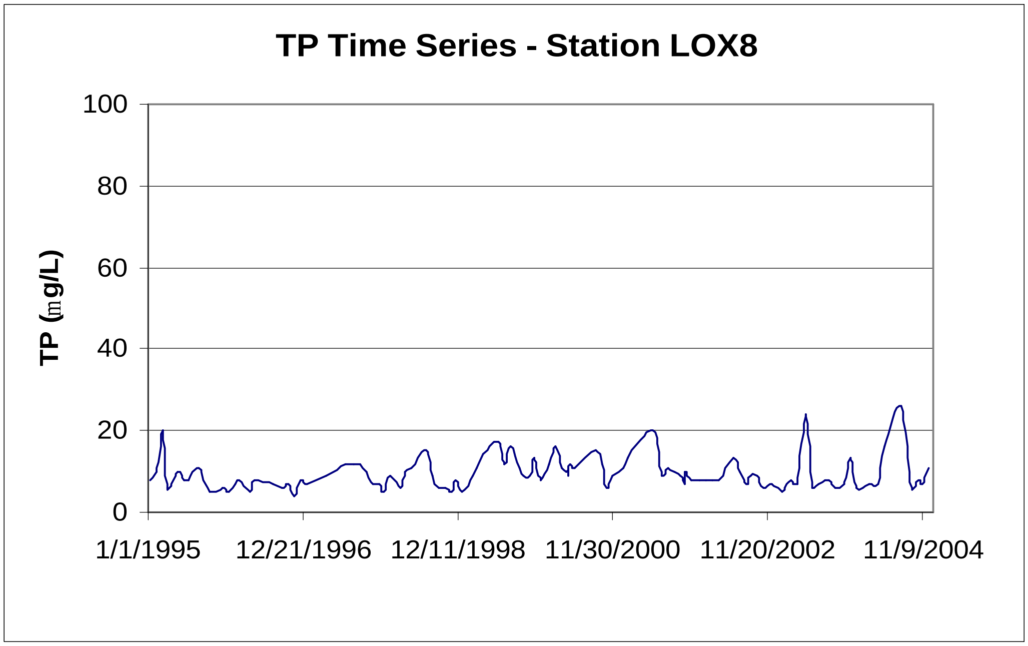

Figure F1.6 TP Time Series – EVPA Station LOX8

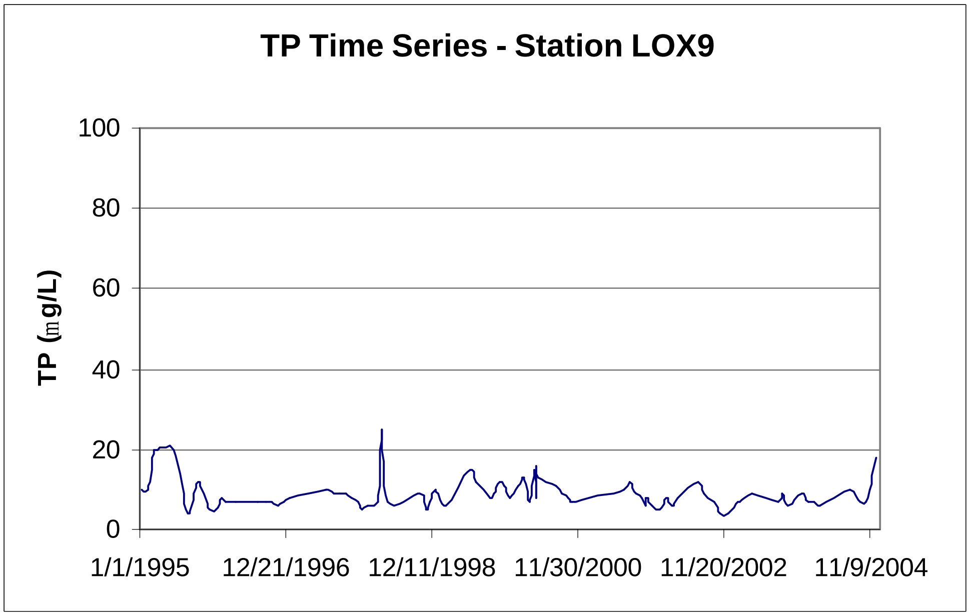

Figure F1.7 TP Time Series – EVPA Station LOX9

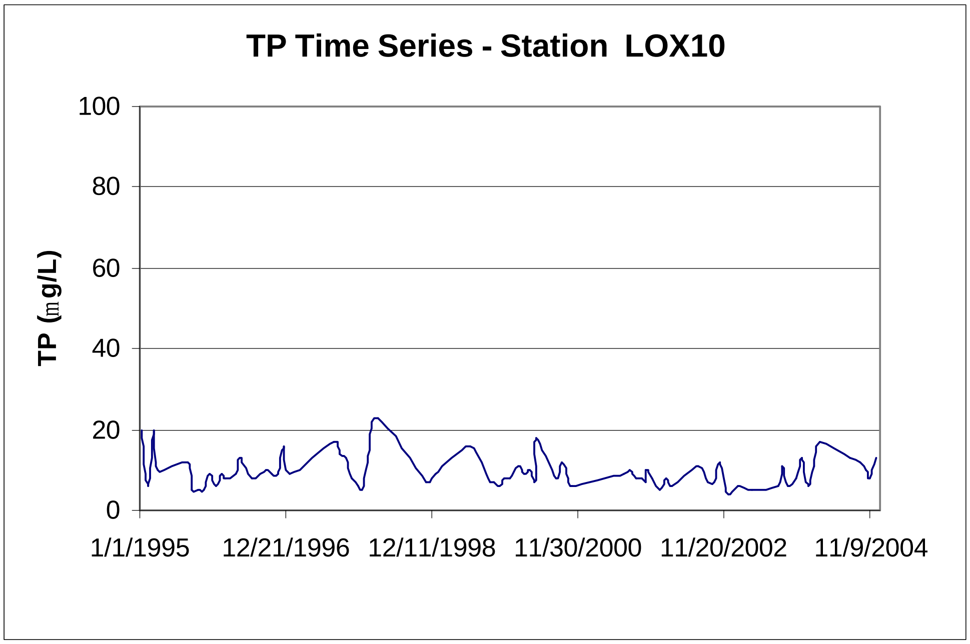

Figure F1.8 TP Time Series – EVPA Station LOX10

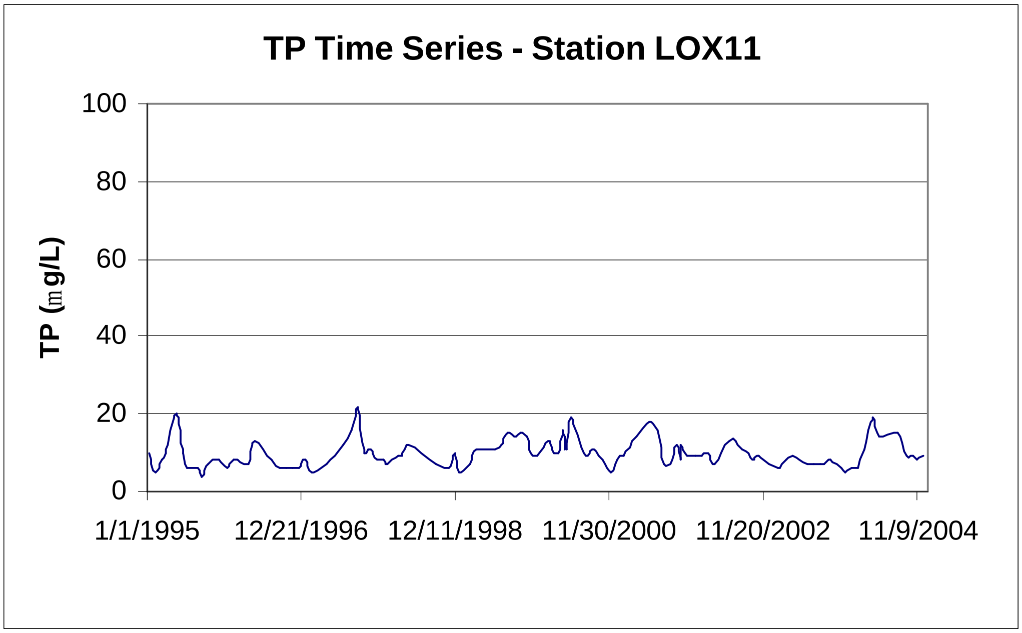

Figure F1.9 TP Time Series – EVPA Station LOX11

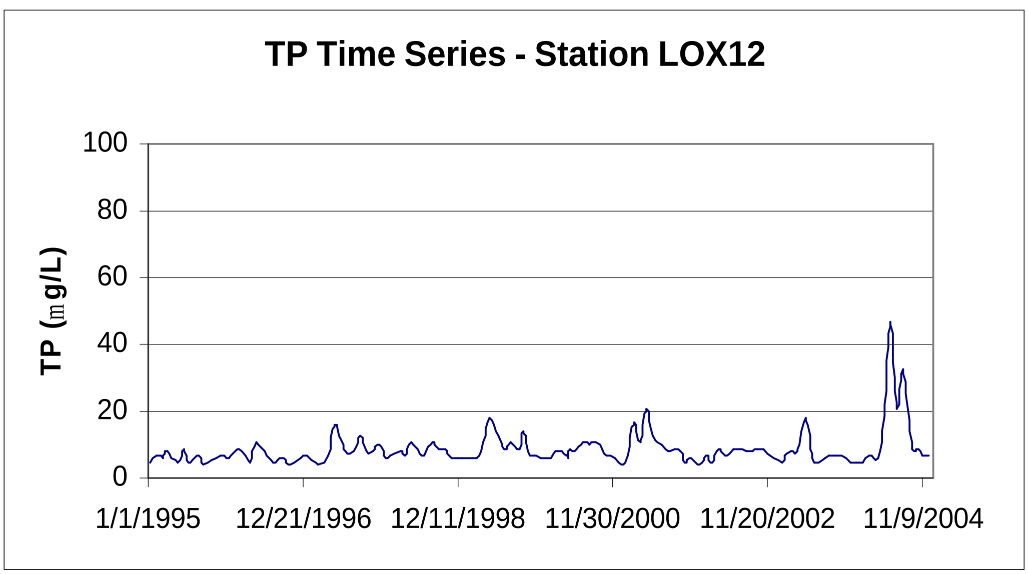

Figure F1.10 TP Time Series – EVPA Station LOX12

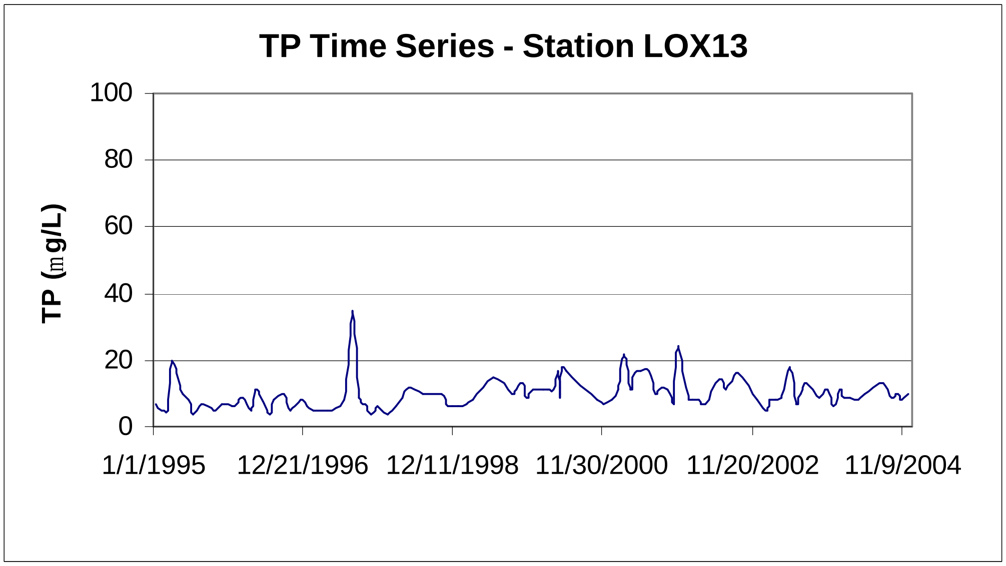

Figure F1.11 TP Time Series – EVPA Station LOX13

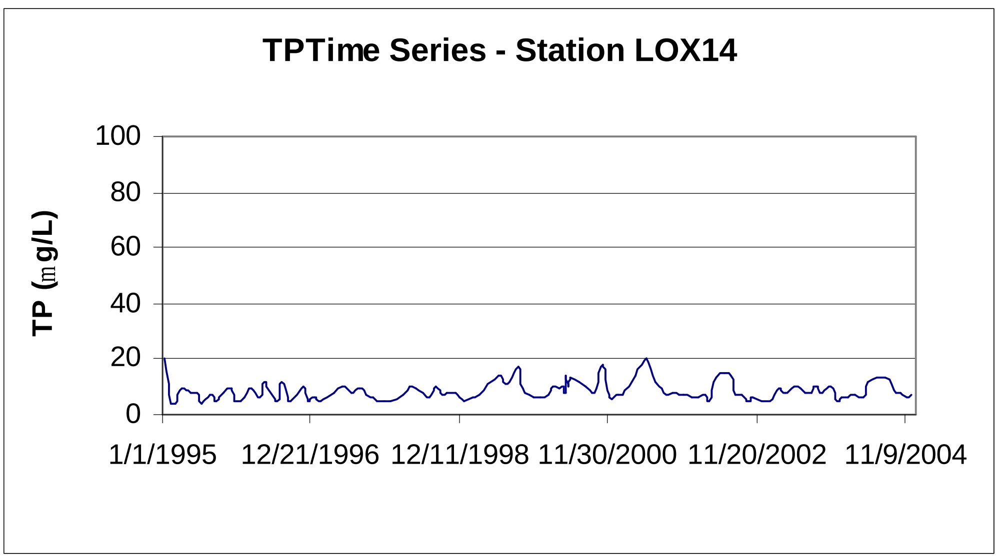

Figure F1.12 TP Time Series – EVPA Station LOX14

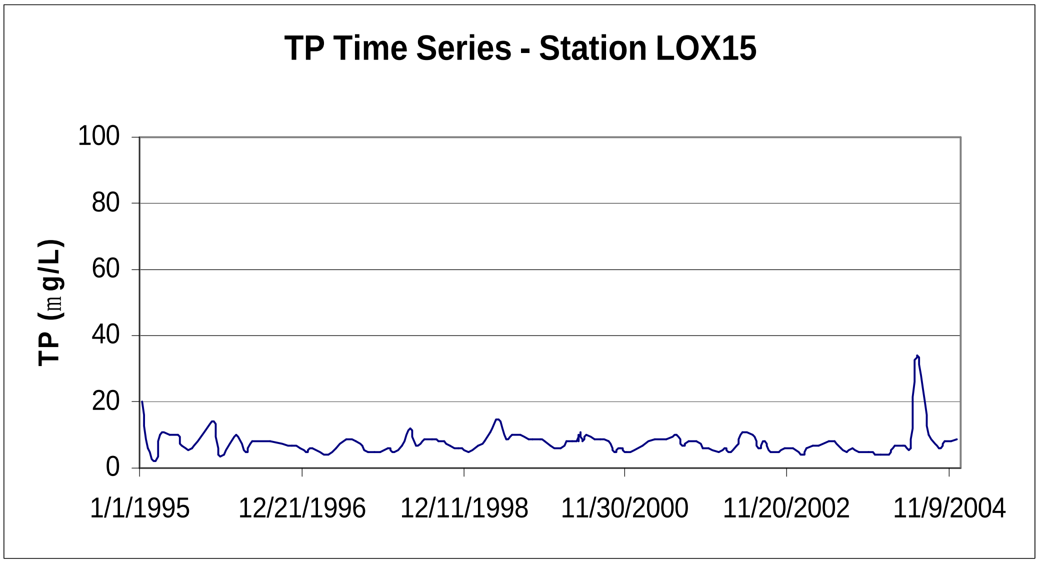

Figure F1.13 TP Time Series – EVPA Station LOX15

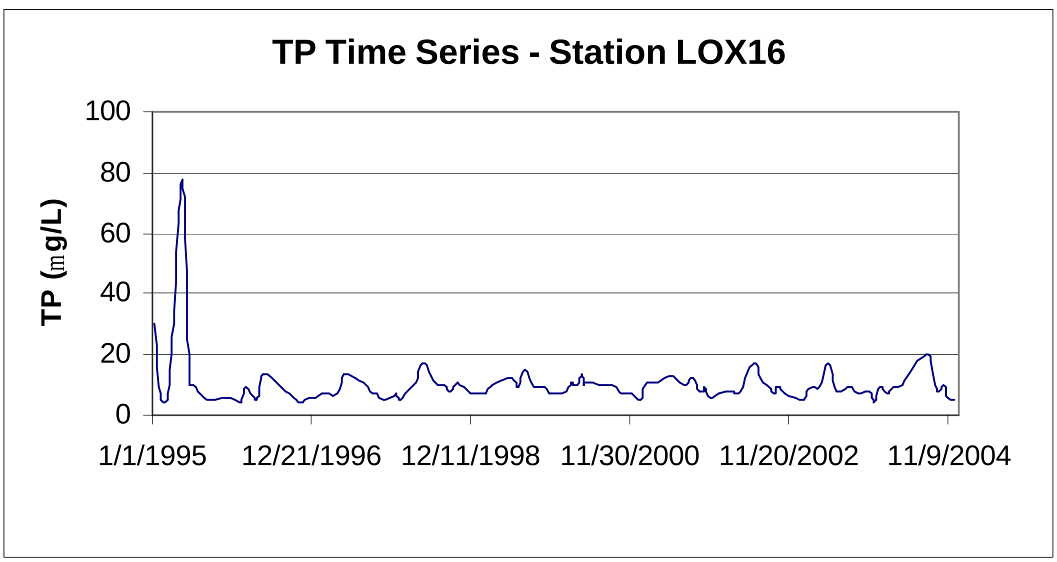

Figure F1.14 TP Time Series – EVPA Station LOX16

APPENDIX F2

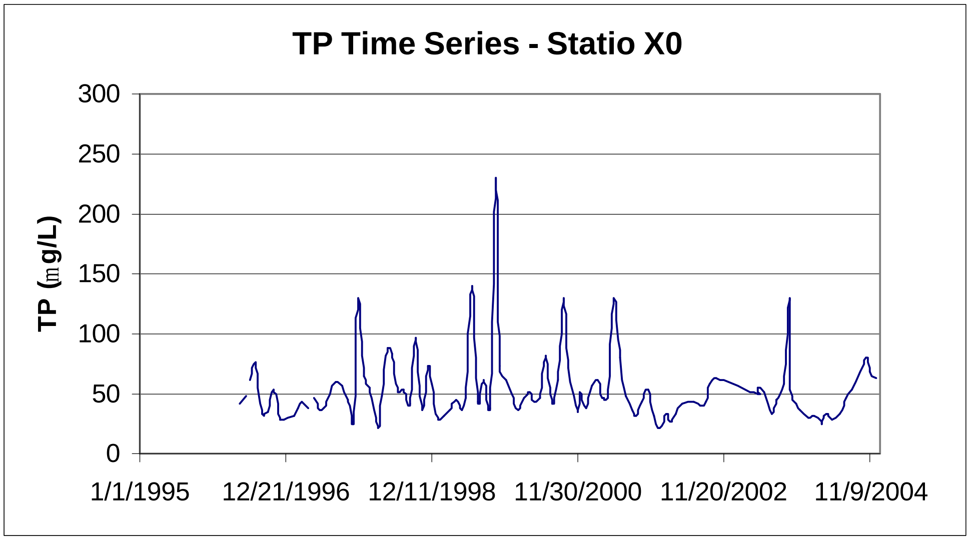

Figure F2.1 TP Time Series – Station X0

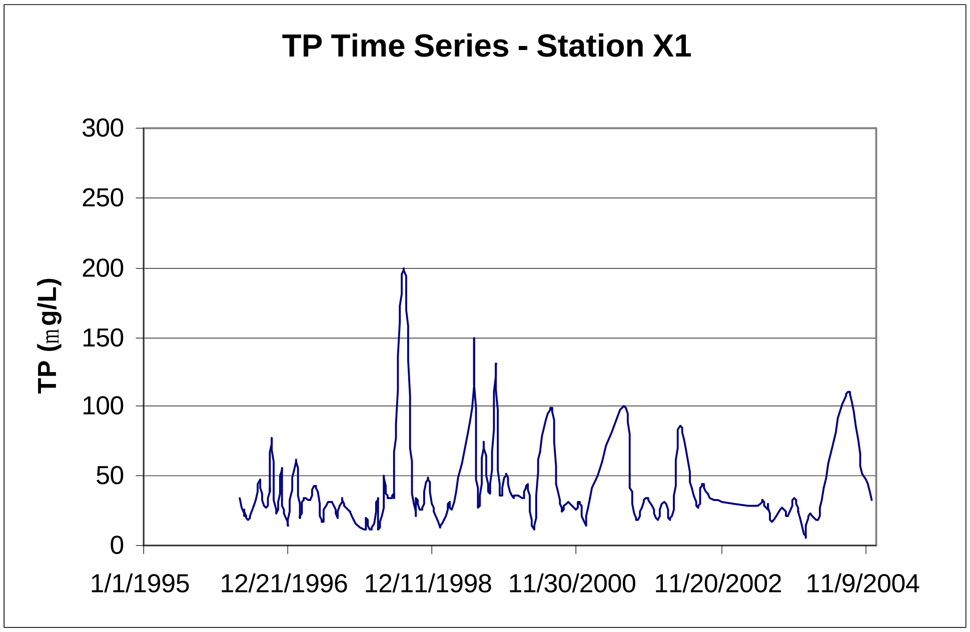

Figure F2.2 TP Time Series – Station X1

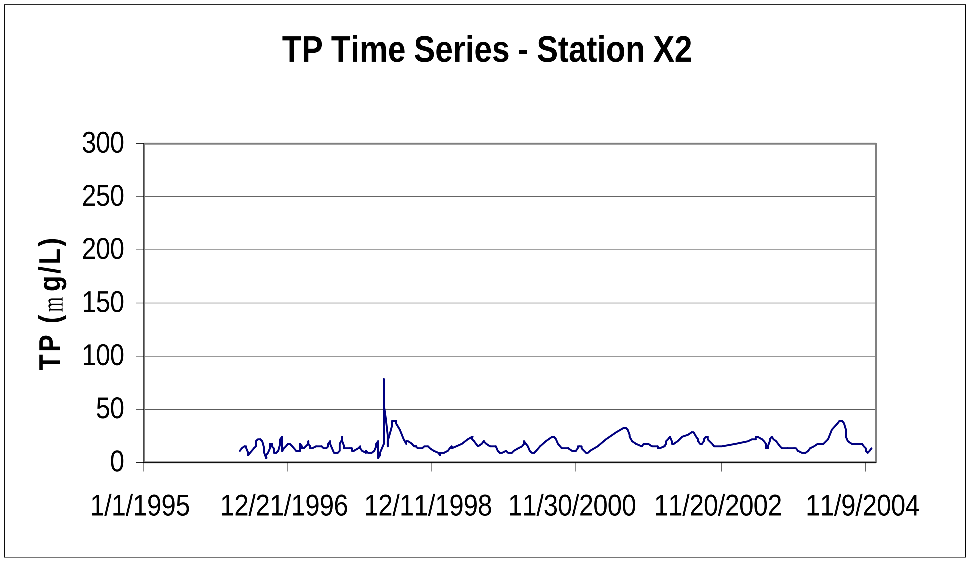

Figure F2.3 TP Time Series – Station X2

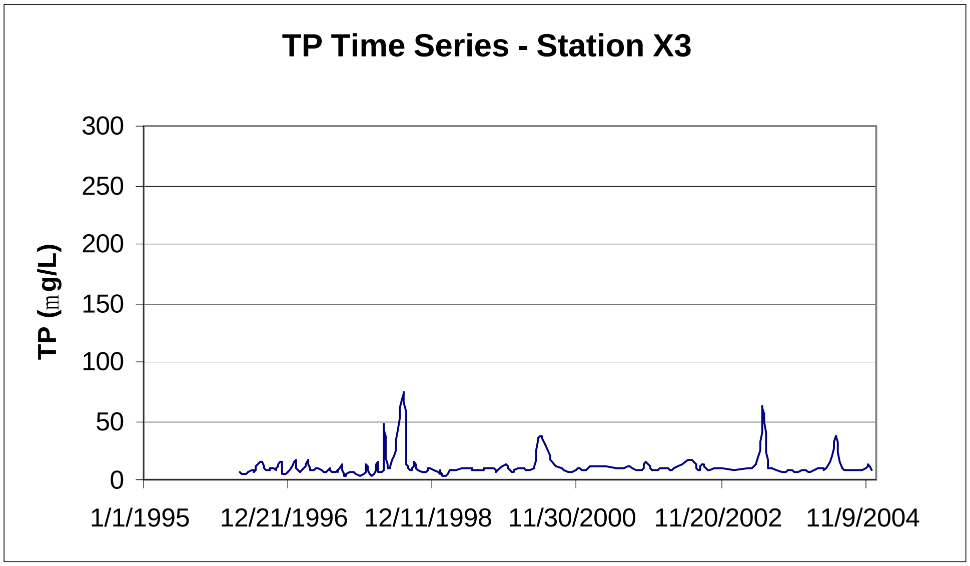

Figure F2.4 TP Time Series – Station X3

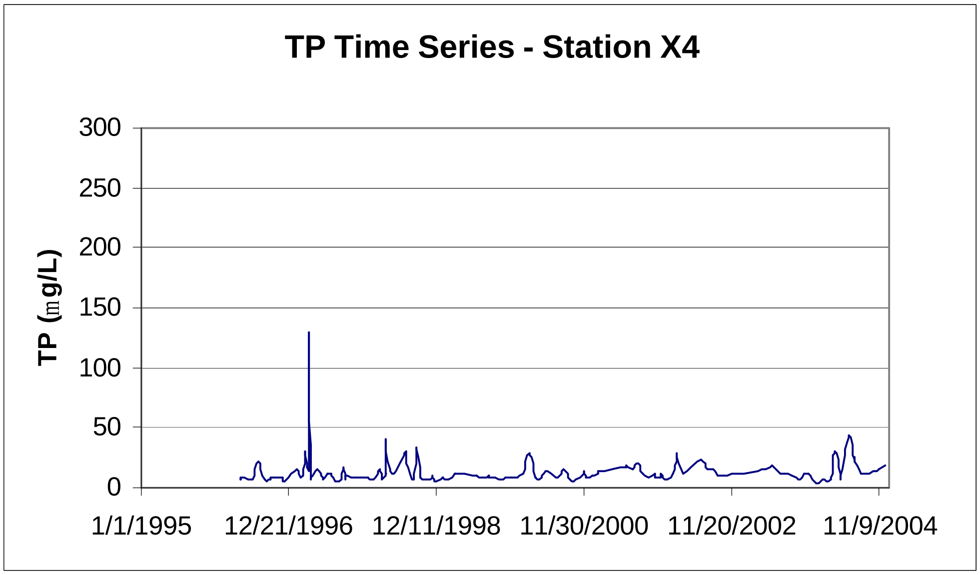

Figure F2.5 TP Time Series – Station X4

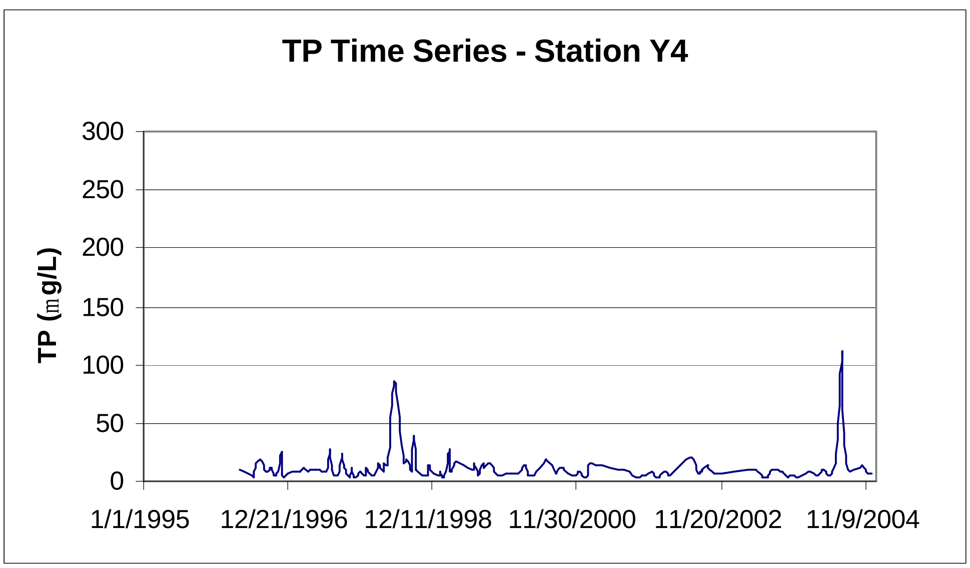

Figure F2.6 TP Time Series – Station Y4

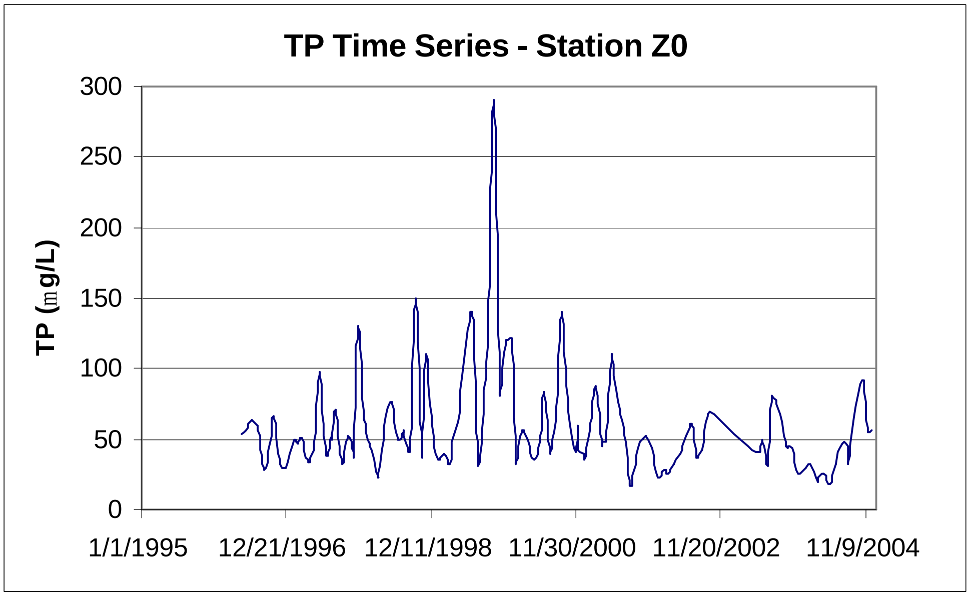

Figure F2.7 TP Time Series – Station Z0

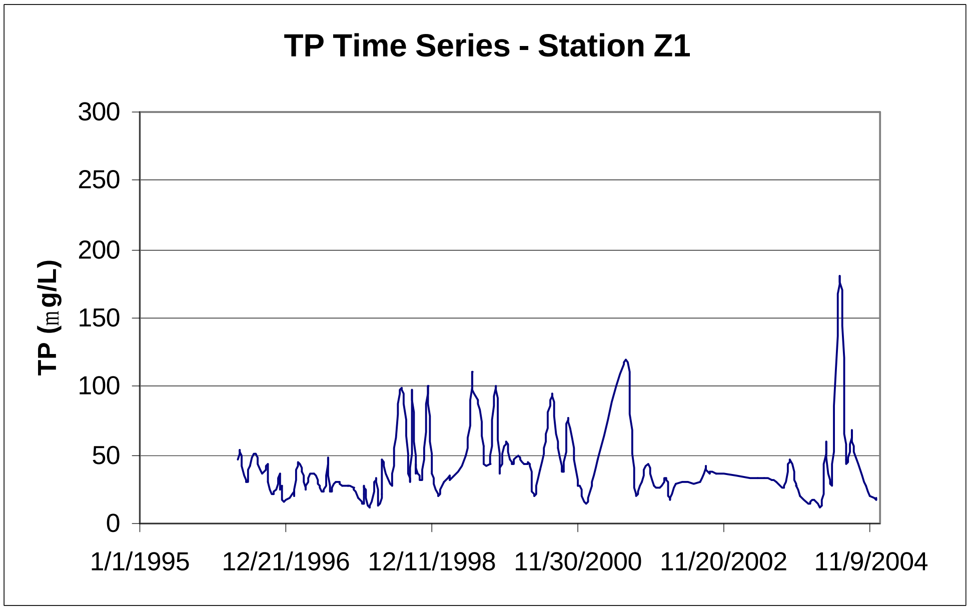

Figure F2.8 TP Time Series – Station Z1

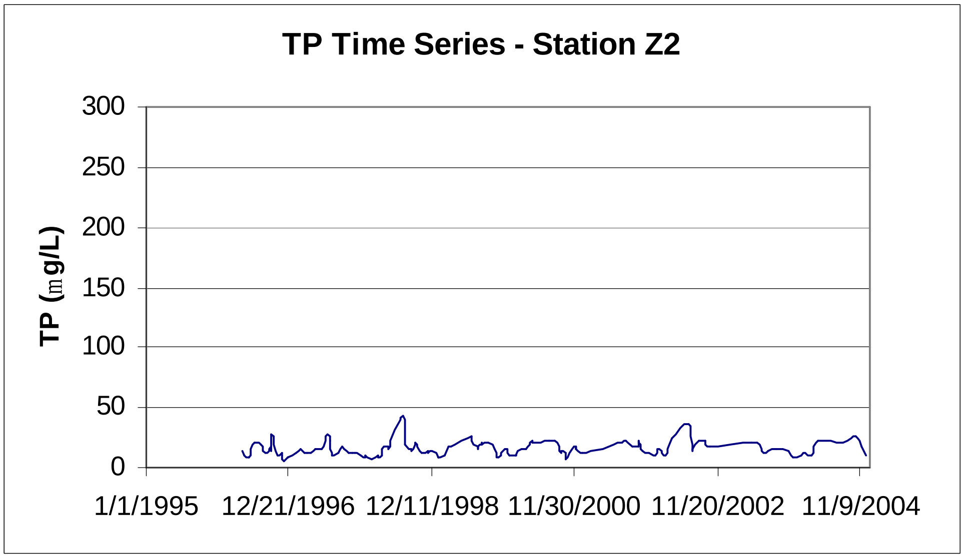

Figure F2.9 TP Time Series – Station Z2

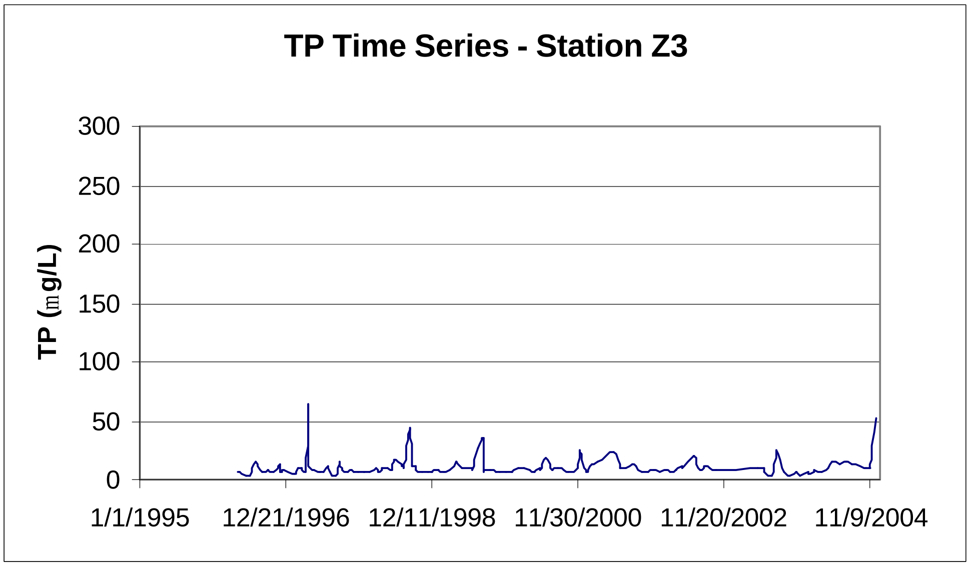

Figure F2.10 TP Time Series – Station Z3

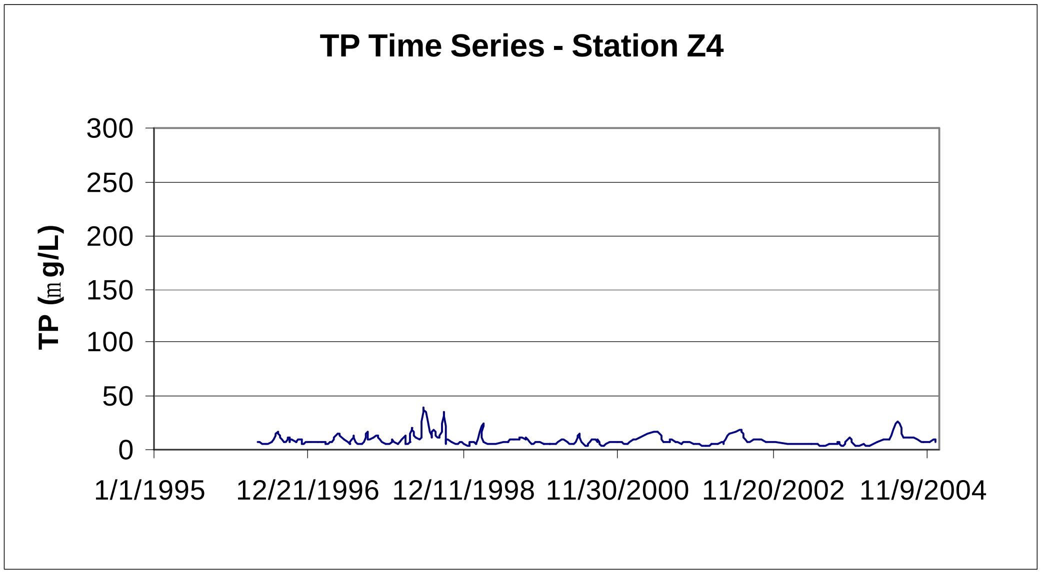

Figure F2.11 TP Time Series – Station Z4

APPENDIX F3

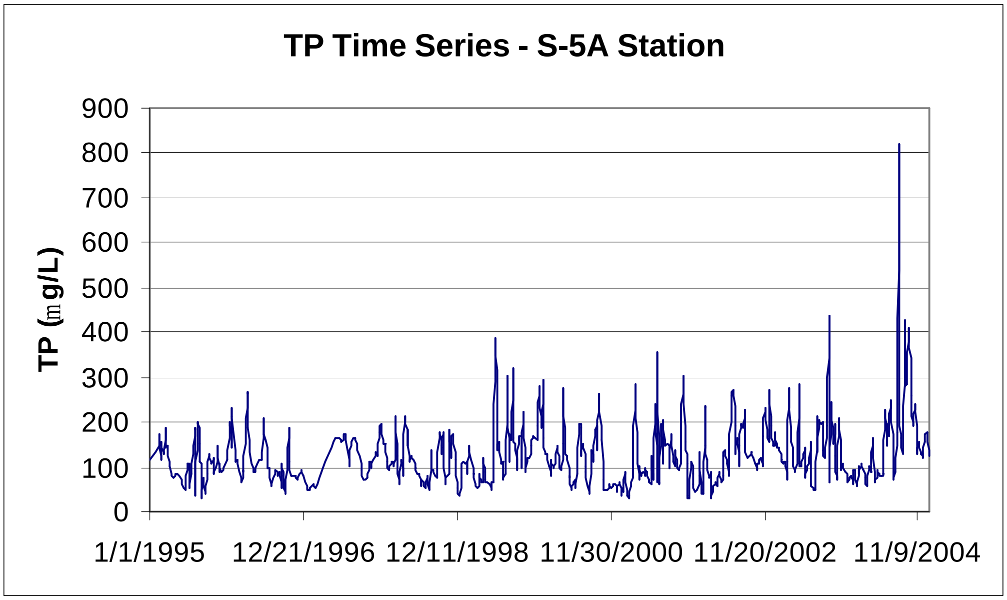

Figure F3.1.A TP Time Series – Station S-5A (Grab Samples)

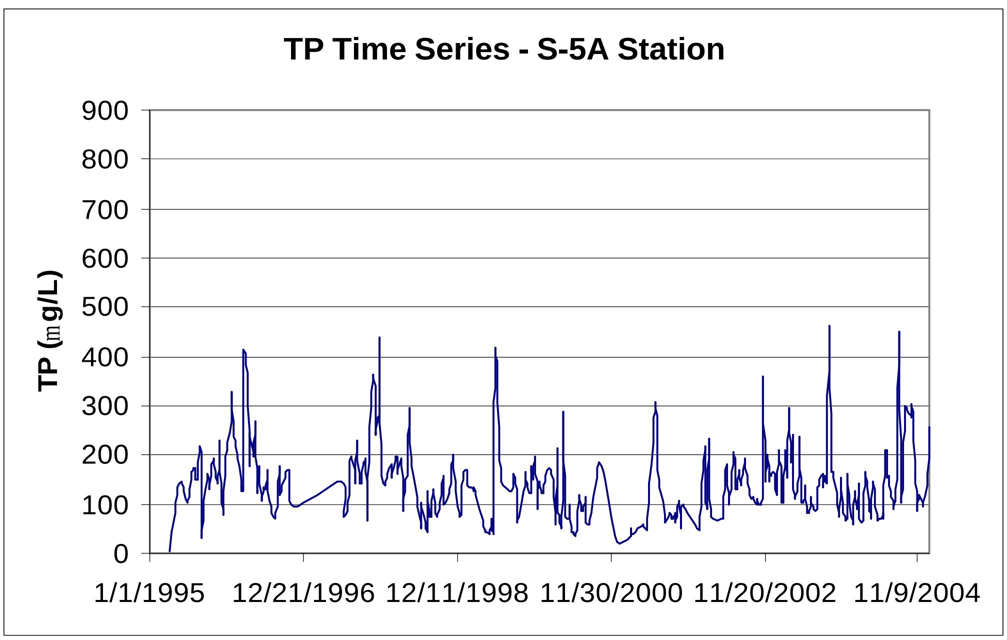

Figure F3.1.B TP Time Series – Station S-5A (Composite Samples)

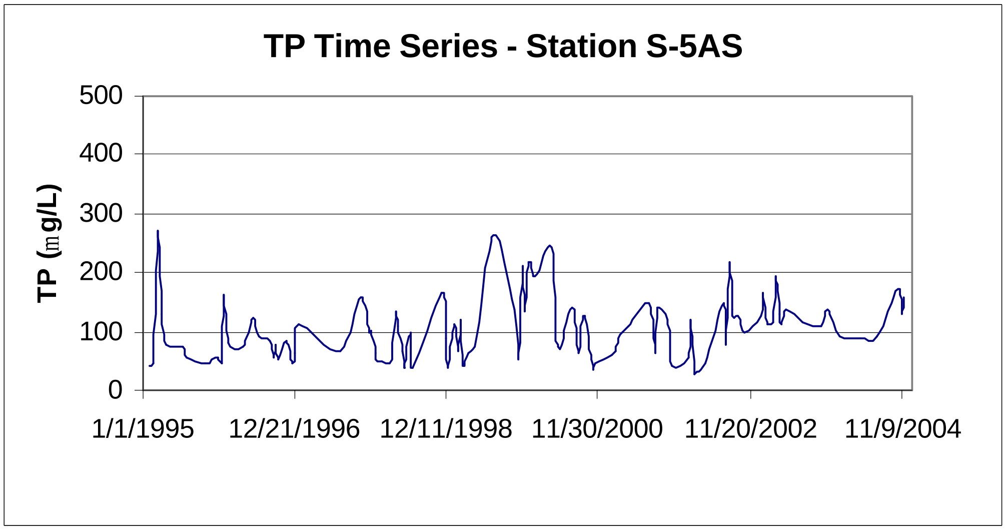

Figure F3.2 TP Time Series – Station S-5AS

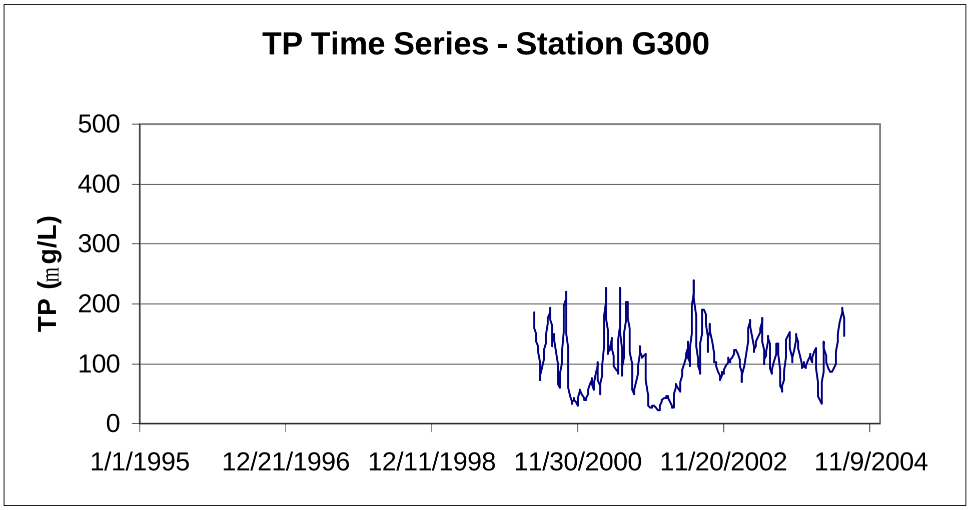

Figure F3.3 TP Time Series – Station G-300

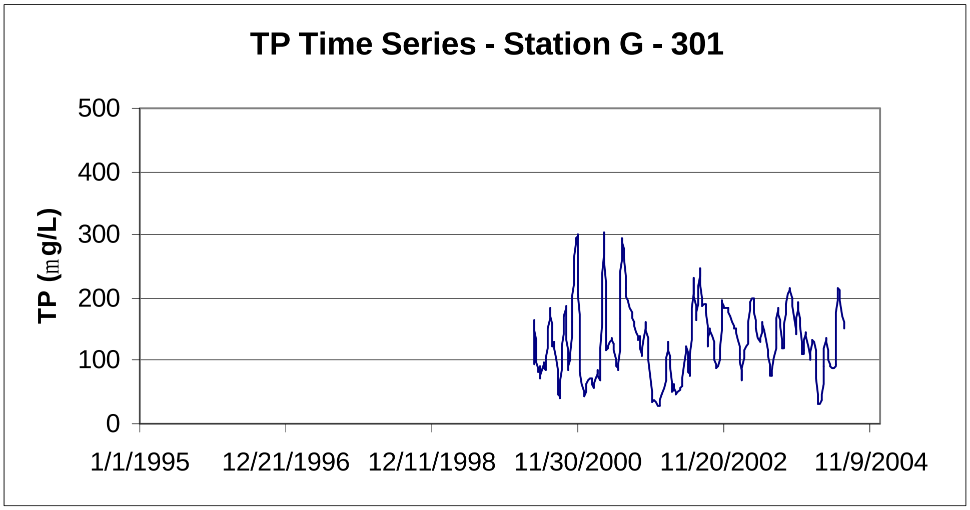

Figure F3.4 TP Time Series – Station G-301

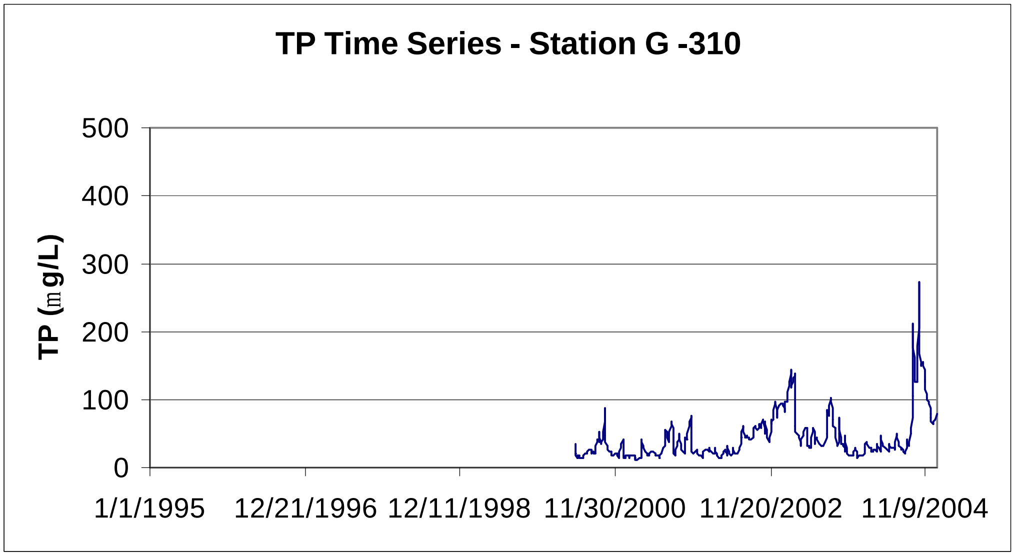

Figure F3.5.A TP Time Series – Station G-310 (Grab Samples)

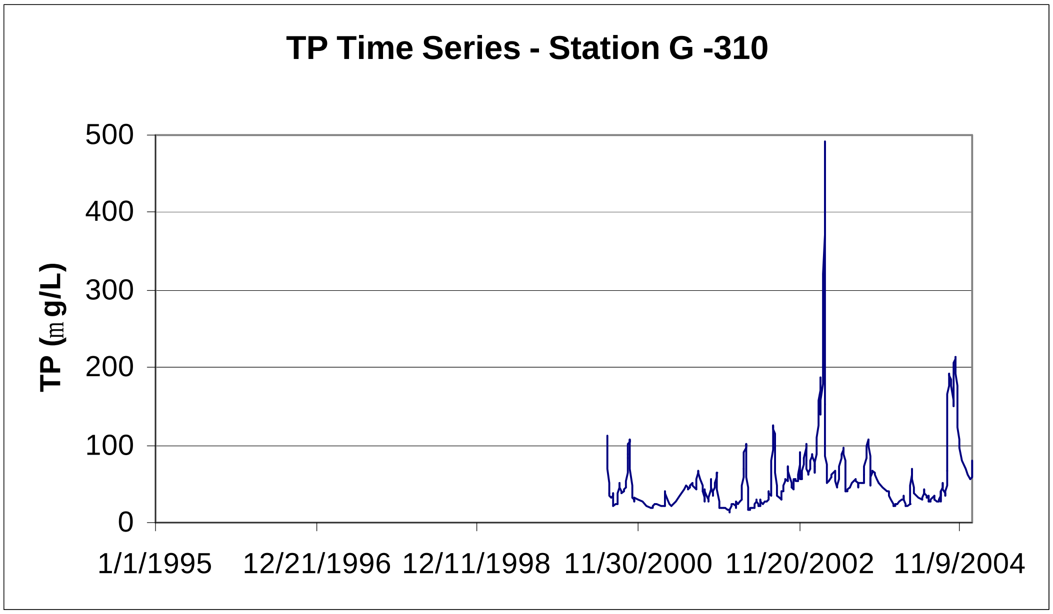

Figure F3.5.B TP Time Series – Station G-310 (Composite Samples)

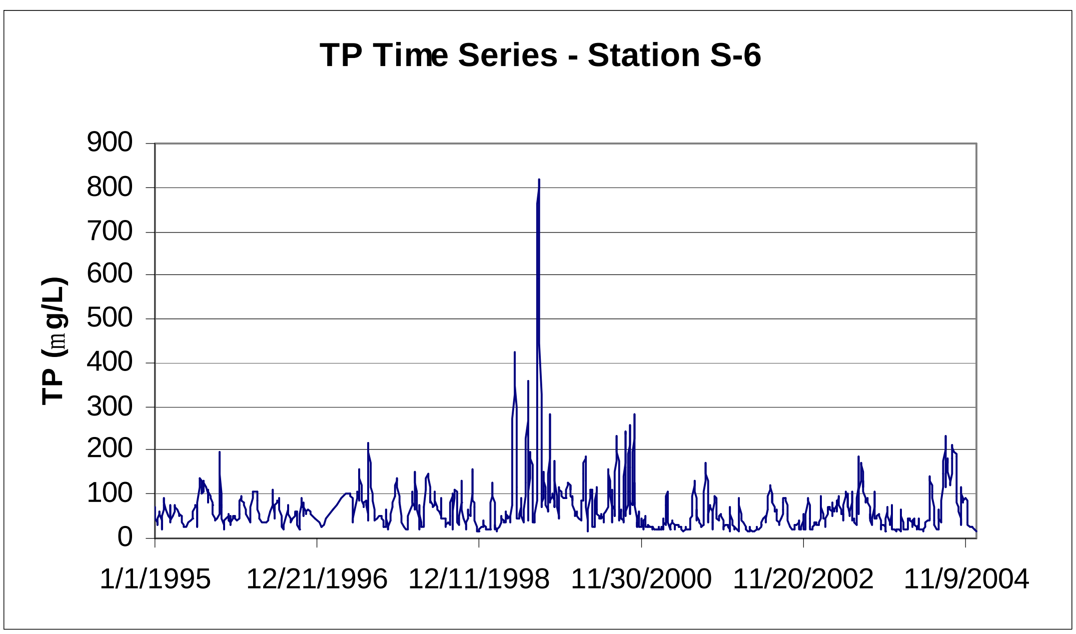

Figure F3.6.A TP Time Series – Station S-6 (Grab Samples)

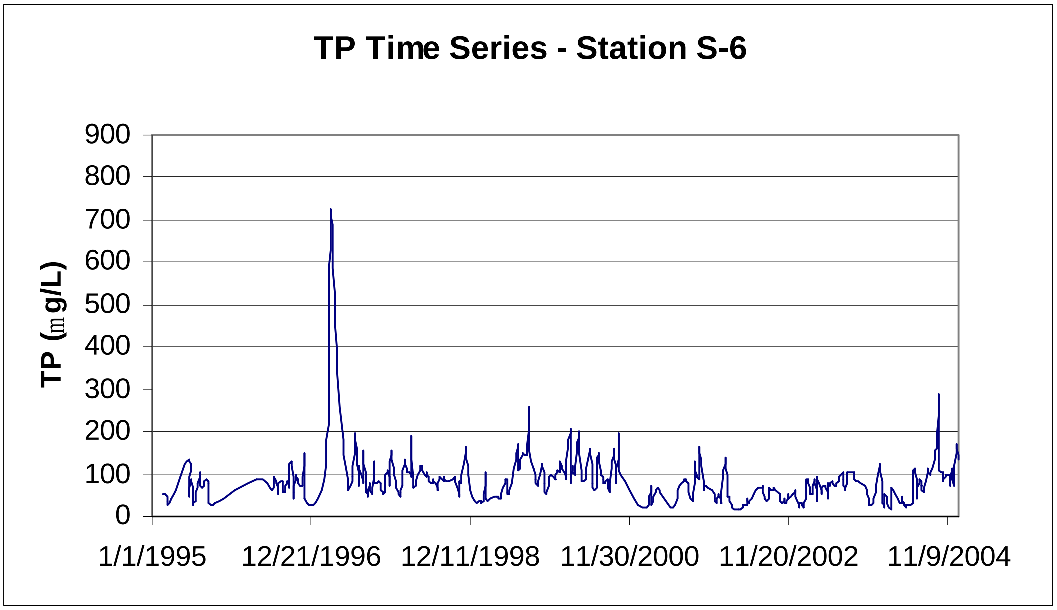

Figure F3.6.B TP Time Series – Station S-6 (Composite Samples)

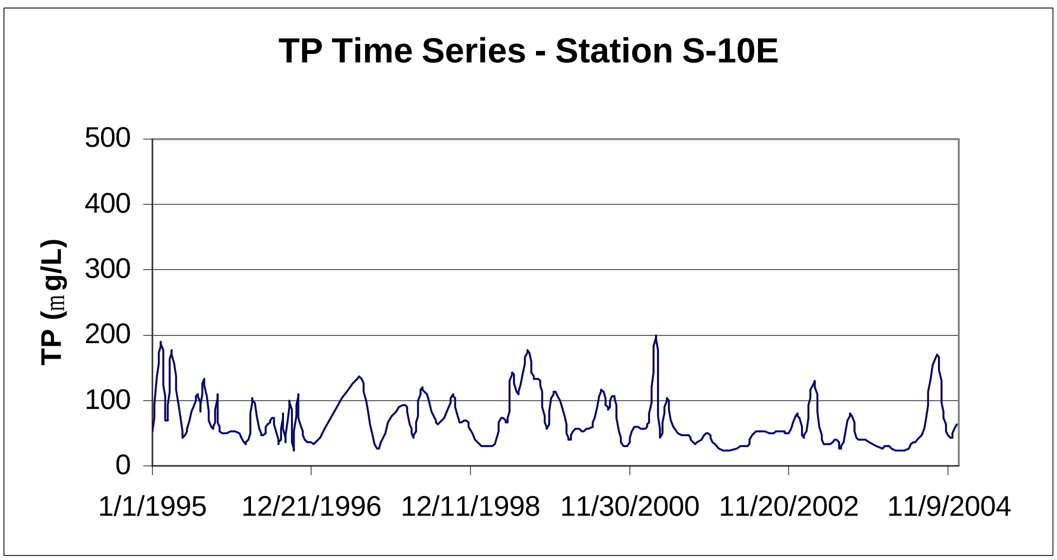

Figure F3.7 TP Time Series – Station S-10E

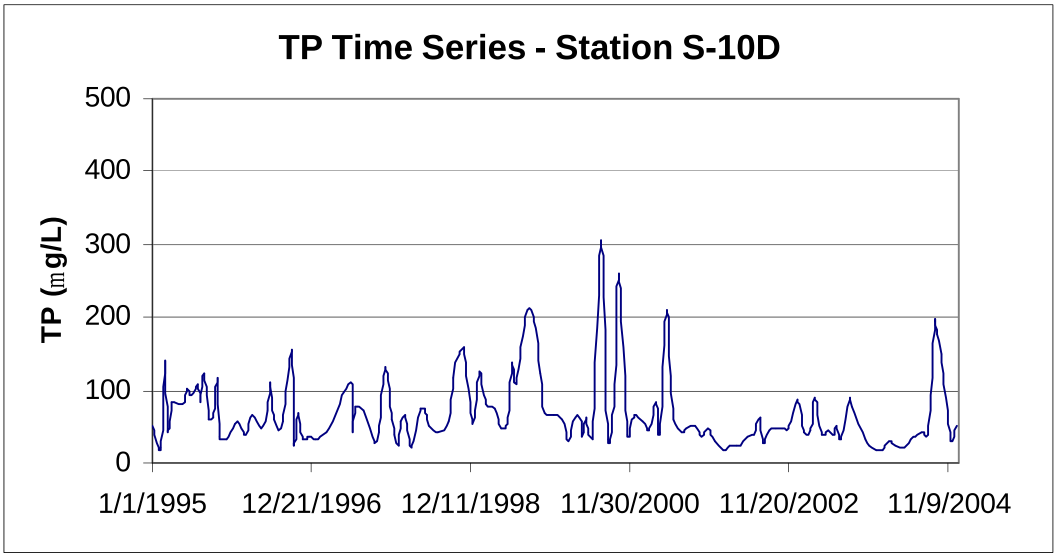

Figure F3.8 TP Time Series – Station S-10D

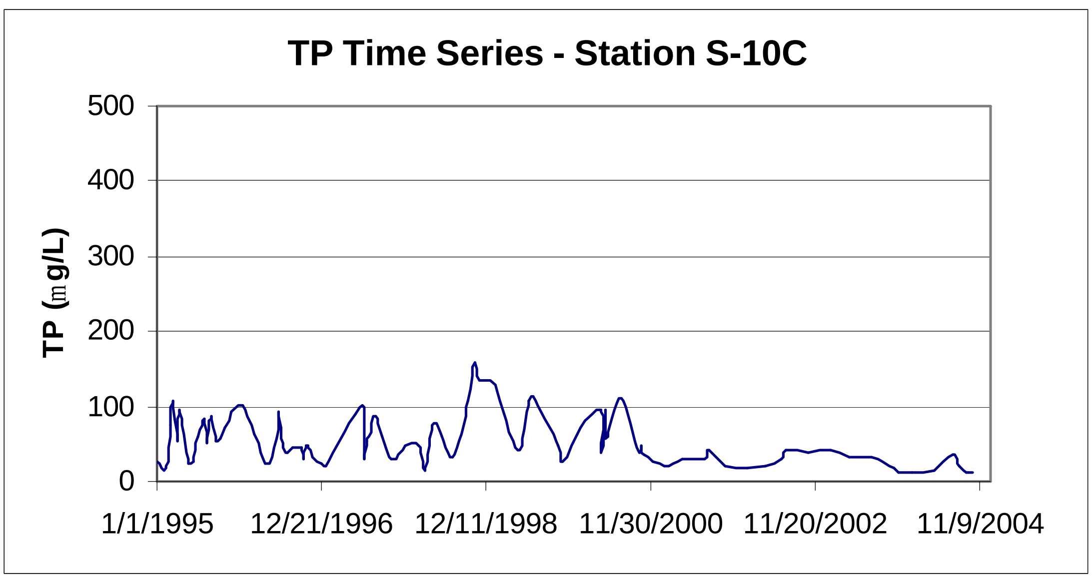

Figure F3.9 TP Time Series – Station S-10C

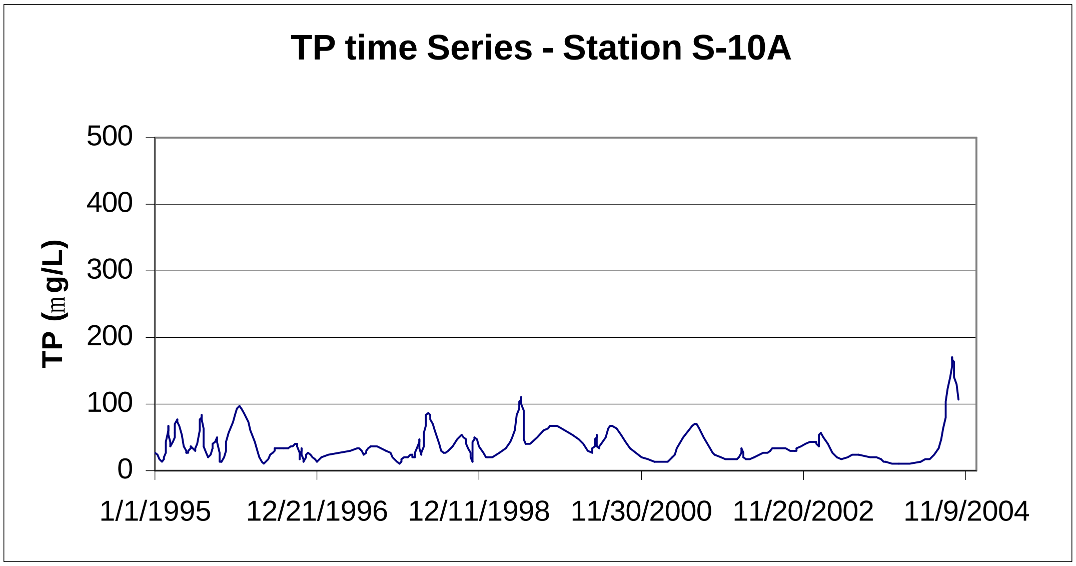

Figure F3.10 TP Time Series – Station S-10A

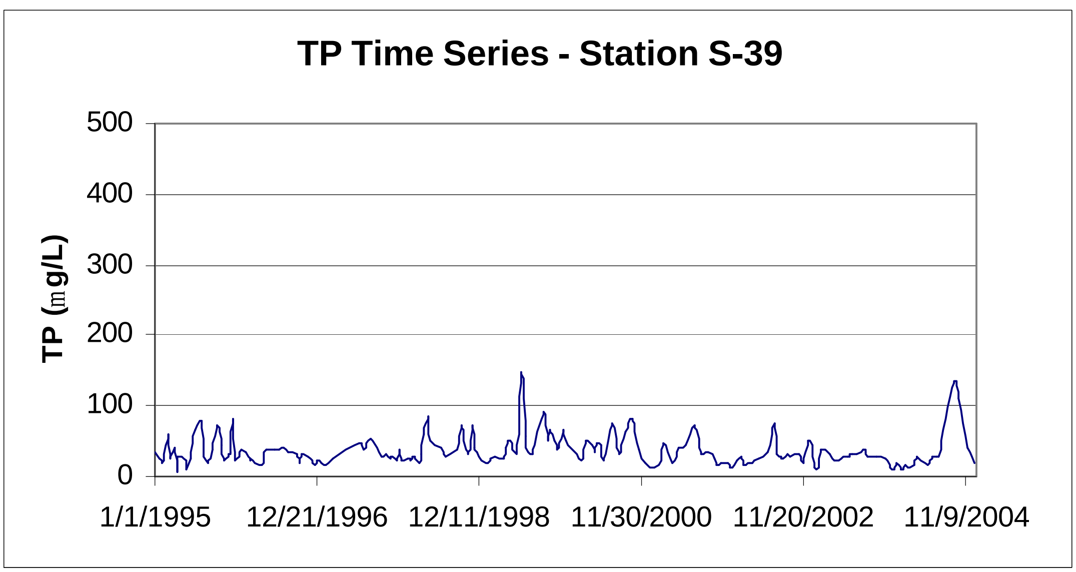

Figure F3.11 TP Time Series – Station S-39

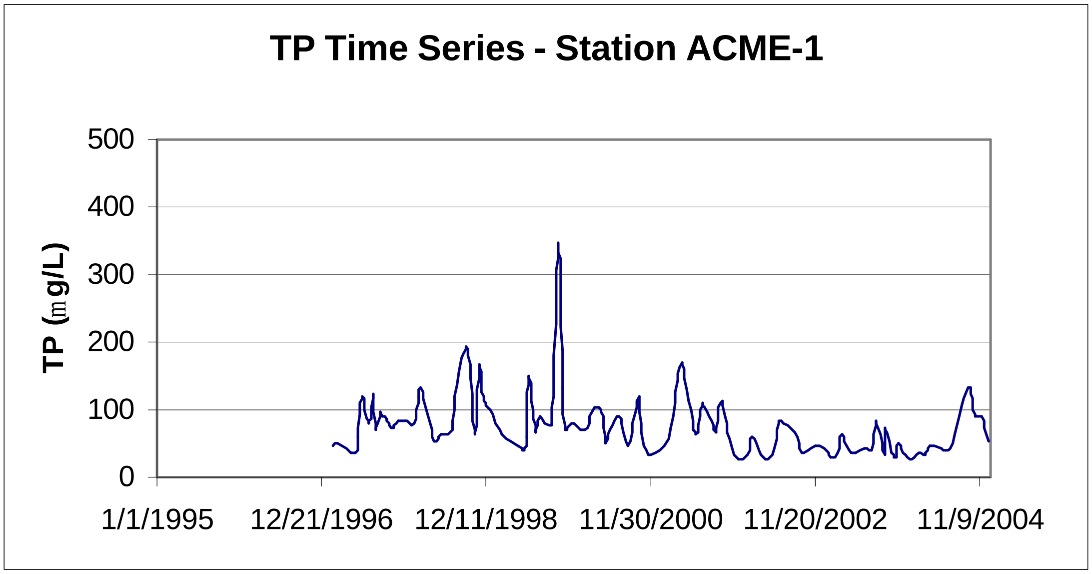

Figure F3.12 TP Time Series – Station ACME 1

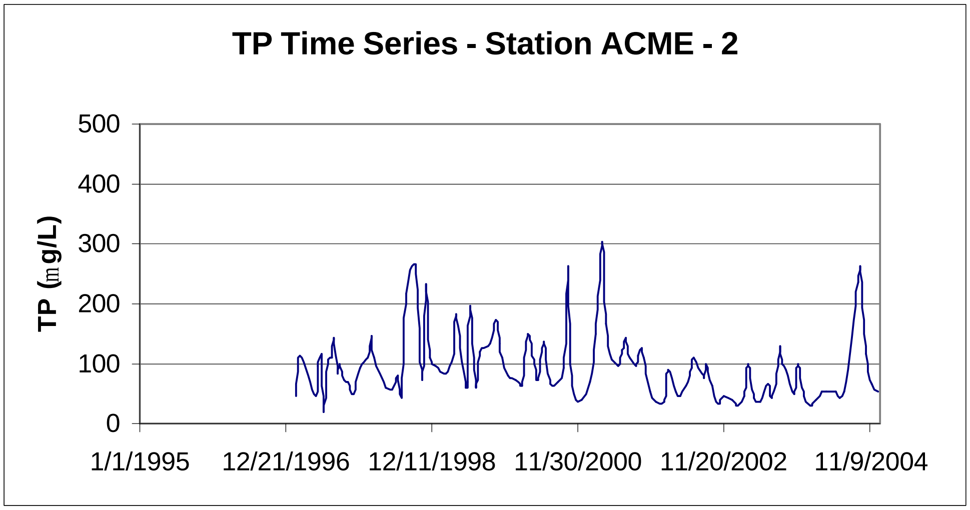

Figure F3.13 TP Time Series – Station G-94D (ACME 2)

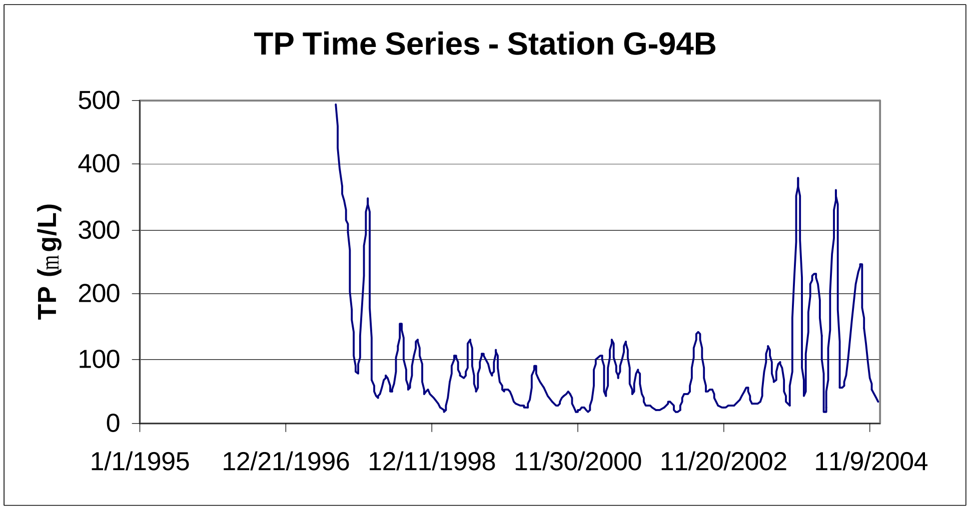

Figure F3.14 TP Time Series – Station G-94B

APPENDIX F4

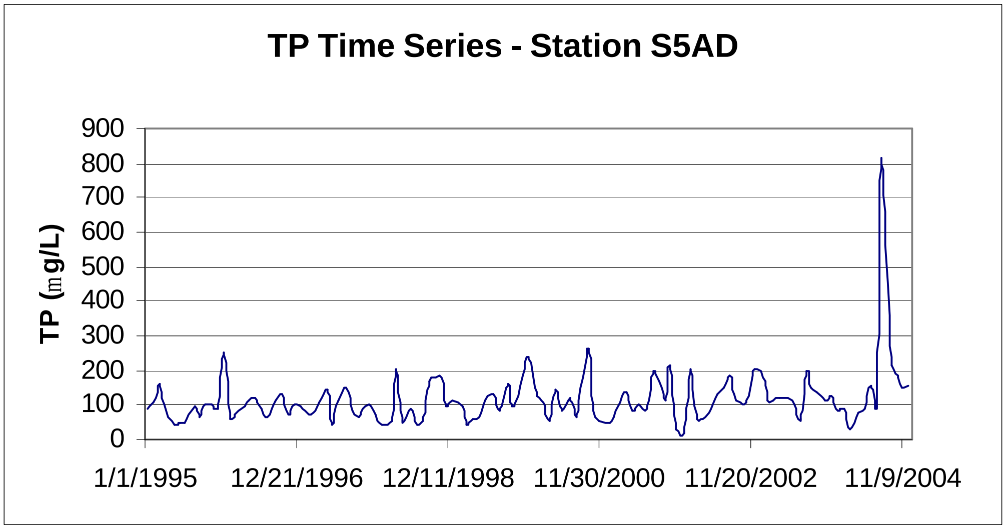

Figure F4.1 TP Time Series – Station S5AD

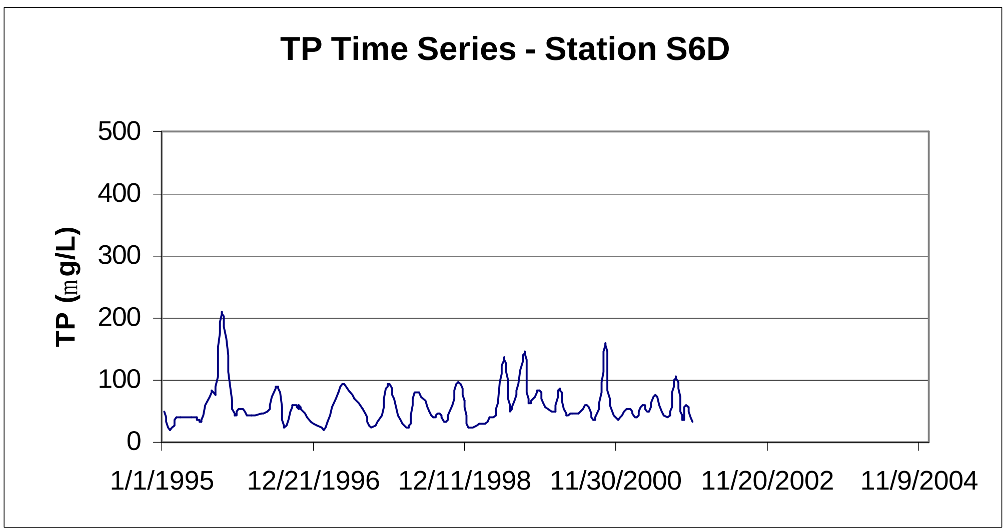

Figure F4.2 TP Time Series – Station S6D

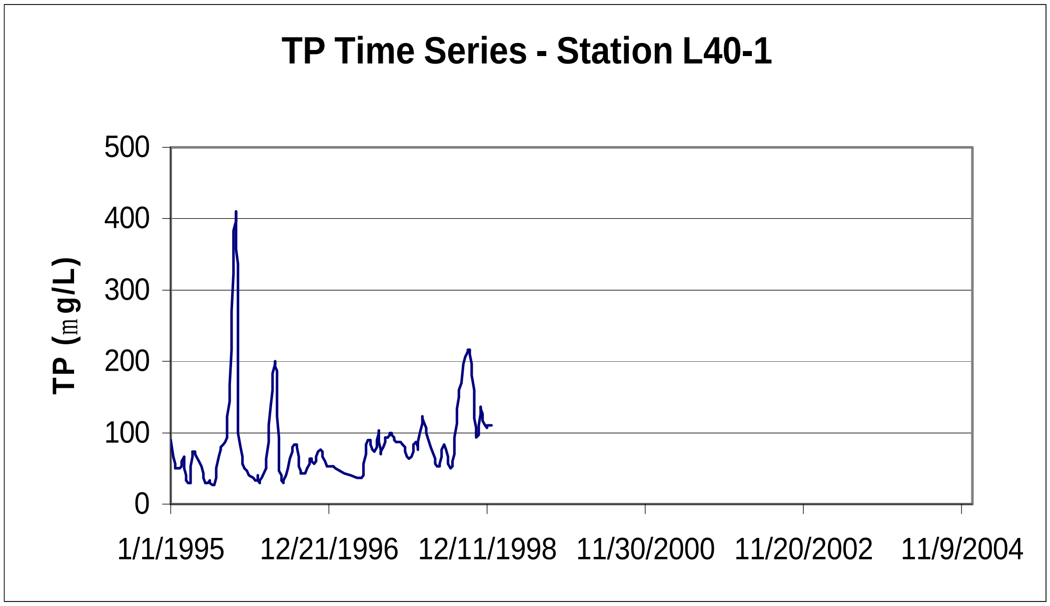

Figure F4.3 TP Time Series – Station L40-1

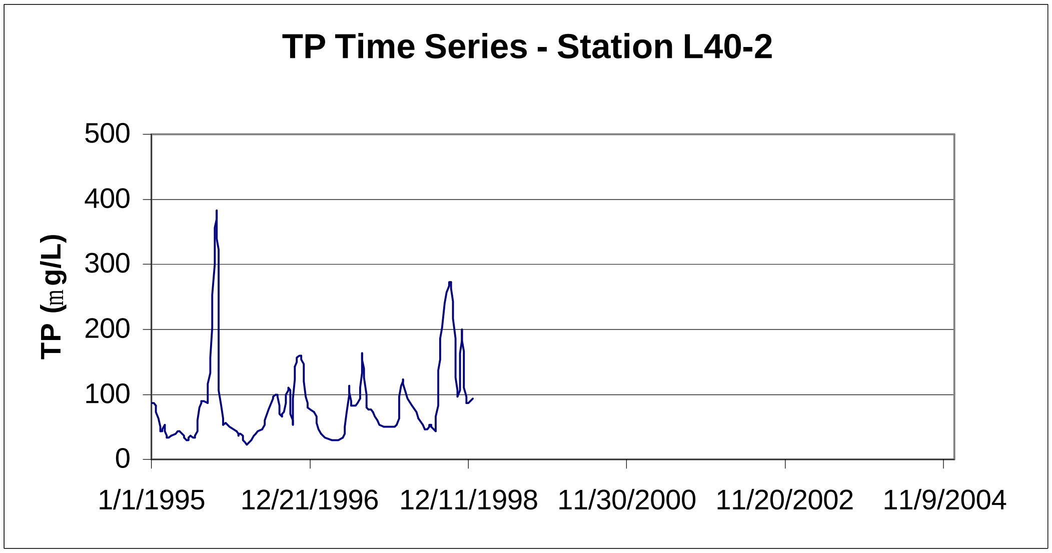

Figure F4.4 TP Time Series – Station L40-2

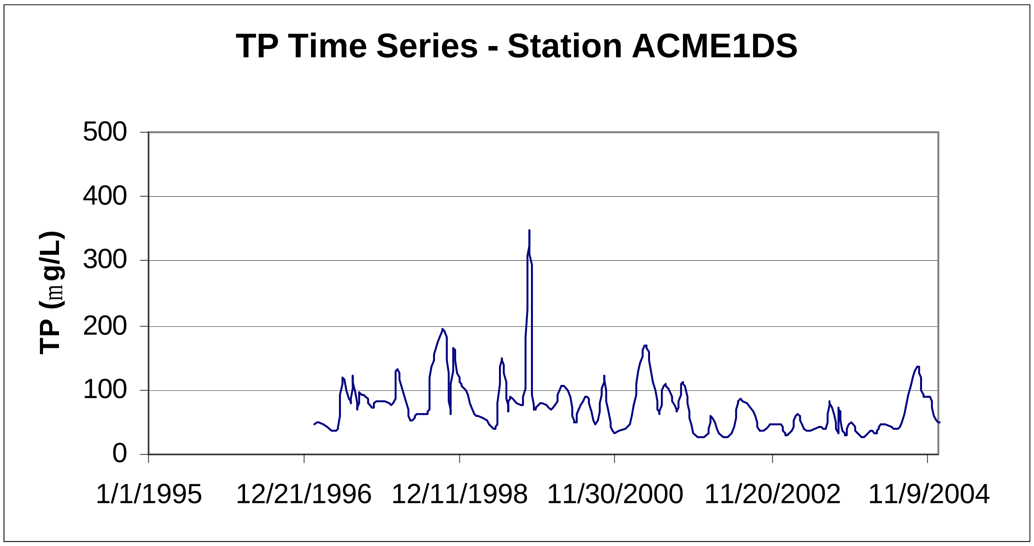

Figure F4.5 TP Time Series – Station ACME1DS

APPENDIX F5

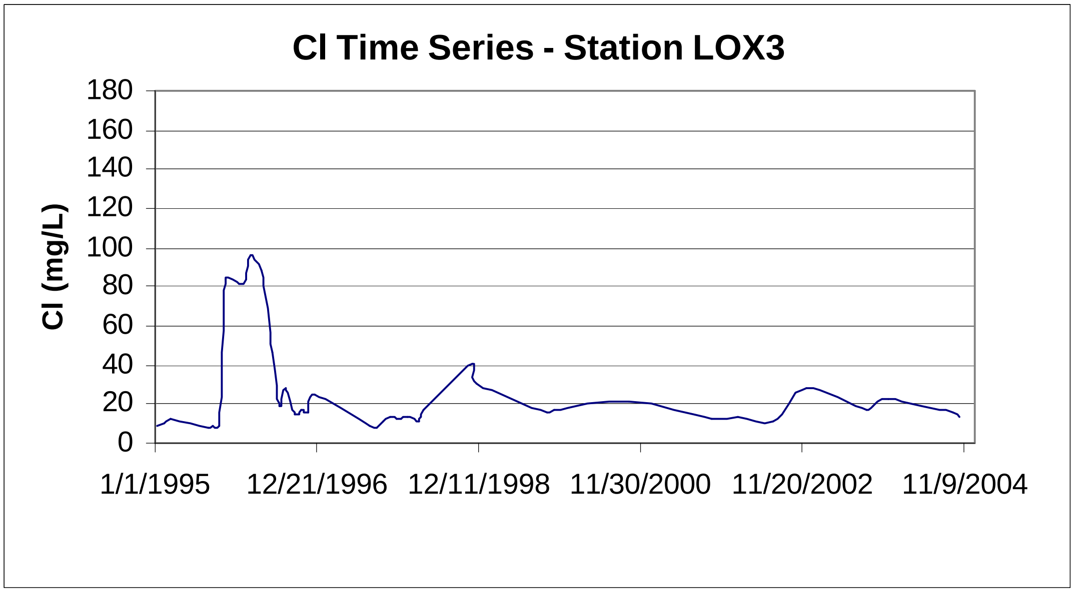

Figure F5.1 Cl Time Series – Station LOX3

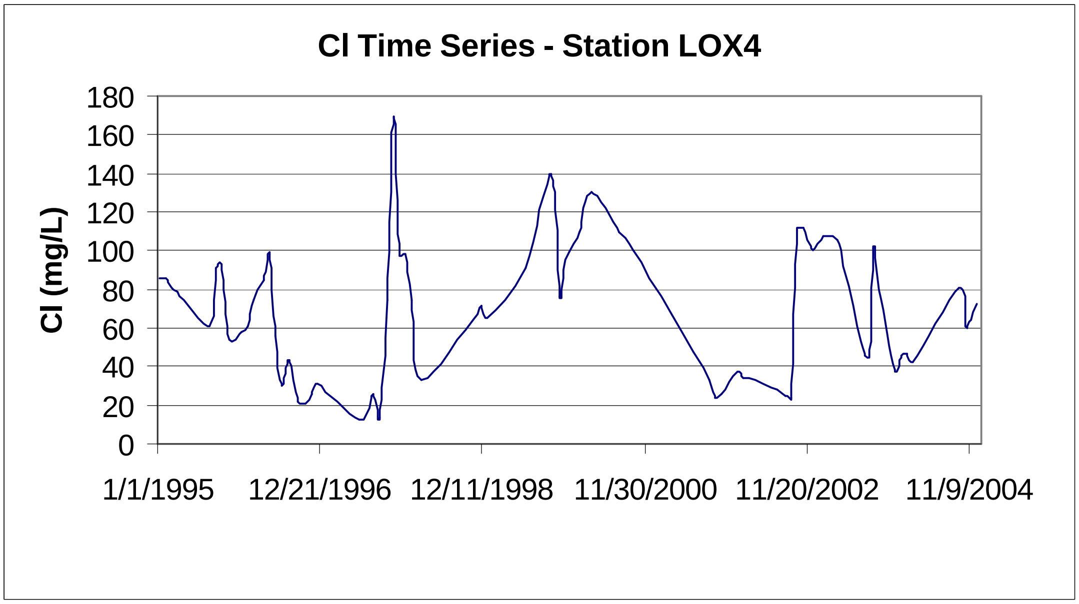

Figure F5.2 Cl Time Series – Station LOX4

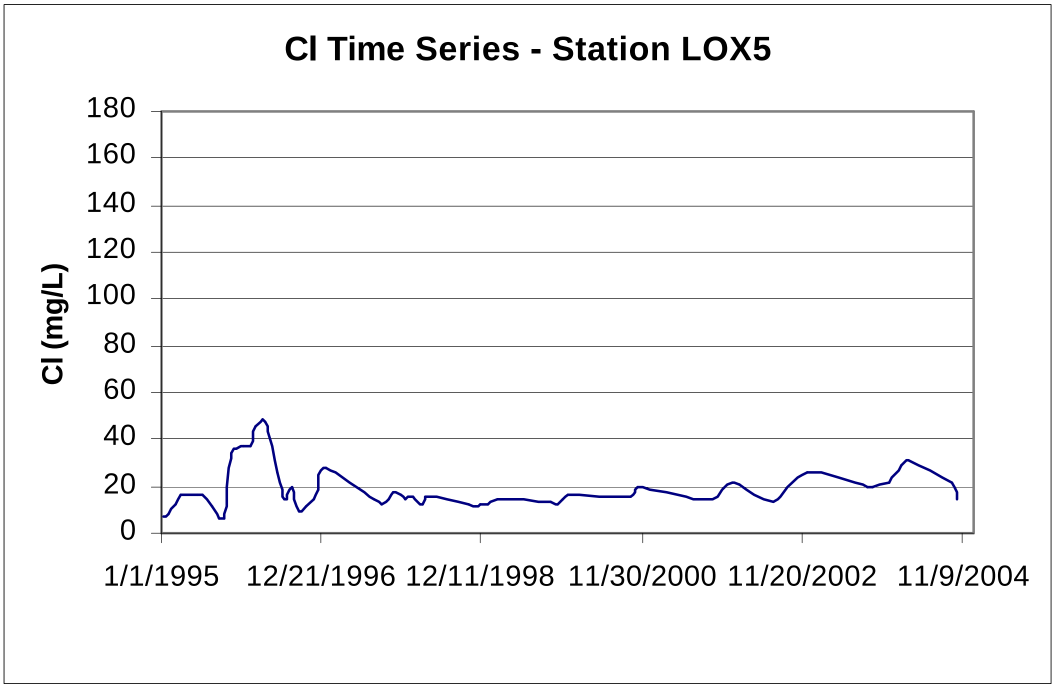

Figure F5.3 Cl Time Series – Station LOX5

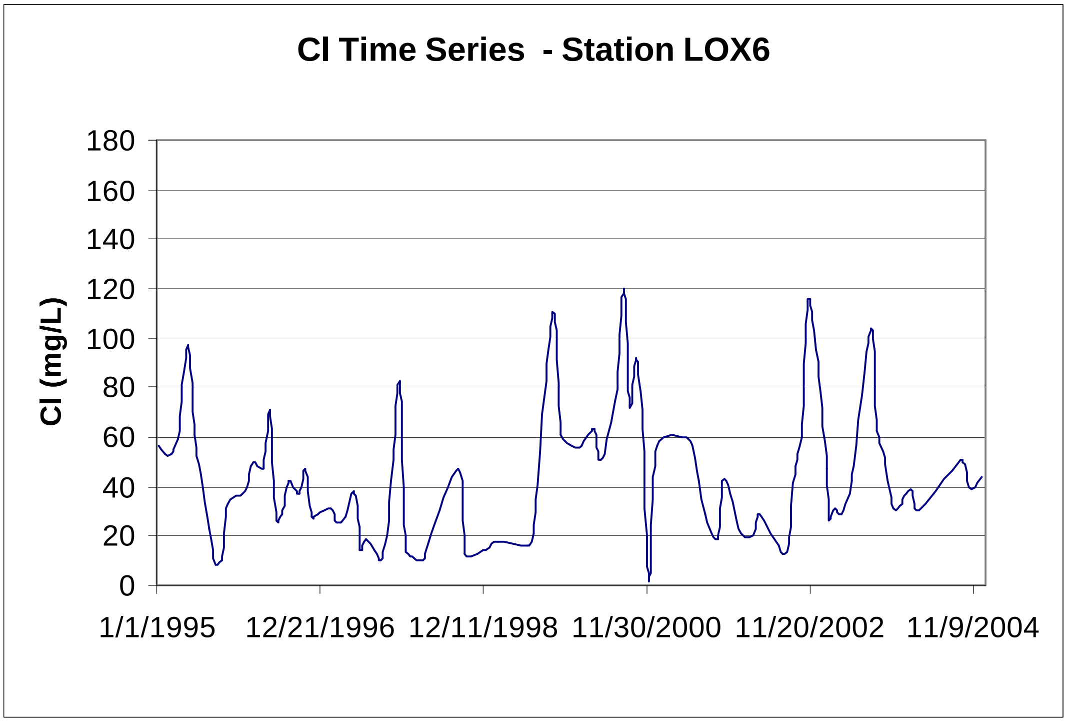

Figure F5.4 Cl Time Series – Station LOX6

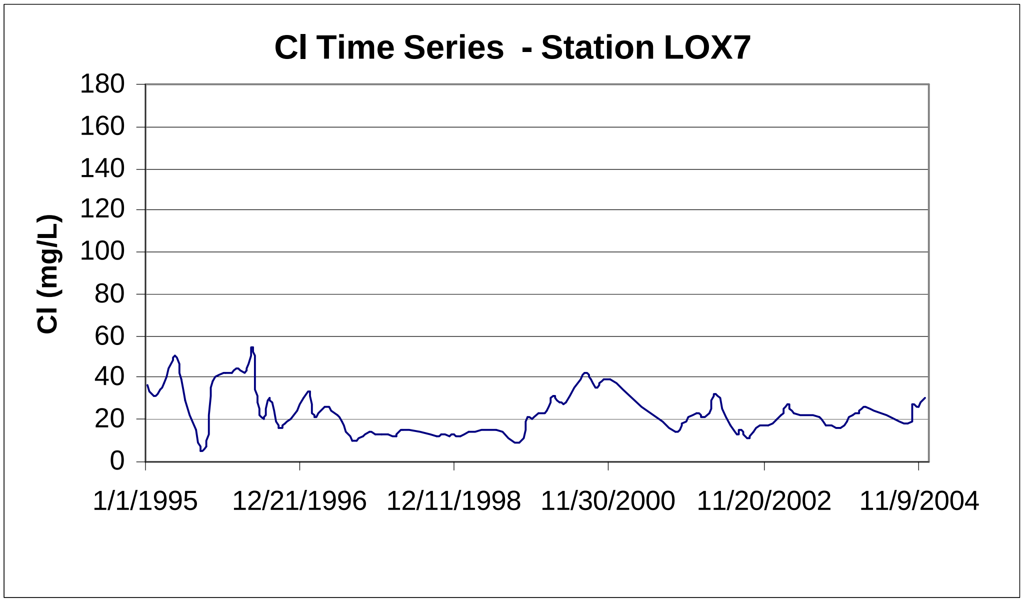

Figure F5.5 Cl Time Series – Station LOX7

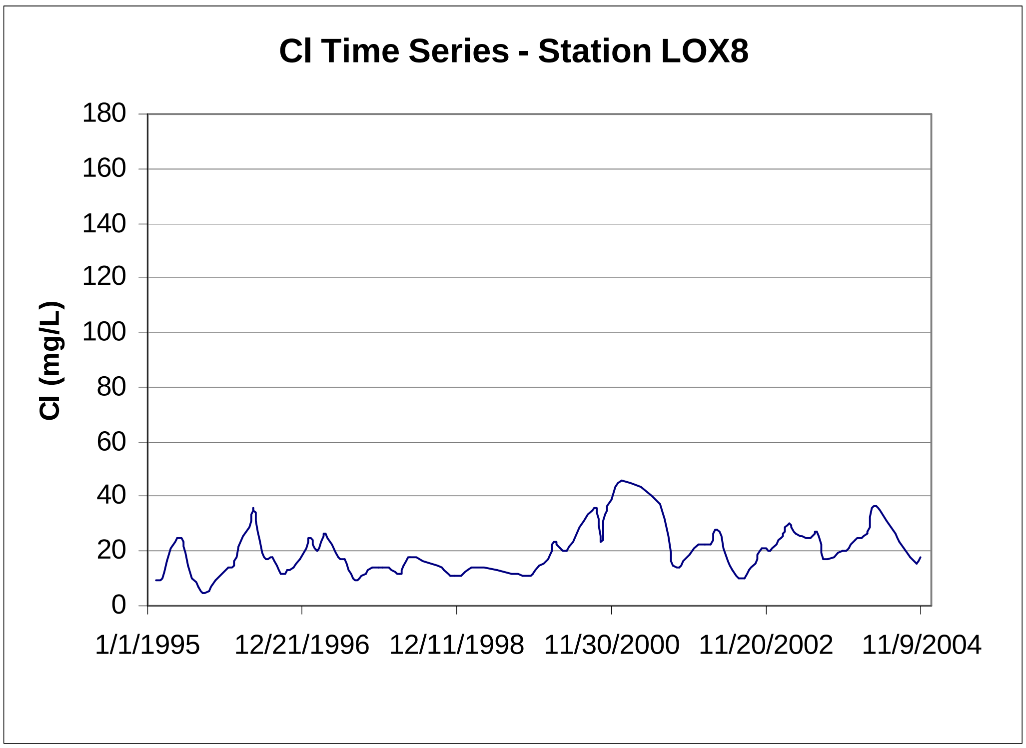

Figure F5.6 Cl Time Series – Station LOX8

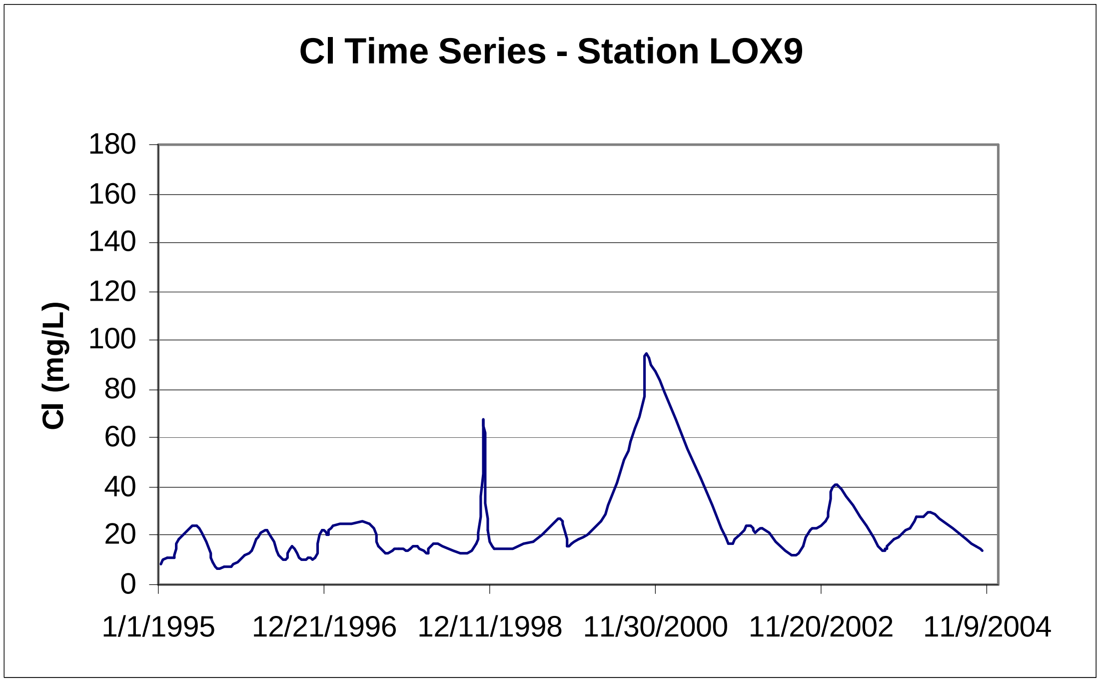

Figure F5.7 Cl Time Series – Station LOX9

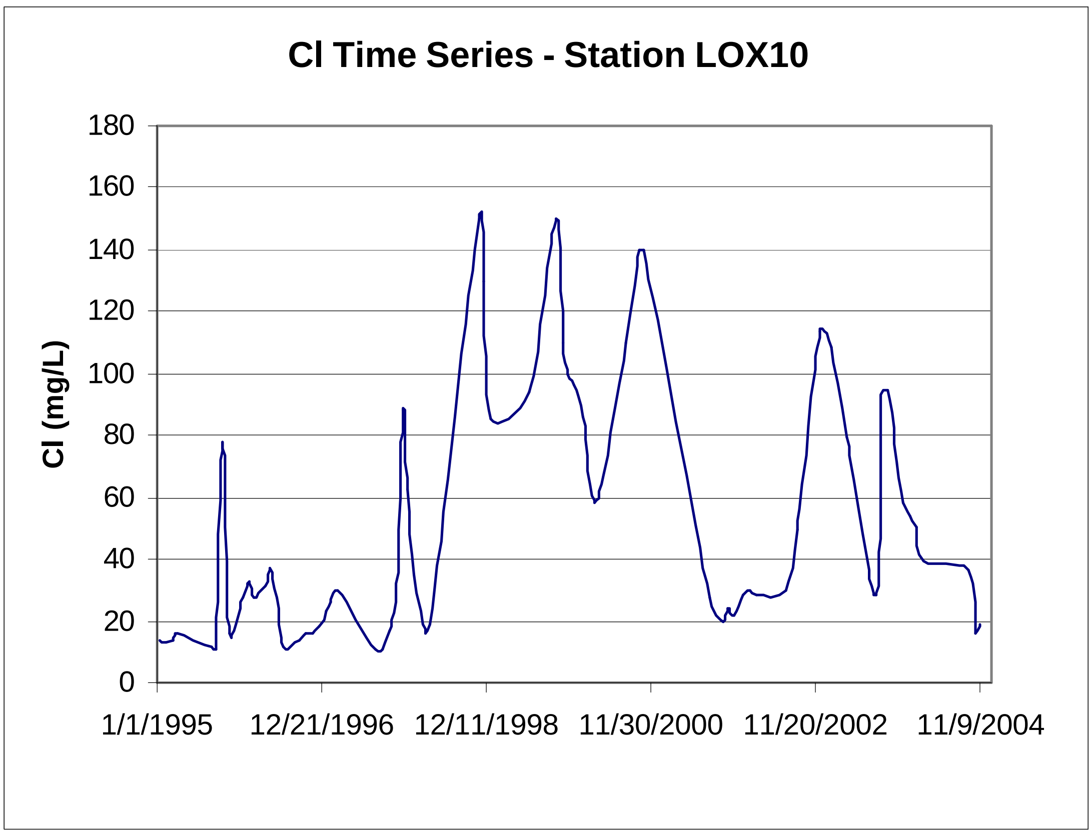

Figure F5.8 Cl Time Series – Station LOX10

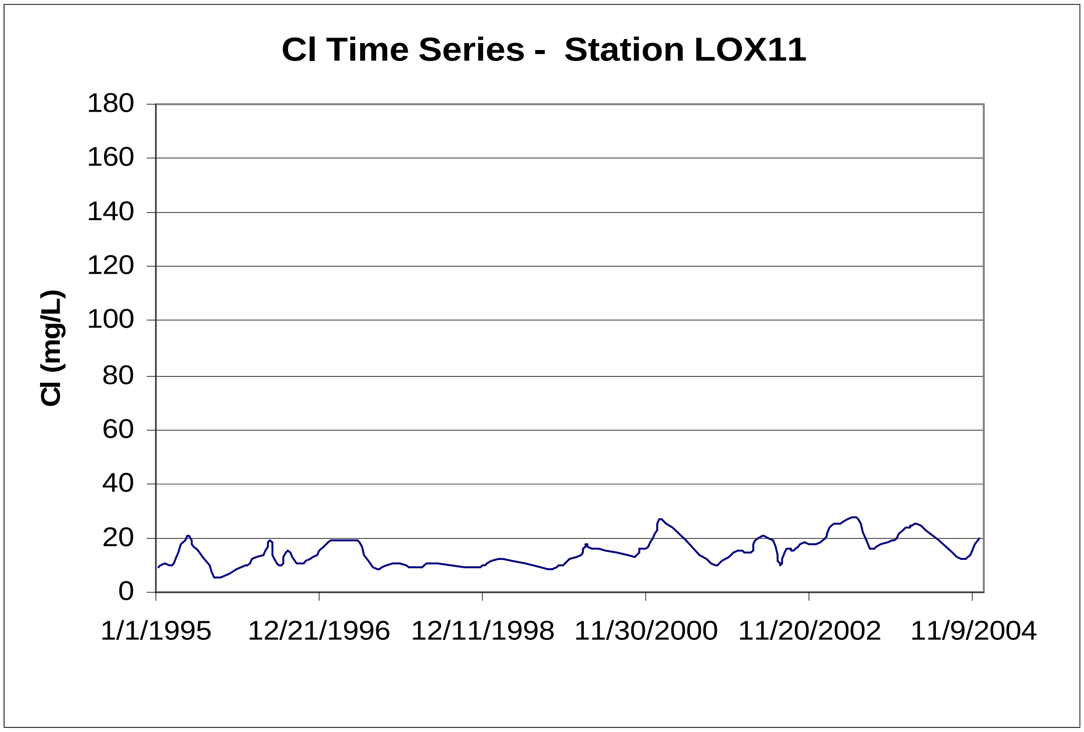

Figure F5.9 Cl Time Series – Station LOX11

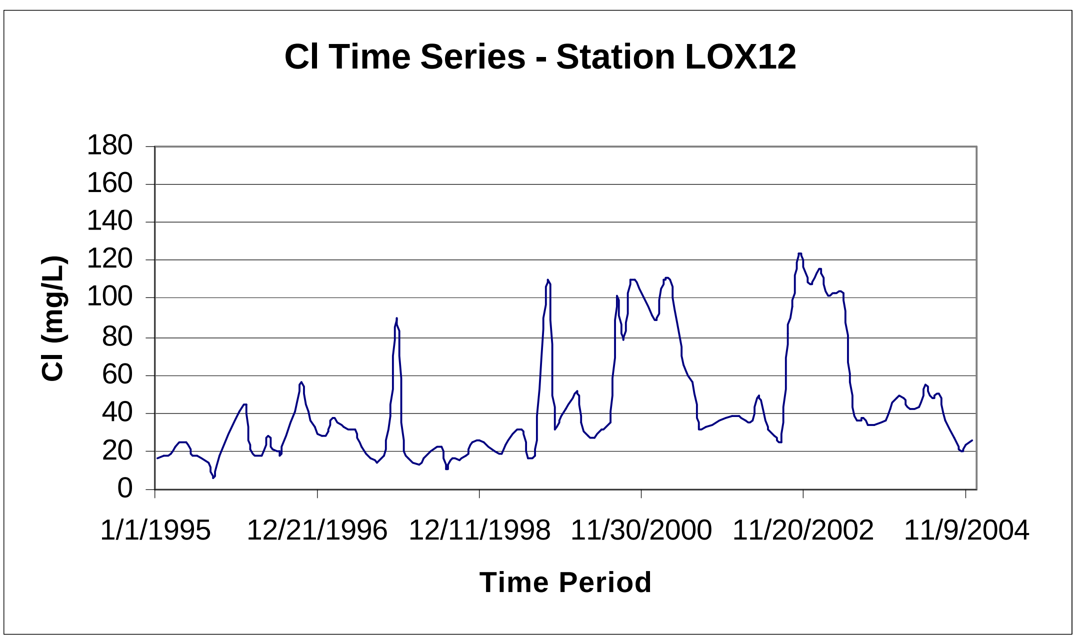

Figure F5.10 Cl Time Series – Station LOX12

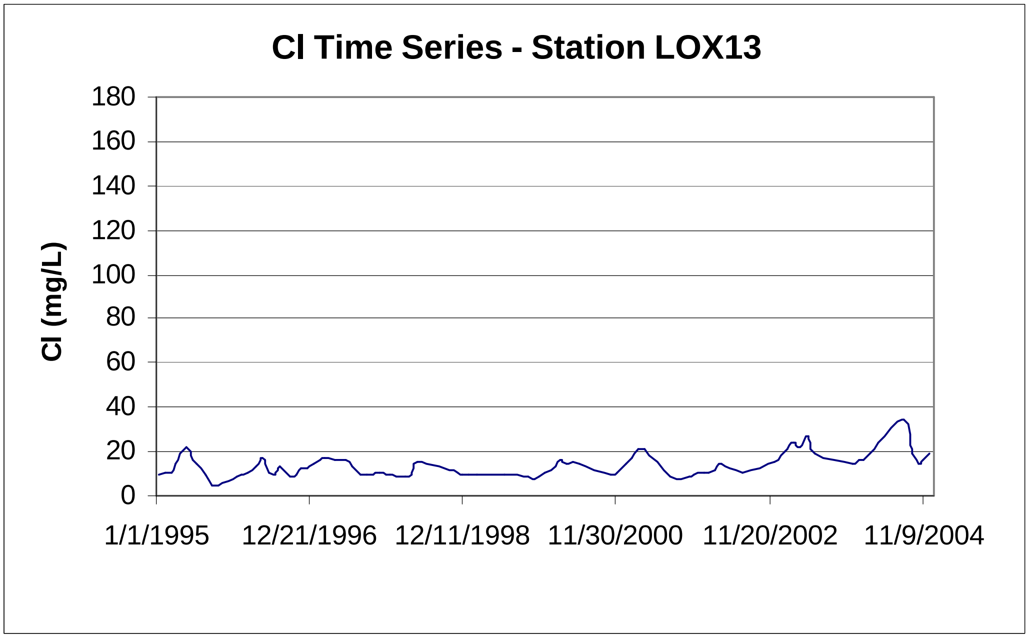

Figure F5.11 Cl Time Series – Station LOX13

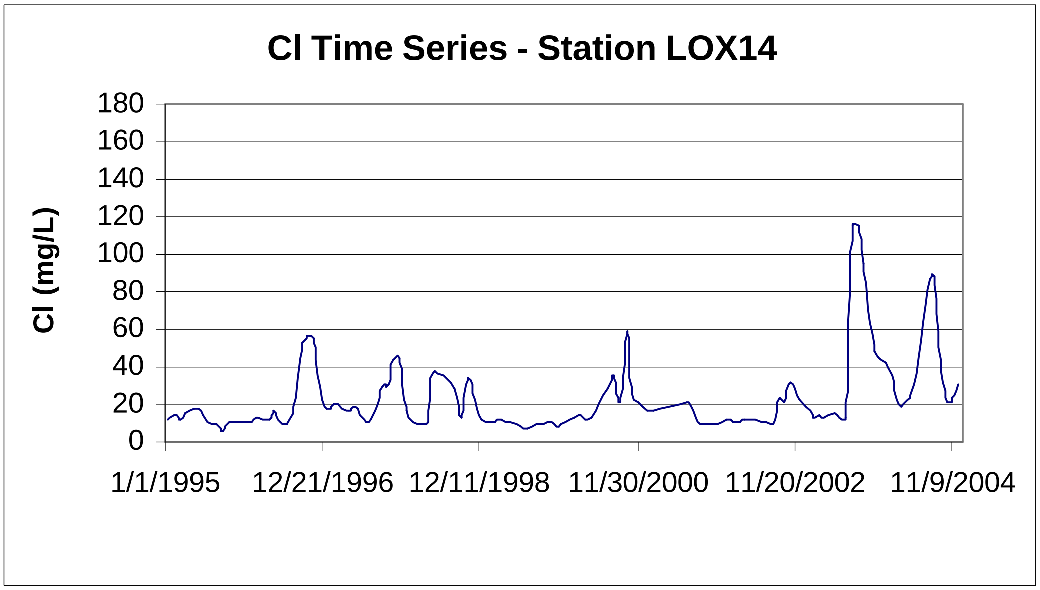

Figure F5.12 Cl Time Series – Station LOX14

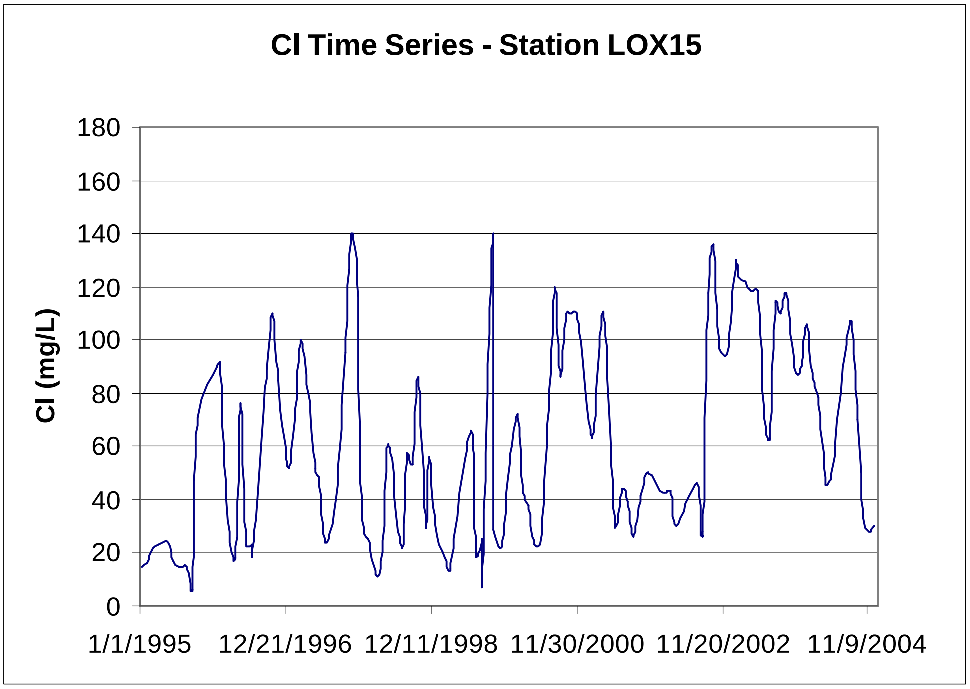

Figure F5.13 Cl Time Series – Station LOX15

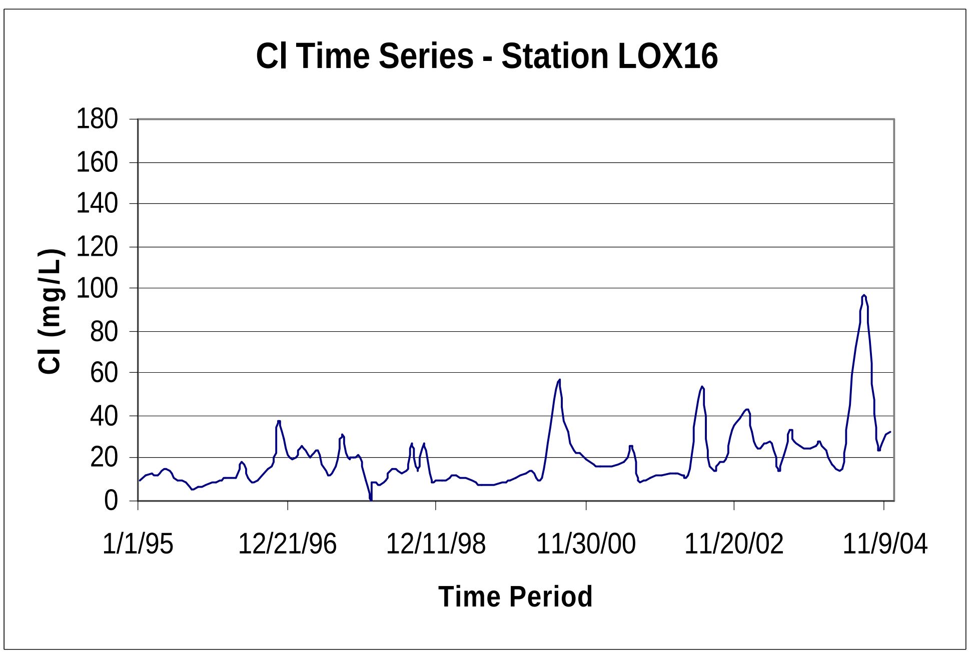

Figure F5.14 Cl Time Series – Station LOX16

APPENDIX F6

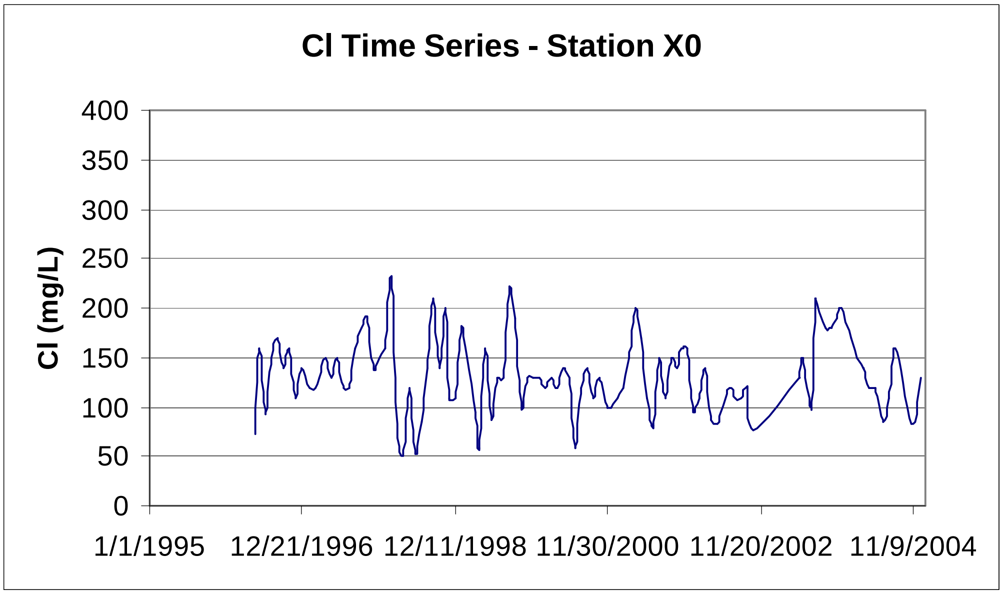

Figure F6.1 Cl Time Series – Station X0

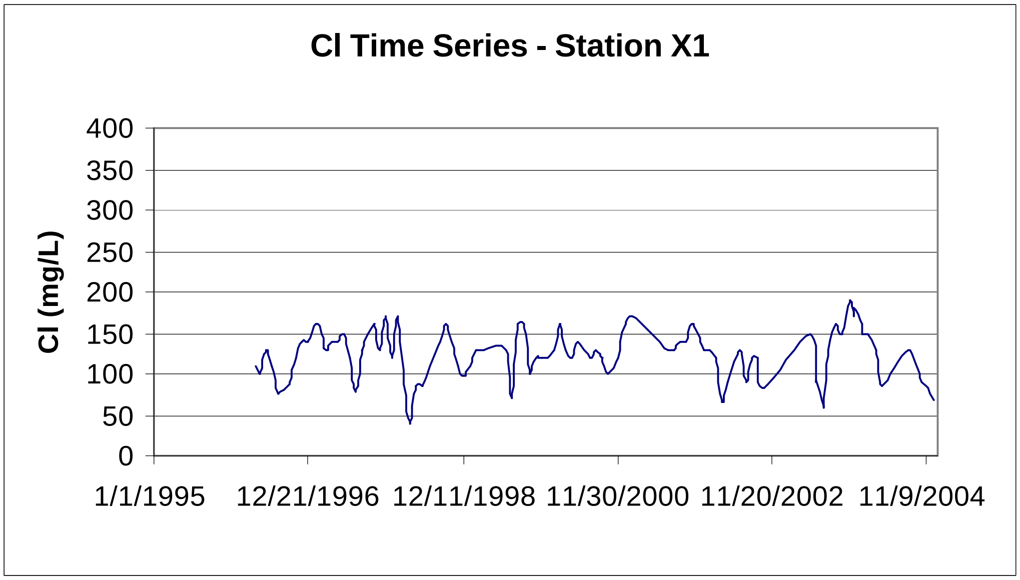

Figure F6.2 Cl Time Series – Station X1

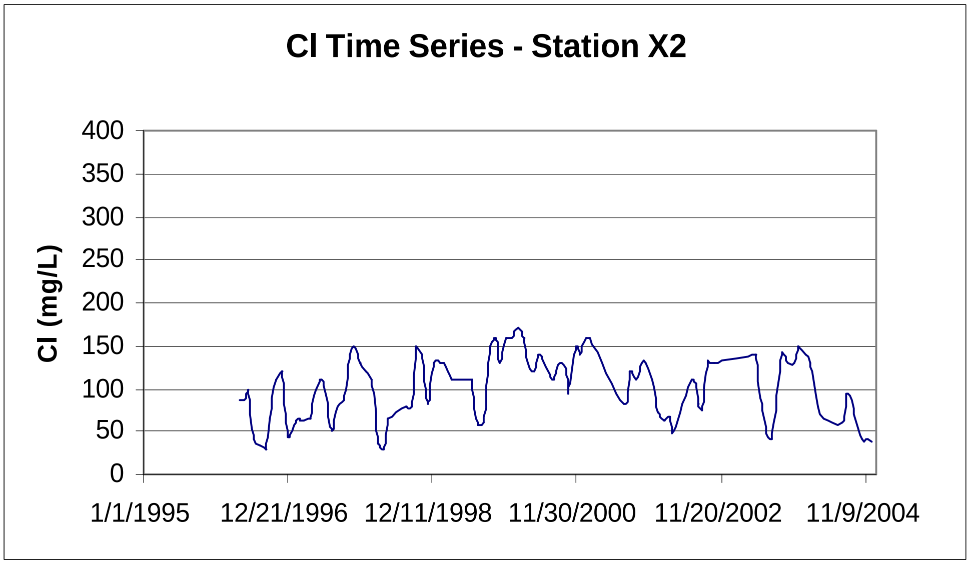

Figure F6.3 Cl Time Series – Station X2

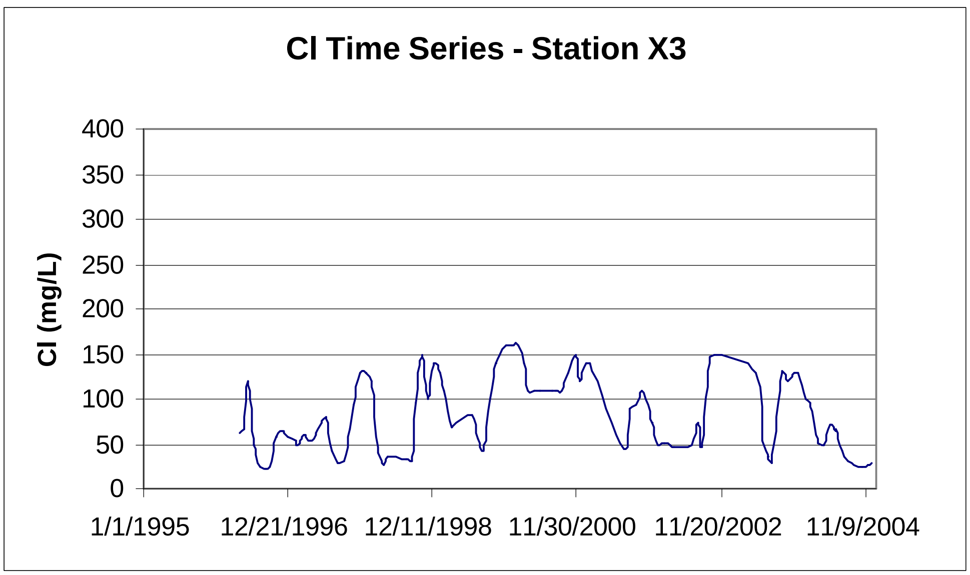

Figure F6.4 Cl Time Series – Station X3

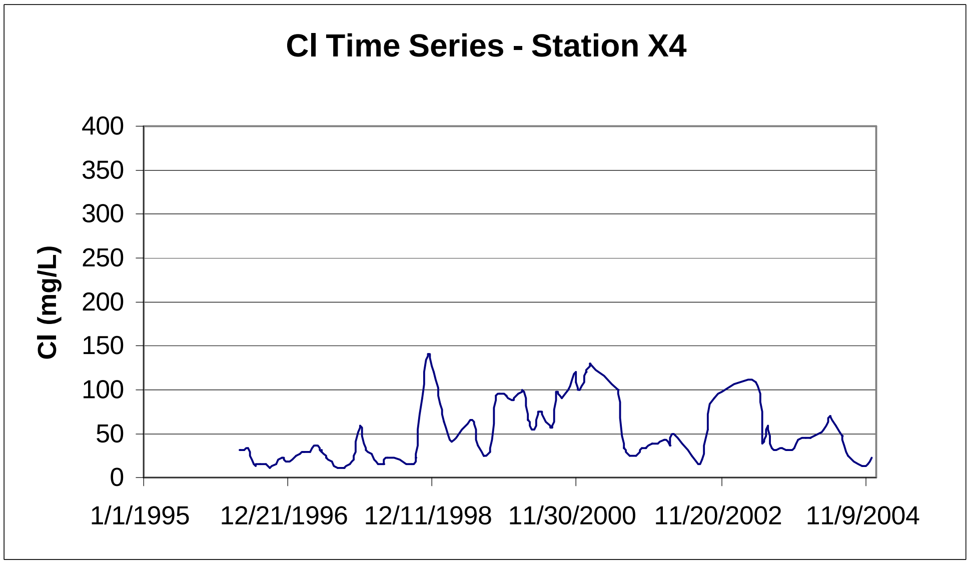

Figure F6.5 Cl Time Series – Station X4

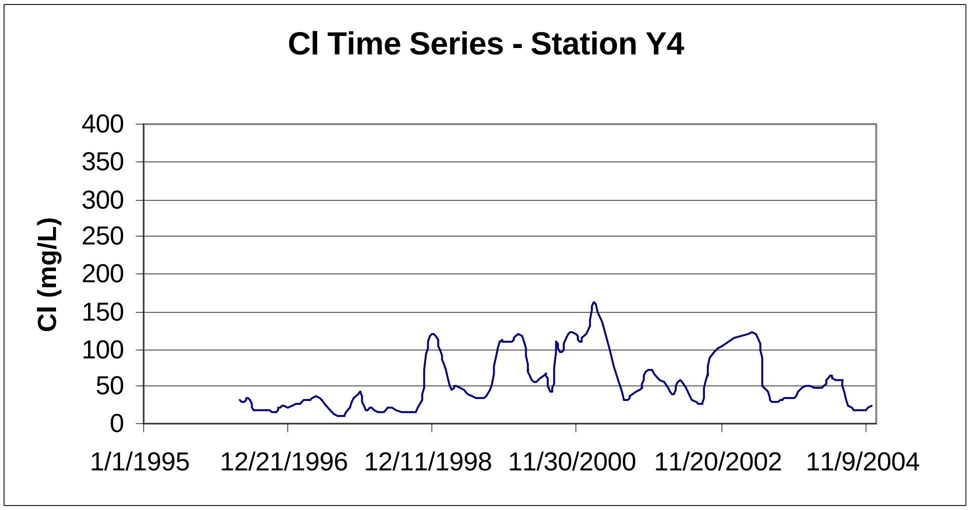

Figure F6.6 Cl Time Series – Station Y4

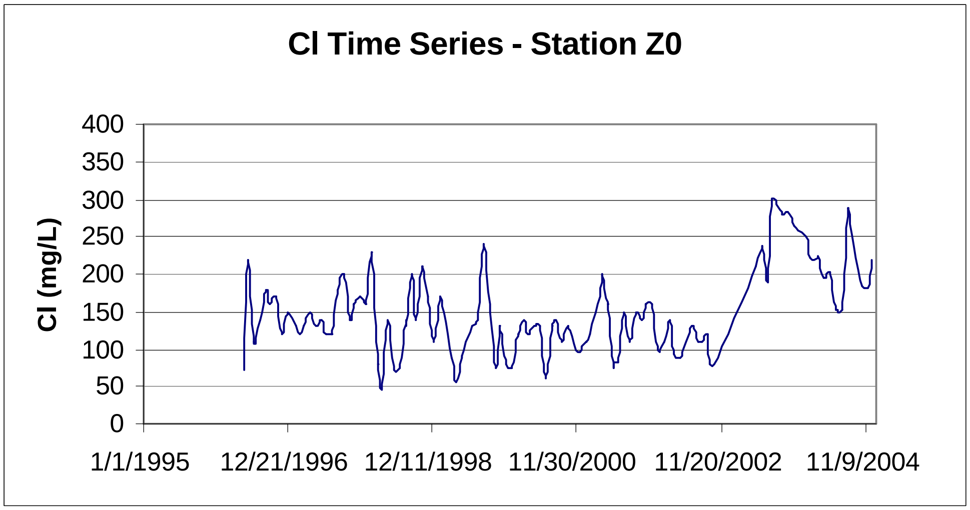

Figure F6.7 Cl Time Series – Station Z0

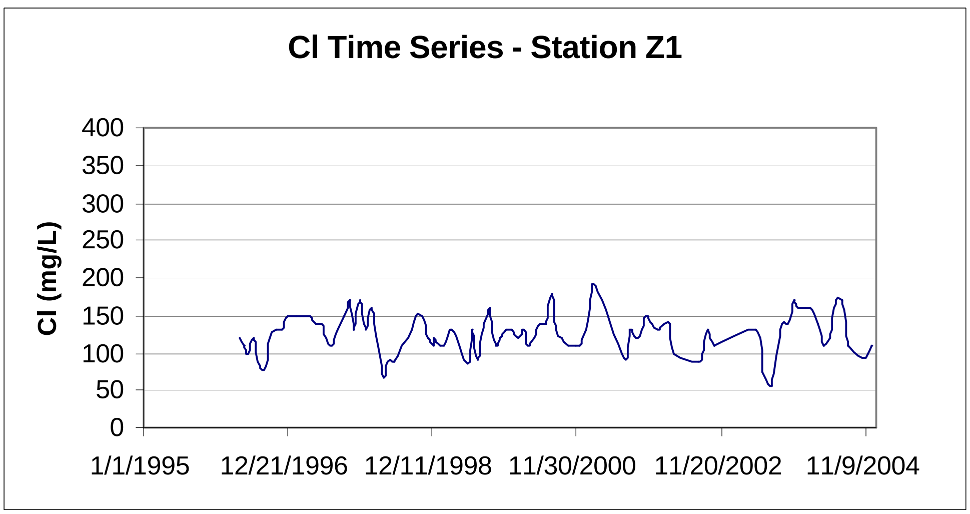

Figure F6.8 Cl Time Series – Station Z1

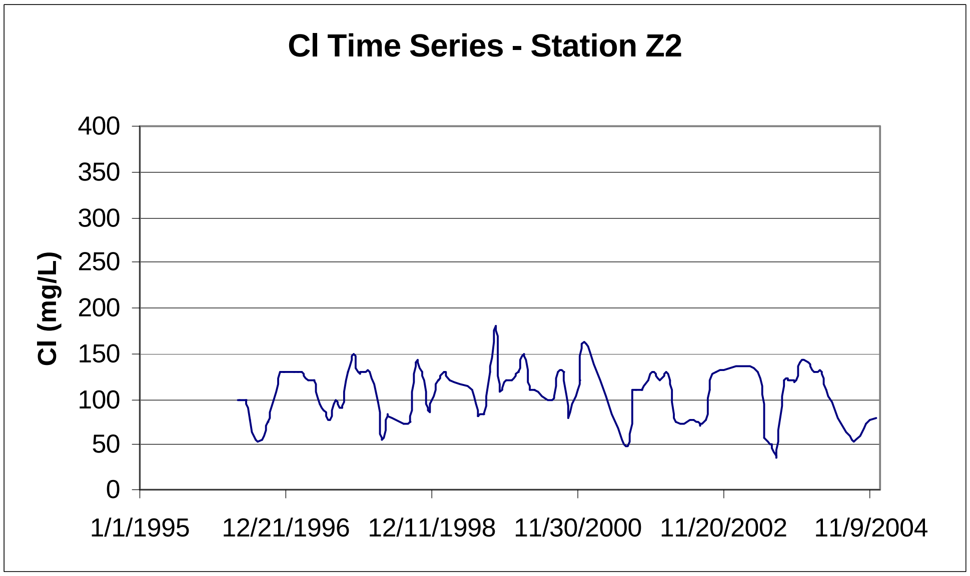

Figure F6.9 Cl Time Series – Station Z2

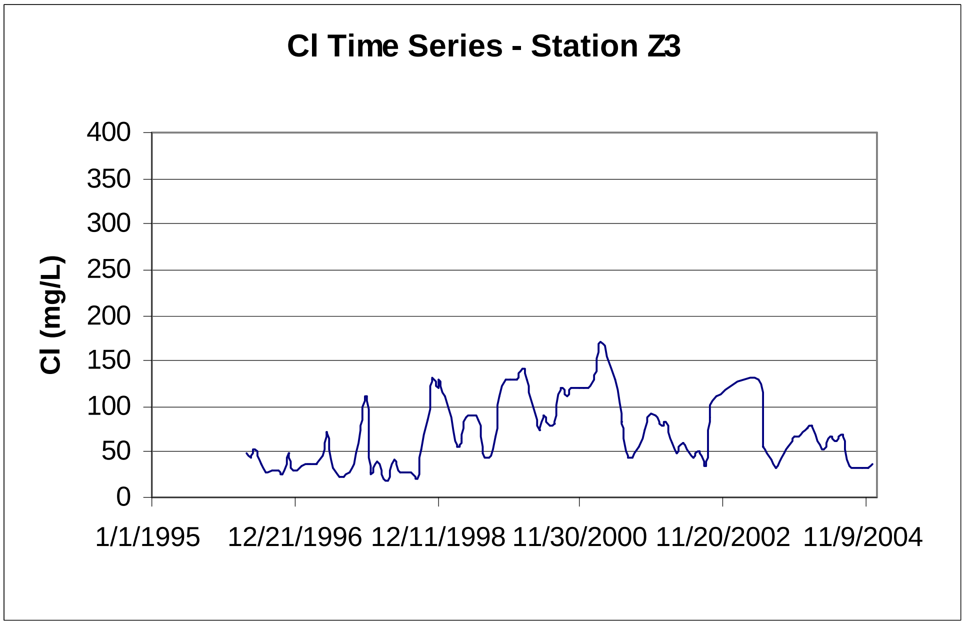

Figure F6.10 Cl Time Series – Station Z3

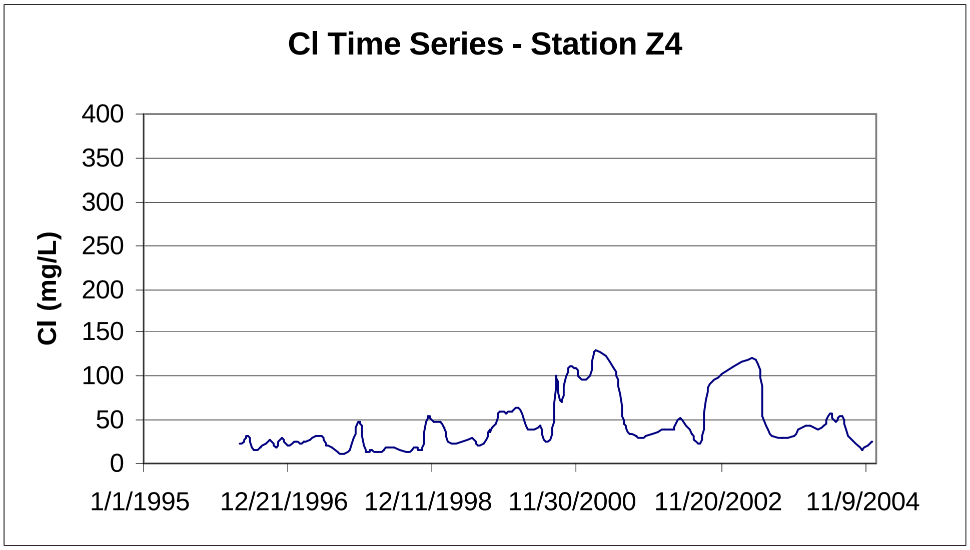

Figure F6.11 Cl Time Series – Station Z4

APPENDIX F7

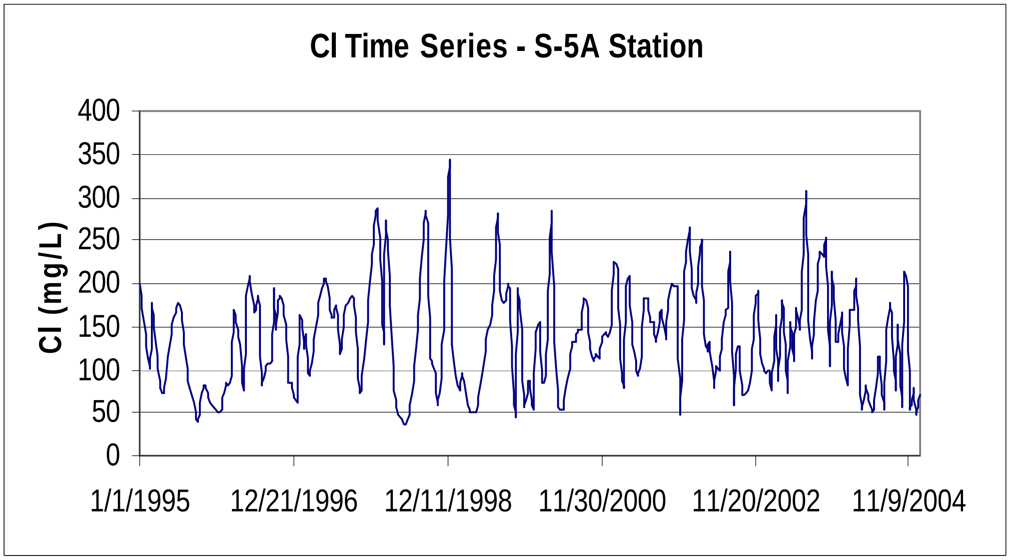

Figure F7.1 Cl Time Series – Station S-5A

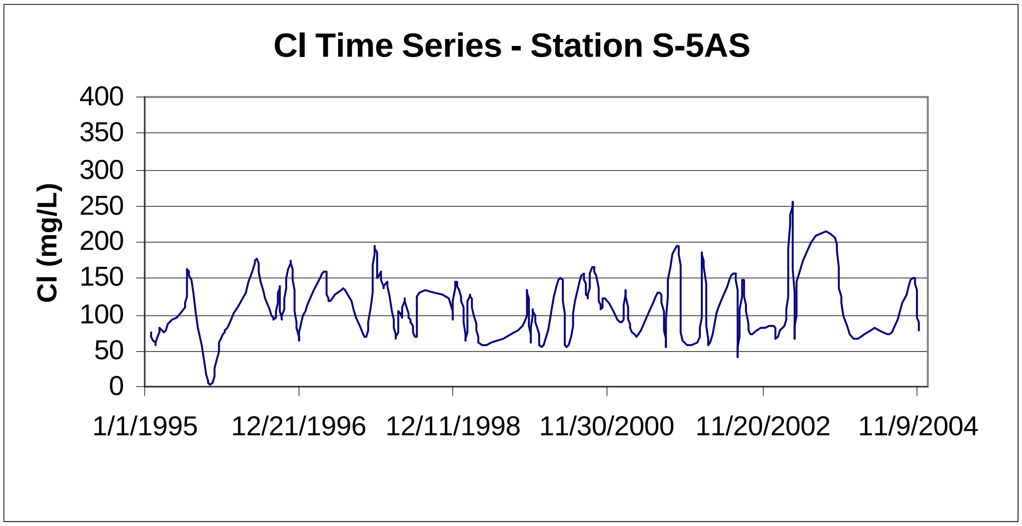

Figure F7.2 Cl Time Series – Station S-5AS

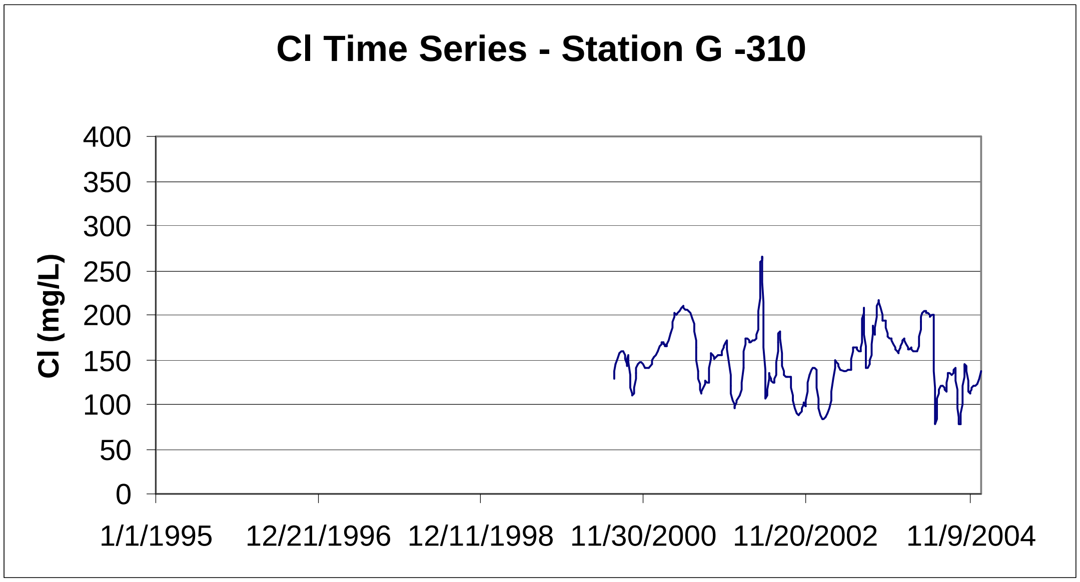

Figure F7.3 Cl Time Series – Station G-310

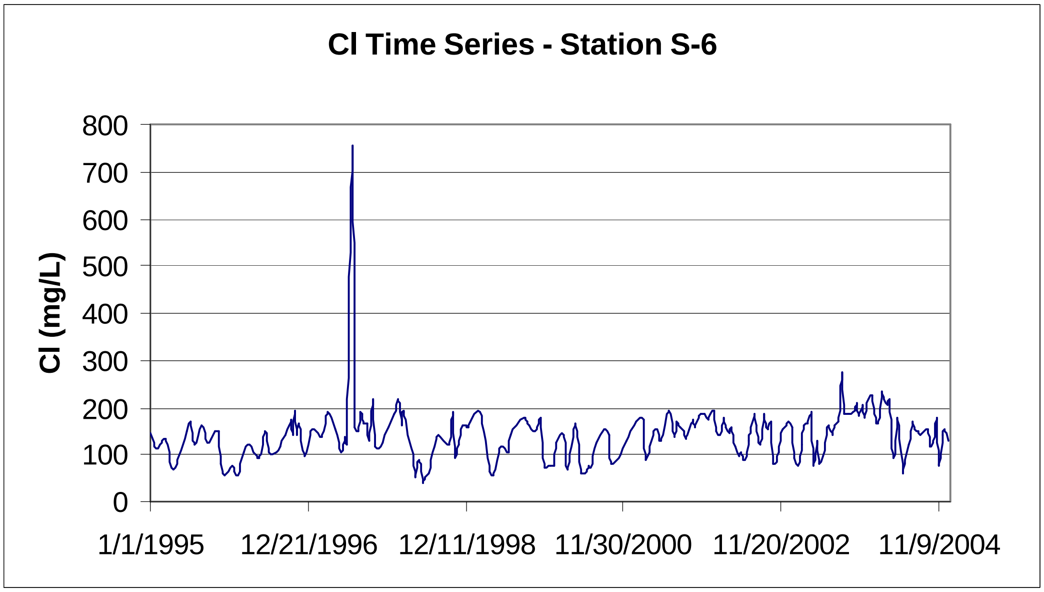

Figure F7.4 Cl Time Series – Station S-6

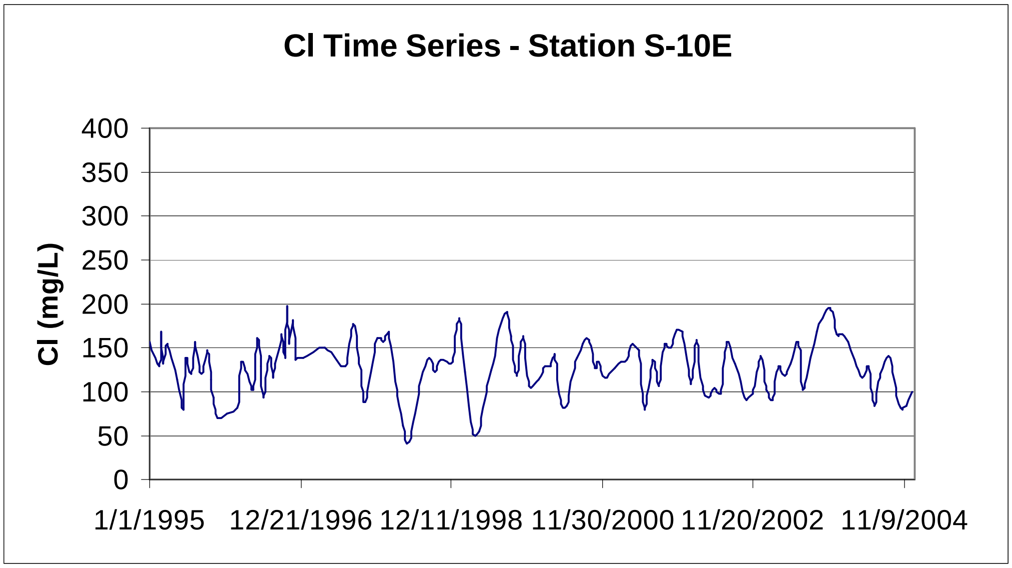

Figure F7.5 Cl Time Series – Station S-10E

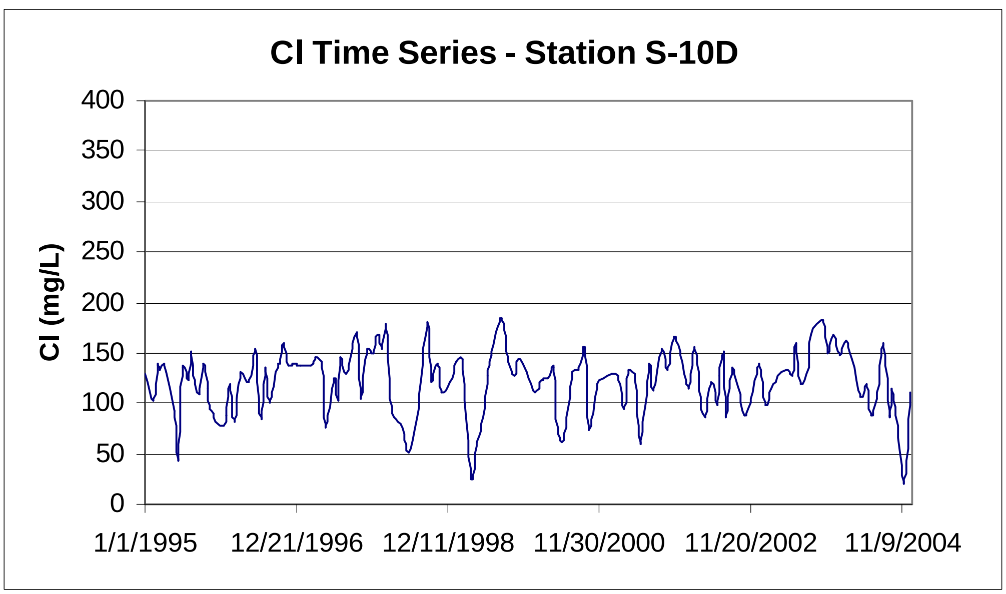

Figure F7.6 Cl Time Series – Station S-10D

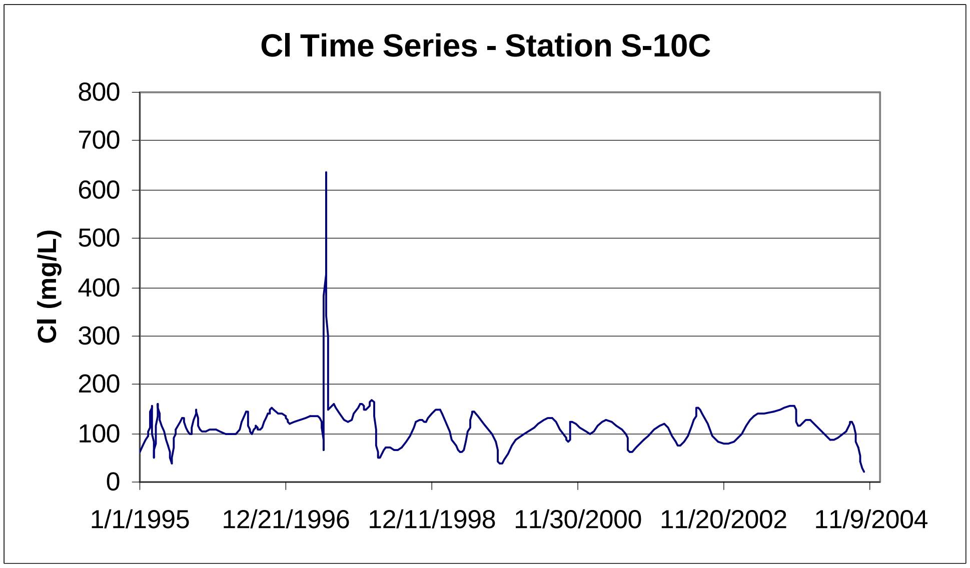

Figure F7.7 Cl Time Series – Station S-10C

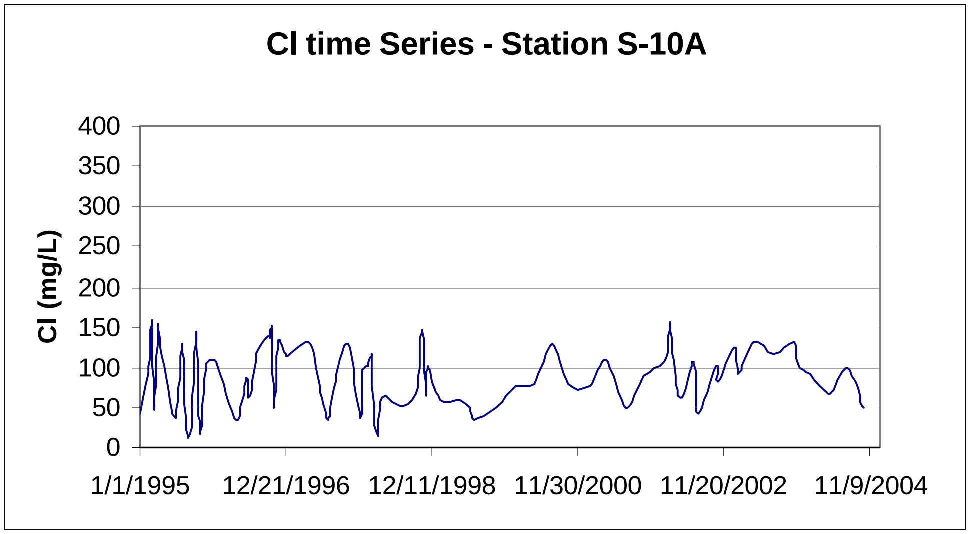

Figure F7.8 Cl Time Series – Station S-10A

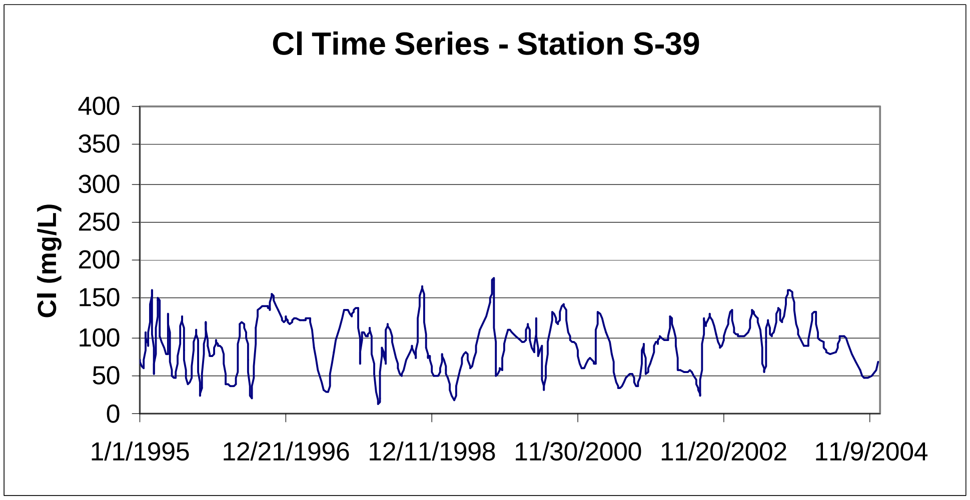

Figure F7.9 Cl Time Series – Station S-39

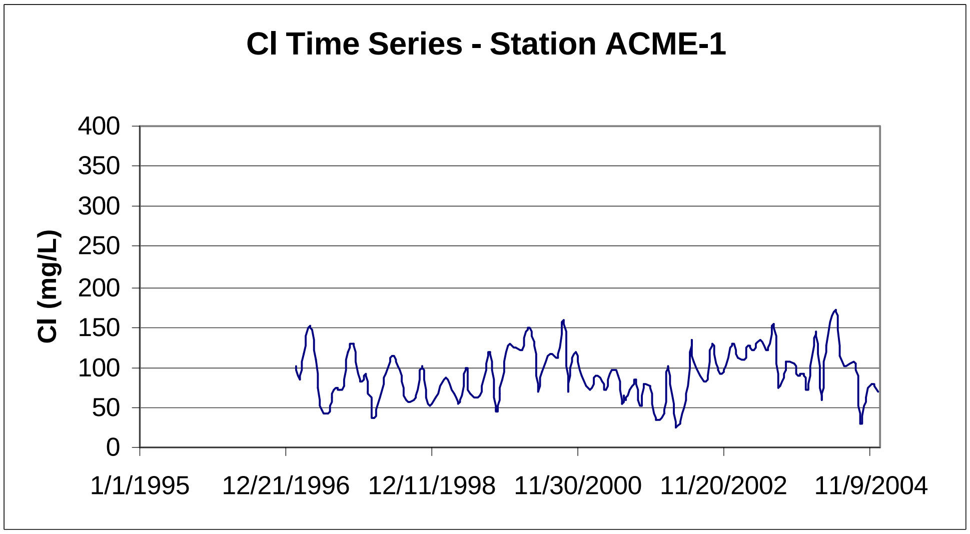

Figure F 7.10 Cl Time Series – Station ACME 1

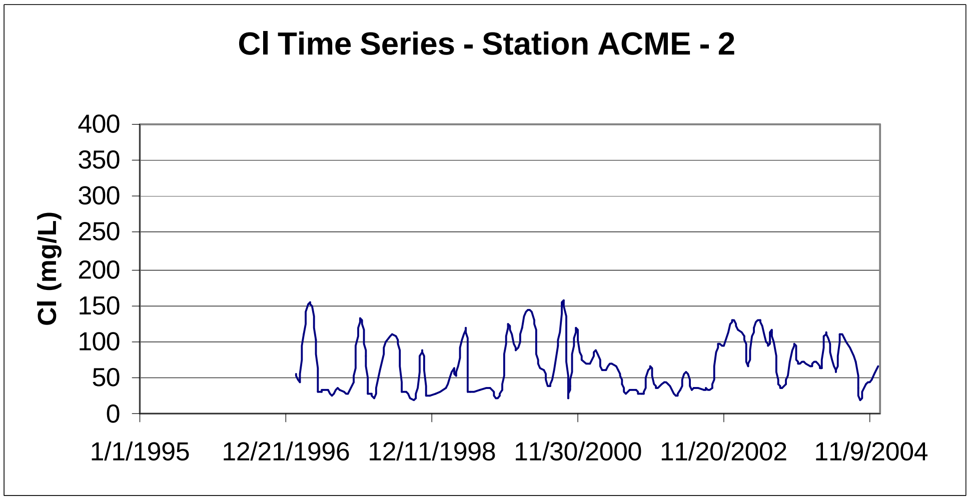

Figure F7.11 Cl Time Series – Station G-94D (ACME 2)

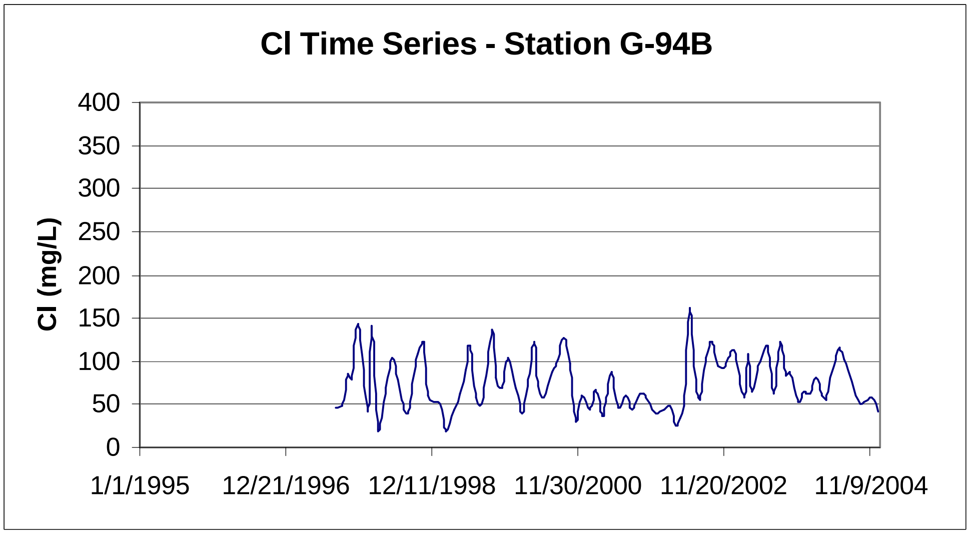

Figure F7.12 Cl Time Series – Station G-94B

APPENDIX F8

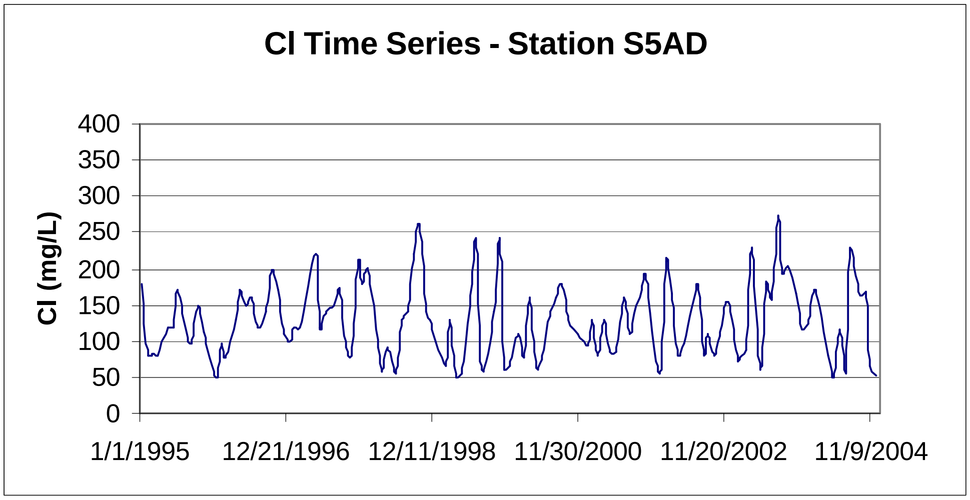

Figure F8.1 Cl Time Series – Station S5AD

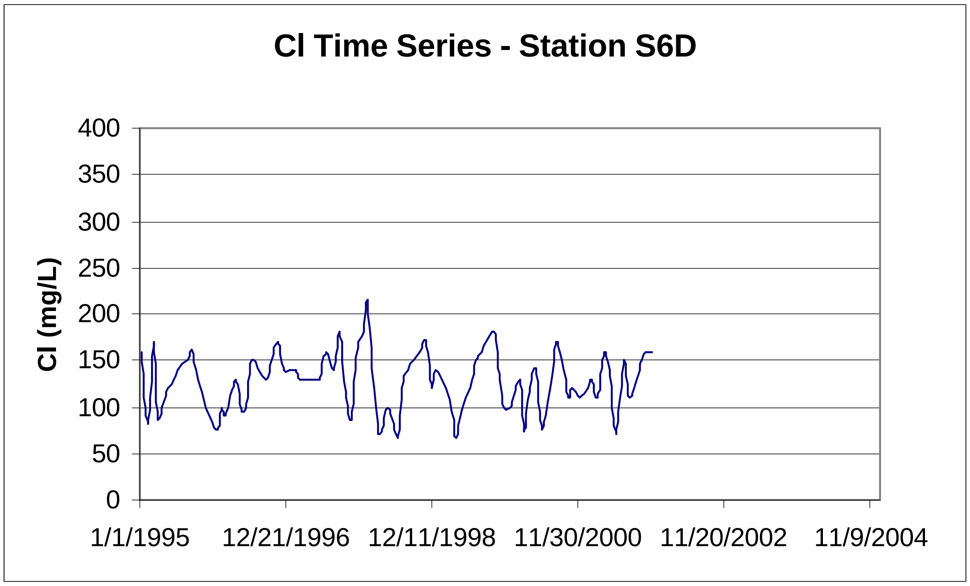

Figure F8.2 Cl Time Series – Station S6D

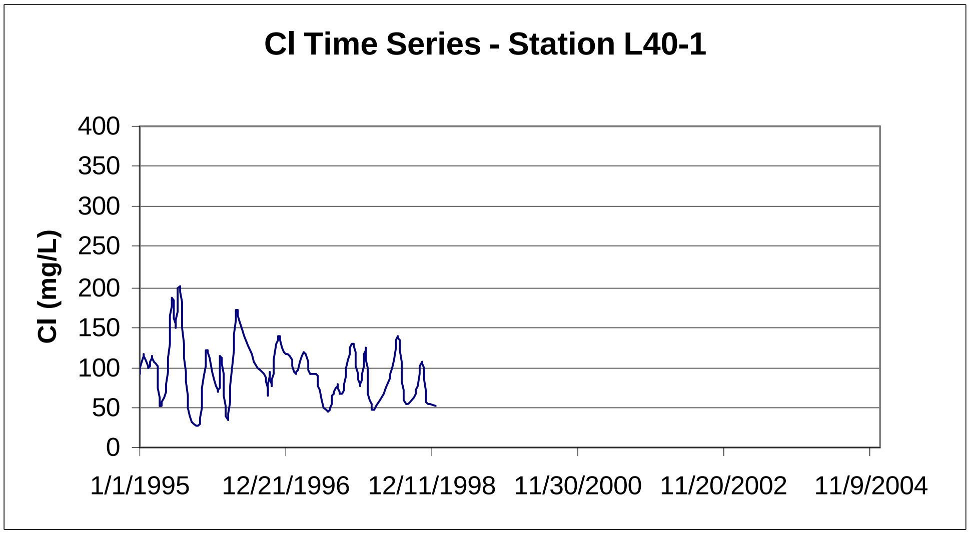

Figure F8.3 Cl Time Series – Station L40-1

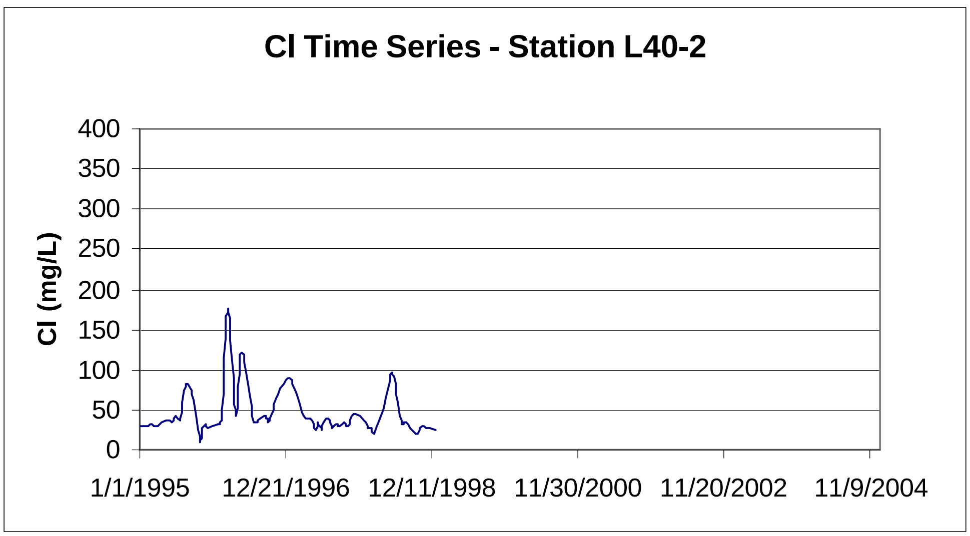

Figure F8.4 Cl Time Series – Station L40-2

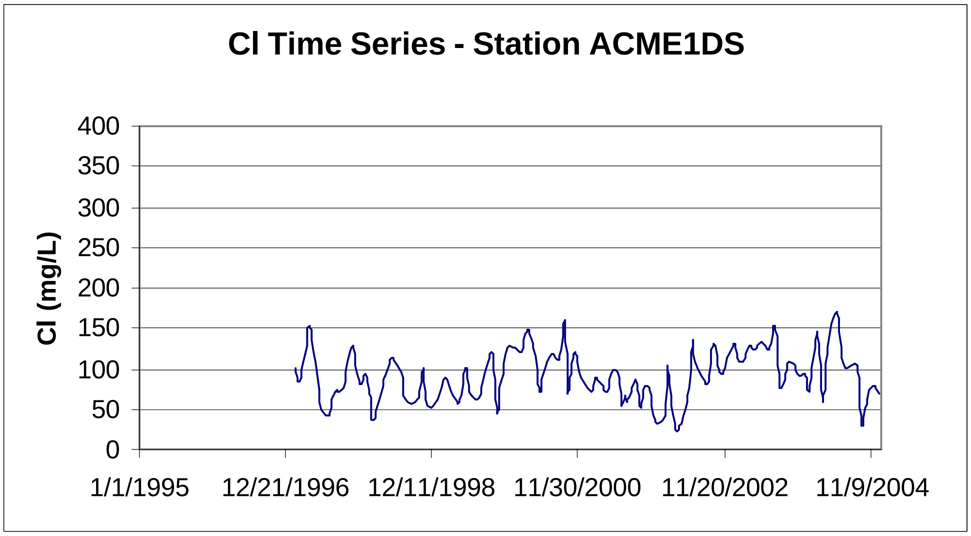

Figure F8.5 Cl Time Series – Station ACME1DS

Appendix G. Monthly Missing Data

Appendix G.1 Interior Station Water Level Data

Station	1995											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	1996											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	1997											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	1998											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	1999											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	2000											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North												
South												

Station	2001											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North						3	2	12				
South						7	2	12				

Station	2002											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T												
1-8C												
1-9												
North					1					1	3	
South					1					1	2	

Station	2003											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T			3	1				1				
1-8C												
1-9												
North			1							1		
South			1							1		

Station	2004											
	J	F	M	A	M	J	J	A	S	O	N	D
1-7												
1-8T			1							1		
1-8C									26	31	30	1
1-9												
North												
South												

Complete data are available for this month.

1 The station was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

The station was not in operation during this period

Appendix G.2 Head and Tail Water Level Data

Station	Data Type	1995											
		J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
S-10E	HW												
	TW												
G-338	HW												
	TW												
S-10D	HW	6			1			4					
	TW	7			1			6	7	6			
S-10C	HW												1
	TW							3	3			7	1
S-10A	HW												1
	TW												11
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94D	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94C	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31

Station	Data Type	1996											
		J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
S-10E	HW												
	TW												
G-338	HW												
	TW												
S-10D	HW												
	TW												
S-10C	HW				9								
	TW							5			2		
S-10A	HW			2	1					10			
	TW	3		2	1				18	7			
S-39	HW												
	TW												1
S-362	HW												
	TW												
ACME#1	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	31	29	31	30	31	30	31	31	30	31	30	31
G-94D	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	31	29	31	30	31	30	31	31	30	31	30	31
G-94C	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	31	29	31	30	31	30	31	31	30	31	30	31
G-94B	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	31	29	31	30	31	30	31	31	30	31	30	31
G-94A	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	31	29	31	30	31	30	31	31	30	31	30	31

Station	Data Type	1997											
		J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
S-10E	HW												
	TW												
G-338	HW												
	TW												
S-10D	HW						2						1
	TW						4		5	4		2	2
S-10C	HW						2	2					
	TW						1						
S-10A	HW						2						
	TW				4		2						
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94D	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94C	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31

Station	Data Type	1998											
		J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
S-10E	HW												
	TW												
G-338	HW												
	TW												
S-10D	HW				4								
	TW		1		4						1		
S-10C	HW												
	TW												
S-10A	HW							1			1		
	TW							3			1		
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94D	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94C	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31

Station	Data Type	1999											
		J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW								6	30	31	1	
	TW								6	30	31	1	
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
S-10E	HW												
	TW					1							
G-338	HW												
	TW												
S-10D	HW												
	TW												
S-10C	HW												
	TW												
S-10A	HW					1			2				
	TW					3			3				
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW	31	28	31	30	31	30	31	31	8			
	TW	31	28	31	30	31	30	31	31	8			
G-94D	HW	31	28	31	30	31	30	31	31	7			
	TW	31	28	31	30	31	30	31	31	7			
G-94C	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW	31	28	31	30	31	30	31	31	30	31	30	31

Water level data are available and complete for this month

Structure was not in operation during this month

20 Structure was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Cont. Appendix G.2 Head and Tail Water Level Data

2000

Station	Data Type	J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
G-338	HW												
	TW												
S-10E	HW												
	TW												
S-10D	HW						5	3					
	TW						5	14					
S-10C	HW												
	TW												
S-10A	HW							1	1				
	TW												
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW												
	TW												
G-94D	HW												
	TW												
G-94C	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	17											
G-94B	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	17											
G-94A	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW	17											

2001

Station	Data Type	J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
G-338	HW												
	TW												
S-10E	HW												
	TW												
S-10D	HW					16							
	TW												
S-10C	HW												
	TW												
S-10A	HW												
	TW												
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW												
	TW												
G-94D	HW												
	TW												
G-94C	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												

2002

Station	Data Type	J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW												
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
G-338	HW												
	TW												
S-10E	HW												
	TW												
S-10D	HW										1	6	
	TW										1	6	
S-10C	HW												
	TW												
S-10A	HW										1	6	
	TW										1	6	
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW								2				
	TW								2				
G-94D	HW												
	TW												
G-94C	HW	31	28	31	30	31	2						
	TW	1	6		10								
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												

2003

Station	Data Type	J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW												
	TW												
G-300	HW												
	TW												
G-301	HW												
	TW												
G-310	HW								31	30	31	30	31
	TW												
G-251	HW												
	TW												
S-6	HW												
	TW												
G-338	HW												
	TW												
S-10E	HW												
	TW					19							
S-10D	HW			3	1	4					1		
	TW	3		3	1	7					1		
S-10C	HW												
	TW												
S-10A	HW			3	1			5	4	5	5		
	TW			3	1	2		12	12	1	7		
S-39	HW												
	TW												
S-362	HW												
	TW												
ACME#1	HW												
	TW												
G-94D	HW												
	TW												
G-94C	HW												
	TW												
G-94B	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW					3	3				10	12	
G-94A	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW										10		

2004

Station	Data Type	J	F	M	A	M	J	J	A	S	O	N	D
S-5A	HW												
	TW												
S-5AS	HW										31	30	31
	TW												
G-300	HW												
	TW												
G-301	HW												4
	TW												
G-310	HW	31	28	31	30	31	30	31	31	30	31	30	31
	TW												
G-251	HW					14							
	TW						10						
S-6	HW												
	TW												
G-338	HW												
	TW												
S-10E	HW												
	TW												
S-10D	HW												
	TW					6	9						
S-10C	HW												
	TW												
S-10A	HW	1							4	1			
	TW	1			1				1				
S-39	HW										10	11	
	TW												
S-362	HW									10	13		
	TW									10	13		
ACME#1	HW									8			
	TW									6			
G-94D	HW									9			
	TW									9			
G-94C	HW		7										
	TW		7										
G-94B	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW			12									
G-94A	HW	31	29	31	30	31	30	31	31	30	31	30	31
	TW			12				6	12				

Water level data are available and complete for this month

Structure was not in operation during this month

20 Structure was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Appendix G.3 Flow Data

Station (1995)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	31	28	31	30	31	30	31	31	30	31	30	31

Station (1996)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	29	31	30	31	30	31	31	30	31	30	31
G-94B	31	29	31	30	31	30	31	31	30	31	30	31
G-94A	31	29	31	30	31	30	31	31	30	31	30	31

Station (1997)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	31	28	31	30	31	30	31	31	30	31	30	31

Station (1998)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	31	28	31	30	31	30	31	31	30	31	30	31

Station (1999)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300								6	30	31	1	
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	28	31	30	31	30	31	31	30	31	30	31
G-94B	31	28	31	30	31	30	31	31	30	31	30	31
G-94A	31	28	31	30	31	30	31	31	30	31	30	31

Station (2000)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C	31	29	31	14								
G-94B	31	29	31	14								
G-94A	31	29	31	14								

Station (2001)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C												
G-94B												
G-94A												

Station (2002)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C												
G-94B												
G-94A												

Station (2003)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362												
ACME#1												
G-94D												
G-94C												
G-94B												
G-94A												

Station (2004)	J	F	M	A	M	J	J	A	S	O	N	D
S-5A												
S-5AS												
G-300												
G-301												
G-310												
G-251												
S-6												
S-10E												
G-338												
S-10D												
S-10C												
S-10A												
S-39												
S-362										8	6	1
ACME#1												
G-94D												
G-94C												
G-94B												
G-94A												

Flow data are available and complete for this month

Structure was not in operation during this month

20 Structure was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Appendix G.4 Rainfall Data

Station	1995												1996												1997												1998												1999											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
S-5A																																																												
S-6																																																												
S-39																																																												
STA1W																																																												
WCA1ME														11		6	31	5			4	31			2	28	31	30	11					8	30	31	31	28	31	30	31	30	31	31	30	17														
LOXWS																							1										13												21	31	30	3		26	3	17								2
Gage1																																																												
Gage2																																																												
Gage3																																																												
Gage4																																																												
Gage5																																																												
Gage6																																																												
Gage7																																																												
Gage8																																																												
Gage9																																																												
Gage10																																																												

Station	2000												2001												2002												2003												2004											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
S-5A																																																												
S-6																																																												
S-39																																5	7						7	3			4		4													2		
STA1W																																																												
WCA1ME					1																									20	18			1																				21	7		28		7	1
LOXWS	6																														25	31	4	1																						2				
Gage1																																																												
Gage2																																																												
Gage3																																																												
Gage4																																																												
Gage5																																																												
Gage6																																																												
Gage7																																																												
Gage8																																																												
Gage9																																																												
Gage10																																																												

Complete data are available for this month.

1 The gage was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Data are not available for this period

Appendix G.5 Evaporation and ET Data

Station	1995											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	16	5	2	15	14	15	16	16	15	9	9	13
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS		4	17	20	17					3		

Station	1996											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	14	13	14	14	20	27	19	12	21	22	20	16
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS		12	19	25	25	16	25	14	17	3	18	31

Station	1997											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	20	12	12	14	15	16	5	18	10	9	18	12
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS	31	26		1					15			

Station	1998											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	15	15	12	10	18	7	14	16	9	11	21	15
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS									22	31	30	4

Station	1999											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	16	13	13	6	15	15	9	9	10	11	15	4
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS		27	4	18								3

Station	2000											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	8	29	11	19	4	13	11	10	11	13	15	18
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS	7			4	3		4	4				

Station	2001											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	17	15	11	16	12	13	14	11	21	12	13	19
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS	1	1	31	15	15	6	7	6			8	

Station	2002											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	15	10	12	14	10	8	8	2	1	4	11	2
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS			5	12	25	3	26	31	6	12		

Station	2003											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	4	9	12	8	13	8	11	5	8	13	14	15
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS			6	27	5				9	1	18	6

Station	2004											
	J	F	M	A	M	J	J	A	S	O	N	D
Pan Evaporation												
S5A	7	12	13	12	11	7	9	9	22	20	21	19
Evapotranspiration												
STA1W												
Potential Evapotranspiration												
LOXWS				12	2			6	5		30	31

Complete data are available for this month.

1 The station was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Appendix G.6 Air Temperature Data

Station	1995											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS												

Station	1996											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS									5		1	

Station	1997											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS									13			

Station	1998											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS									21	31	30	3

Station	1999											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS		26	3	17								2

Station	2000											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS	21			1					6			17

Station	2001											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS			8	10								

Station	2002											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS							25	31	4	8	12	

Station	2003											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS				10								

Station	2004											
	J	F	M	A	M	J	J	A	S	O	N	D
Air Temperature												
LOXWS				11				4				

Complete data are available for this month.

1 The station was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Appendix G.7 Wind Data

Station (1995)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS												
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (1996)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS												
S-5A												
PBI												
USGS-1		13	3	1								
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1		12	3									
USGS-2												
USGS-3												
USGS-4												

Station (1997)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS			1			13						
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3								28	30			
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI											1	
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (1998)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS	3								21	31	30	3
S-5A							16	13				
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4		13	4									18
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI		1										
USGS-1												
USGS-2												
USGS-3												
USGS-4		13	4									18

Station (1999)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS		26	3	17								2
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4				10	11	10	6	5	20			
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI											1	
USGS-1												
USGS-2												
USGS-3												
USGS-4				10	11	10	6	5	20			

Station (2000)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS	6			1								
S-5A												
PBI						2				1		
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (2001)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS												
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (2002)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308			1									
LOXWS							25	31	4	8		
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (2003)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308												
LOXWS						5						
S-5A												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI												
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Station (2004)	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed												
ENR308									5			
LOXWS				2	5			4		12		
S-5A												
PBI					1							
USGS-1												
USGS-2												
USGS-3												
USGS-4												
Wind Direction												
West Palm Beach International Airport (PBI)												
PBI					2				2			
USGS-1												
USGS-2												
USGS-3												
USGS-4												

Complete data are available for this month.

1 The station was in operation during this month but there are some missing data. The number inside the box indicates the total days of missing data for this month

Data are not available for this period